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32ND BLED ECONFERENCE

HUMANIZING TECHNOLOGY FOR A SUSTAINABLE SOCIETY

JUNE 16 – 19, 2019, BLED, SLOVENIA

CONFERENCE PROCEEDINGS

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32ND Bled eConference Humanizing Technology for a Sustainable Society

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For publisher full prof. Zdravko Kačič, PhD
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32ND Bled eConference Humanizing Technology for a Sustainable Society

ANDREJA PUCIHAR (ET AL.)

Abstract Bled eConference, organized by University of Maribor, Faculty of Organizational Sciences, has been shaping electronic interactions since 1988. Bled eConference is the oldest, most traditional and well renowned conference in the field with more than 30 years of tradition. The theme of this year's 32nd conference is dedicated to "Humanizing Technology for a Sustainable Society". In 2018, European Commission emphasized that in the future, competitiveness will be dependent on the ability to move towards sustainability, resource-efficiency and the ability to exploit the advantages of digital technologies. In the context of digital society, implementation of digital technologies to achieve higher efficiency and competitive advantage is insufficient. Society calls for different economy models; more responsible, righteous and less exploitative. In this year's conference, we address various aspects of these challenges and provide directions and guidelines for organizations to meet and overcome these challenges on their way towards successful digital transformation. Themes covered in the papers of these proceedings are focused on: digital transformation; business model innovation; blockchain and social media; big data, data science, and decision support systems; e-health, digital wellness and wellbeing; new applications and organizational models; and novel approaches and cases in education in digital economy.

Keywords: • Digital Transformation • Digital Technology • Innovation • Digitalization • Sustainability •

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The Role of Electronic Transportation Management Systems in Seaport Digitalization

MARIJA JOVIĆ, EDVARD TIJAN, SAŠA AKSENTIJEVIĆ &
BOŽIDAR SOTOŠEK

Abstract The volume and speed of information exchange among the stakeholders rose with the increase of transport and cargo volume in seaports. Several ways of communication between stakeholders exist, such as electronic exchange systems, shipping web portals and eCommerce. Electronic Transportation Management Systems (e-TMS) tackle the issue of non-uniform format standards and the means of messages exchange which can be solved by the adoption of Mediation Service Software and Electronic Transaction Platforms. With this adoption, the difference between efficient and inefficient traffic management systems becomes clearly visible. Inefficient systems do not possess the possibility to optimize business processes. The development of e-TMS also aims to solve economic and ecological issues. It allows centralized monitoring of business processes, optimization of transport chain management, and gathering data in a way that enables improved decision making.

Keywords: • Electronic Transportation Management Systems • Seaports • Digitalization • Business Processes • Seaport Digitalization •

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1 Introduction

Business processes, i.e. physical transactions that are present in seaports differ in developed and underdeveloped seaports. While the electronic data exchange is the basic mode of information exchange in developed ports, the flow of information is slower in less developed ports, mainly because of the presence of paper document exchange. According to Deloitte Port Services, there are four levels of seaport digital integration ("Deloitte Port Services - Smart Ports," 2017): port authority digitalization, port terminal integration, port-city integration and wider supply chain integration. Initially, the ports were focused only on loading and unloading operations and the development of infrastructure. The next phase of integration includes digitalization of the port terminals which includes the unification and standardization of the business processes of the seaport and the surrounding area (other stakeholders), while the final phase refers to broader integration that includes the whole supply chain, leading to full integration.

The need for faster business operations among agents, forwarders and their customers increased with traffic and cargo volume increase. According to European Commission's Proposal for a Regulation of the European Parliament and of the Council on electronic freight transport information (the European Commission, 2018), the information exchange is still largely conducted via paper documents, in a variety of formats; 99% of cross-border transport operations on the territory of the EU still involve paper-based documents at one stage of the operation or another. Costs, time and predictability are decisive factors for companies' competitiveness ("2017 Transportation Management Systems Trends," 2017). One of the problems, or issues that arise from the traditional (paper-based) data exchange in transportation are increased administration costs. Electronic data exchange allows a cut in administrative costs which could create savings of between €20 and 27 billion within the transport sector over the period from 2018 to 2040, according to Commission estimates (the European Commission, 2018). Electronic transportation management systems (e-TMS) can save companies' money by lowering their freight spend (ARC Advisory Group, 2018).

Harmful emissions represent the other problem caused by increased traffic volumes and traffic congestion. Close to 25% of the global CO2 emissions is caused by transport, and between 30 and 40% of this total is produced by cargo transport ("Transport's role in reducing CO2 emissions," 2018). The effective transportation systems should provide an optimal route with recommended optimized non - work stops (Nimchuk and Mckinney, 2018). However, not all participants are taking advantage of the vast benefits a TMS provides (Cerasis, 2016). According to Dreßler, each participant organizes his own transport processes without informing other participants, although the smooth flow depends on communication (Dreßler, Beißert, Beyhoff, and Wirtz, 2016), (Mei and Afli, 2017).

This article focuses on the following research question: What is the role of electronic transportation management systems in seaport digitalization? This question was addressed through a systematic literature review.

The authors will analyse the current state-of-the-art in using electronic transportation management systems, and compare the consequences of using the electronic/digital document exchange, as opposed to paper document exchange. The goal of the research is to prove the importance of electronic transportation management systems in seaport environment. Transparency and easy access to data are the basis for successful seaport business. Therefore, the research problem stems from increased costs and lost time due to the archaic or inadequate execution and monitoring of business processes. This paper presents a review of research papers dealing with this topic, providing a better understanding of eTMS implementation.

2 Methodology

The literature review was conducted in order to research the theoretical foundations of electronic transportation management systems. This article follows a systematic literature review method, which adheres closely to a set of scientific methods that aim to limit systematic error (bias), mainly by attempting to identify, appraise and synthesize all relevant studies (Reis, Amorim, and Melao, 2018). The systematic literature review method is also used as a key mechanism to promote diversity of knowledge in a certain domain (Savaget, Geissdoerfer, Kharrazi, and Evans, 2019).

The authors started with the inclusion criteria by using a combination of keyword "electronic Transportation management system" and alternative keyword "Transportation management system" (title, abstract and keywords). Google Scholar, ResearchGate and SpringerLink's databases were mainly used for this purpose. The search for articles was conducted according on the time limitations (2016-2018) and mostly included journal articles and conference papers. To ensure that possible useful findings from various fields were not excluded, the authors did not limit the queries to a specific field or index.

3 Theoretical framework

Several IT-based solutions exist that enhance communication between agents, shippers, forwarders and other stakeholders:

1. eCommerce: can be categorized according to the type of product, service and platform(Dr Wu, Starr, and Tan, 2017),
2. Shipping web portal or Multi Carrier Web Portal: Shipping portals are web-based communities that allow access to multiple carriers' services through a single site and on a global level,
3. Electronic exchange systems: e.g. Port Community System (PCS).

"Transportation management system adoption rates for smaller shippers has hovered in the 10% range, according to Bart De Muynck, Gartner research director, while about 25% of medium-sized firms and 50% of large organizations used the application to manage their freight activities" ("2017 Transportation Management Systems Trends," 2017). Another research about TMS has been conducted by MarketsandMarkets, a company which, according to their claims, provides quantified B2B research on 30,000 high growth emerging opportunities/threats which will impact 70% to 80% of worldwide companies' revenues ("Market Research Reports, Marketing Research Company, Business Research by MarketsandMarkets," 2018). According to their data, it is anticipated that "the global transportation management system market is expected to grow from USD 78.20 billion in 2017 to USD 202.14 billion by 2022, at a Compound Annual Growth Rate (CAGR) of 20.9%"("Market Research Reports, Marketing Research Company, Business Research by MarketsandMarkets," 2018). Bart De Muynck mentioned two emerging growth markets for TMS; first, the continued international growth in Asia (especially China) and Europe in 2017, and second, the continued growth of TMS in smaller organizations with less complex transportation management needs (Muynck, 2018).

According to S. Kaewunruen, J. M. Sussman, and A. Matsumoto, there is a variety of transportation systems, including land transportation (road, rail, and maglev), aviation (airplanes, rockets), maritime (ferries, ships, ports), and pipeline (tunnelling, risers, Hyperloop) (Kaewunruen, Sussman, and Matsumoto, 2016). Because of the different priorities of key stakeholders (carriers, shipping companies, agencies) involved in transport management, different technologies are needed for a specific business area. "These complex sociotechnical systems are interconnected, and undoubtedly, the behind-the-scene catalyst is essential for building new capabilities and innovation as well as improving efficacy and effectiveness of other businesses and industry sectors, such as resource logistics, agriculture, real estate, etc."(Kaewunruen et al., 2016).
Within TMS, one building block that composes it is the vehicular ad hoc networks (VANETs), which provides data exchange between vehicles, roadside units and Traffic Management Centers. Two communication types are enabled in TMS by VANETs. The first one is vehicle-to-vehicle (V2V) communication, used when the vehicles communicate among themselves without the need for any infrastructure. The second one is vehicle-to infrastructure (V2I) communication, used when a vehicle needs to send its information or request some information to/from a central entity and also when a vehicle needs to access certain content in the Internet(De Souza et al., 2017).

Electronic data exchange (EDI) is the electronic, computer-to-computer exchange of business information in a structured format between business trading partners or between various units within an organization (Njoni, Semutwa, Mbaabu, and Osoro, 2016). EDI is being used by many companies to order and pay for goods from suppliers to arrange transportation with carriers to receive orders from customers to invoice customers, and to collect payments from customers (Njoni et al., 2016). In addition to the freight transport problems, problems can arise in the TMS software itself. The problem of the TMS software is "the lack of uniform standards for format and ways of exchanging messages" (Petrović, V.; Badurina, R.; Tijan, 2017). Two solutions used for communication between transport organizers and shipping companies are (Petrović, V.; Badurina, R.; Tijan, 2017):

1. Mediation Service Software (MSS): The mediation services include sending the compulsory data regarding the weight of goods, transport booking, sending shipping instructions, tracking the movement of containers, the exchange of bill of lading data, etc.

2. Electronic Transaction Platform (ETP): Users of electronic transaction platforms are able to communicate with a large number of global shipping companies in a standardized way. It is possible to use a software package (dedicated web portal or an application) or to integrate own applications with the electronic transaction platform.

4 Transportation issues

There are a lot of transport issues such as traffic congestions, redundant administration, loss of time due to unnecessary waiting, etc. "Traffic jams become a common obstacle, so the companies have to move containers as early as possible in the morning and complete all tasks in the afternoon before the rush hours; the overall operational performance of drivers is not efficient since they waste more time on waiting for containers for loading on trucks" (Shi, Arthanari, Liu, and Yang, 2018). Furthermore, traffic jams can also be considered from an ecological point of view. Sustainability is one of the main business considerations, and a lot of effort is being invested in the creation of guidelines and processes that will enable sustainable business.

The difference between an effective and ineffective transportation management system is shown in the Figure 1.

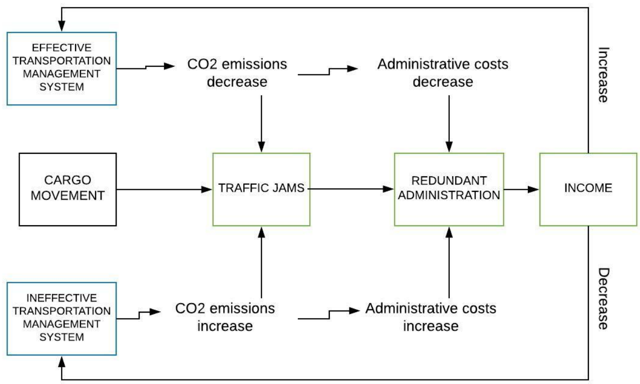

Figure 1: The difference between an effective and ineffective transportation management system. Source: Authors, according to (the European Commission, 2018), ("Transport's role in reducing CO2 emissions," 2018), (Shi et al., 2018)

The total logistics costs in supply networks varies in different countries, from 10% of the GDP in the US to 20% of the GDP in Singapore or the Russian Federation (Lukinskiy and Dobromirov, 2016). A large-scale analysis enables categorizing expenses by their basic components: transportation (40-45%), storage and stock management (30-40%), and administrative and managerial functions (up to 15%) (Lukinskiy and Dobromirov, 2016). According to the European Commission, total costs spent processing freight transport for all transport modes were 7,89 billion euros in 2018; road sector amounted to 5,962 billion euros, rail sector 507 million euros, inland waterways 582 million euros, maritime sector 814 million euros and aviation sector amounted to 25 million euros. Increased administrative costs are the result of increased traffic, but also weak acceptance of platforms that allow electronic data exchange(the European Commission, 2018). The official report of the United Nations Commission on International Trade Law (UNCITRAL) estimates the costs of the shipping documents at $ 420 billion per year at a global level (Mai and Doan, 2018). In particular, in 2014, the Maersk shipping company estimated that "a shipment from East Africa to Europe could involve nearly 30 people and approximately equal number of organizations and generate about 200 communications and transactions"(Mai and Doan, 2018).

The importance of electronic data exchange and the need for elimination of old-fashioned business practices has been shown in the European Commission's Proposal for a Regulation of the European Parliament and of the Council on electronic freight transport information(the European Commission, 2018). Baseline scenario in Table 1, depicting assumed situation, is used as a basis for comparison. Table 1 shows the forecast of administrative costs per sector and the means of document exchange (the European Commission, 2018).

Table 1: Estimated administrative costs in the baseline scenario (millions of euros)

Sector	**2025**			**2030**		
	Digital	Paper	Total	Digital	Paper	Total
Road	140	6474	6614	250	6776	7026
Rail	40	536	576	66	559	625
IWT	7	628	635	18	656	674
Maritime	9	873	882	25	901	926
Aviation	11	20	31	15	21	36
Total	8738			9287		

Source: Proposal for a Regulation of the European Parliament and of the Council on electronic freight transport information, European Commission, 2018., part1/2 https://eur-lex.europa.eu/resource.html?uri=cellar:810e3b10-59bb-11e8-ab41-01aa75ed71a1.0001.02/DOC_1&format=PDF (07.01.2018.)

From the table, it is apparent that the costs of paper exchange would be much higher than the digital/electronic information exchange. The majority of costs would be incurred in the road sector which would maintain its dominant role within the EU in 2025 and 2030. The aviation sector would record the lowest administrative costs.

The importance of electronic exchange of maritime cargo documents, that are increasingly present in international trade, can be seen through the example of the "Bill of Lading" (BL). BL is one of the most important documents in the transportation sector. According to C. Dr Wu, L. Starr, and J. Tan, three main problems associated with the paper BL are (Dr Wu et al., 2017):

1. Delays: Ships frequently arrive at the discharge ports before the paper BL as the paper BL has to be transported from party to party usually by courier service. The non-availability of the paper BL at the discharge port means that the cargo cannot be delivered.

2. Costs: The cost of issuing and managing paper BLs, Letters of Indemnity (LOI), and other paper documents are estimated to constitute upwards of 15% of the physical transportation costs. When electronic BLs are used, the requirement for LOIs is reduced by some 90% (Dr Wu et al., 2017). This means a huge reduction in costs for the participants involved.
3. Security risks: Paper BLs are easily misplaced, stolen or lost. Again, when a paper-form BL is missing, the carrier often agrees to deliver the cargo against a LOI or a bank guarantee. The carrier, however, remains responsible for mis-delivery claims under forged BLs and stolen BLs.

Since ports as traffic nodes cannot act autonomously, it is necessary to develop good ties with the hinterland, and ultimately create a platform that will connect all the supply chain stakeholders. Some seaports operate without integrated e-business platforms covering all business processes, and that is why certain stakeholders are not sufficiently integrated into the transport chain. In such cases, certain segments of the information systems are combined, but parallel records are required to track business processes in the transport chain.

Due to the large differences in information flows within companies, but also between them, data exchange and electronic transaction management can be difficult. The presence of inefficient paper-based exchange was researched in a survey conducted in 400 IT and non-IT managers in the US, Canada, Brazil, the UK, France, Germany, Australia, and Japan employing over 500 people ("Digital transforms the game of business -digital transaction management emerging as key solution," 2015). In this survey the companies had to self-declare the adoption of paperless business processes, depending on "completely analogous (paper-based processes), to fully digital", and to evaluate whether IT managers understand the importance of digitalization of business processes and digital transaction management compared to the results of non-IT managers. Although most of the processes are digitalized, IT managers have declared that 71% of the processes are "fully digital", while non-IT managers have declared that 58% of the processes are "fully digital". The results show that 30% to 42% of their processes are partially digitalized. 80% of the costs and inefficiencies in their transactions are caused by an analogous mode of operation, which imposes a significant burden on companies.

It is important to timely recognize which trends affect the company's development. Core findings of the DVV Media Group GmbH study “Trends and strategies in logistics and supply chain management” are as follows (Kersten, Seiter, Von See, Hackius, and Maurer, 2017):

1. Digitalization of business processes and transparency in the supply chain are the most important trends that companies will need to develop considerably in the future,
2. Compared to 2012, the importance of sustainability has markedly increased, and
3. The overwhelming majority of companies still have a substantial potential for improvement in terms of their individual capacity to adapt to existing trends.

5 Discussion: Positive Effects of Transportation Management Systems Transportation issues

The advantages of electronic or digital data exchange are demonstrated in the aforementioned survey (“Digital transforms the game of business -digital transaction management emerging as key solution,” 2015). According to the survey, the positive effects of the advanced transactions management are: improving efficiency (such as eliminating costs associated with paper-based transactions); improved security and compliance with clearer tracking and monitoring of documents and approvals; improved customer experience with faster access to documents and a more streamlined experience; greater agility (such as the ability to make changes faster); accelerated revenue (reducing of transaction cycle time and faster business closing) and improved business insight through reporting and analytics. According to Cerasis , “Rather than having a single person keeping track of multiple products, shipments, and solutions, these transportation management systems organize everything into precise, easy to read lists that can then be used effectively to make the best decision possible” (Cerasis, 2016).

The TMS should be implemented throughout the supply chain as the transportation is a very important segment of each supply chain. According to Dreßler, existing IT-systems do not support a holistic planning of transport considering all participants and their available resources (Dreßler et al., 2016).

According to Mei and Afli, the benefits of using the supply chain management systems are (Mei and Afli, 2017):

1. It provides all the elements involved in the cycle with the right information at the right time,
2. It helps to eliminate unnecessary waste of materials and resources,
3. It contributes to reducing the overhead cost of production since it gives the manufacturer the target amount of goods and services to be produced at a particular time and period, and
4. It helps organizations to meet the needs of their customers in time.

Currently, the attention is being paid not only to economic but also to the ecological issues of seaport business, with the aim to lower the damaging impact on the environment. The most developed seaports draw attention to the priority development tasks which refer to business and the overall development of the seaport system. Unfortunately, in certain less developed seaports, a lack of awareness of the importance of the seaport system development is present. Development of Electronic Transportation Management System could have positive effect on fuel consumption and the reduction of CO2 emissions and other harmful emissions (Shi et al., 2018).

Transportation Management Systems, as stated before, reduce overall costs of transportation. They collect data such as rates and vendor options in a clear, simplified, and prioritized format to aid in the decision-making process. TMS are used by companies to strategize, plan, and execute shipments (Cerasis, 2016). According to OECD research on "Trade facilitation indicators", harmonizing trade documents, streamlining trade procedures, making trade-related information available and using automated processes could reduce total trade costs by 14.5% for low-income countries, 15.5% for lower-middle-income countries and 13.2% for upper-middle-income countries (COMCEC, 2017).

According to the survey-based research of ARC Advisory Group "The Transportation Management Systems Market Research Study", freight savings of approximately 8% could be achieved with the use of an TMS application. Nearly 60% of respondents indicated that less than 10% of the net savings were attributed by the TMS. These freight savings can be attributed to network design, load consolidation, multi-stop route optimization, improved data for procurement and freight audit (ARC Advisory Group, 2018). According to G. Nimchuk and D. McKinney, “Drivers using this system may be given the ability to manipulate portions of dispatched trip plans through selection of alternative stop locations. The transportation management system may also be configured to calculate and frequently update the ETA for every stop on a planned trip; such updating of the ETA may be performed by the system during the trip planning stage and during actual execution of the trip plan” (Nimchuk and Mckinney, 2018).

6 Conclusion

Business processes related to the transport of goods include numerous stakeholders such as agents, forwarders, carriers etc., (depending on the type of transport). Seaports are important hubs in international trade. The role of seaports was initially focused solely on loading and unloading operations, and not on the development of quality relationships with stakeholders, especially clients. Electronic information exchange and digitalization efforts were usually initiated by the seaport authorities. Over time, electronic exchange was applied by a wide range of stakeholders.

Transparency and easy access to data are of the utmost importance for successful seaport business. The most advanced seaports draw attention to the priority tasks related to business development and the overall seaport system development. Unfortunately, in less developed seaports, there is lack of awareness about the importance of seaport system development. The development of e-TMS enables the stakeholders to centralize the monitoring of business processes. Its implementation provides a number of advantages such as the optimization of the transport chain management, as the key stakeholders such as seaport administrative bodies, freight forwarders and carriers become interconnected. The e-TMS arranges all available information in an accurate and easy-to-read manner, and it helps to make optimal business decisions. Furthermore, not just economic but also ecological issues have been considered, where damaging environmental effects could be reduced by the adoption of e-TMS. It enhances the level of business organization which also reduces harmful emissions that may be caused by, for example, traffic congestion.

Mediation Service Software and Electronic Transaction Platforms represent solutions for communication between transport organizers and shipping companies. The main issue thwarting the adoption of the TMS software is the lack of uniform standards for message formatting and means of their exchange. The consequence of insufficient networking on the intermodal level leads to many problems such as increased costs and time loss caused by non-harmonization of business information systems, with the final consequence being reduced interoperability between the information systems.

The research (through a systematic literature review) proved that the management and decision-making in the modern ports can be made more efficient, effective and sustainable by using e-TMS. It can also be used as a basis for future research and further theoretical development.

The research is based solely on the literature review and as such offers the initial overview of transportation issues and the positive e-TMS impacts, which is also the main limitation.

Future research will be focused on the real challenges that transportation enterprises face regarding the e-TMS implementation. For that purpose, case studies of leading enterprises will be presented in order to identify the factors which affect the successful implementation of e-TMS. Furthermore, based on these results a wider survey will be conducted among a larger set of transportation enterprises.

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Proposal for Pervasive Elderly Care: A Case Study with Next of Kin

HANNA-LEENA HUTTUNEN, RAIJA HALONEN & SIMON KLAKEGG

Abstract This paper reports how interaction between family members and caregivers as perceived by family members could be improved via context-aware, imperceptible internet of things (IoT)-based solutions. The study focused on investigating experiences of the family members and the communication between caretakers in sheltered accommodation. Interviews including both open and closed questions revealed that there is high need for improving the communication, adding to the sparse earlier knowledge. The study revealed that the family members were willing to adopt an application to improve the communication that currently was experienced as too limited and vague. The results provide a fruitful base for further actions to improve communication between family members and professional caretakers.

Keywords: • Caregivers • IoT • Sheltered Accommodation • Mobile Application • Family Member •

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1 Introduction

The purpose of our study was to investigate how family members of the elderly experience the potential use of assistive technology in sheltered accommodation when interacting with caretakers. The motivation for this study arose from earlier studies that revealed a lack of or slender interaction between caretakers and family members of elderly care centre residents.

The numbers of elderly are increasing globally, and the growth is expected to continue (Medjahed et al., 2011). The supportive role of family members in assisting their elderly is important and may lead to reduced costs down the line (Bolin et al., 2008). Along with ageing, the need for assistance and care increases, and the elderly are moving to accommodation that can offer more support than at private homes (Hainstock et al., 2017). However, the rising number of ageing occupants also means an increased need for care and resources from the caregivers (Alam et al., 2012).

Guiding family members is one of the duties of nurses. Family members bring meaning, continuity and importance to the lives of the elderly. It is important to encourage and support relatives to interact with the elderly and nursing staff (Andersen, 1995; Doty, 1986). The current study investigated the possibilities of state-of-the-art technology to support interaction between caretakers and visiting family members and other next of kin of the occupants. The research problem was compressed into a research question: How do next of kin of the elderly living in sheltered accommodation consider using assistive technology when communicating with personnel who take care of the elderly? To answer the research question, methods of qualitative research were applied in a home (dubbed Comfort in this paper) offering sheltered accommodation for elderly. Qualitative interviews were carried out in Comfort, and eight persons representing the next of kin participated in the study.

By identifying the family members' worries during their visit, it was hoped the bottlenecks resulting from the care work can be reduced, enabling family members to participate in different stages of the care. In addition, there already are devices that provide intelligent surveillance technology to help elderly people live in safety while providing energy efficiency, comfort and automation (Wong et al., 2017).

However, the question remains: Are family members willing to apply assistive technology to ease information sharing and reduce uncertainty related to the wellbeing of their elderly?

2 Earlier Knowledge

2.1 Elderly in Sheltered Accommodation

The proportion of aging populations is growing worldwide, and explosive growth is expected to continue (Medjahed et al., 2011). When supporting the elderly to maintain their independence and quality of life, the role of family is crucial. However, the next of kin can experience too heavy a burden in caring for their elderly and continuing their lives (Hainstock et al., 2017). Sheltered accommodation and treatment costs are rising, and illness is more prominent, requiring additional resources for nursing staff (Alam et al., 2012). Studies show that the life of the elderly is more meaningful in nursing homes than in an institutional care facility (Nikmat et al., 2015; Tuominen et al., 2016). In the nursing home, the elderly can have their own rooms and live in their own apartments surrounded by their own belongings. Nursing staff is available 24/7 (Coelho et al., 2015); however, with an increasing number of residents, so does the workload of nursing staff increase, thus weakening the premise of better care of patients, mostly due to efficiency bottlenecks (Huttunen et al., 2018). Intelligent care systems provide many opportunities to overcome such challenges, and elderly well-being, health and functional ability have been shown to improve with wearable sensors and personal area networks (PAN) (Wong et al., 2017).

It is natural for the nursing staff to recognise the limitations of older people's ability to perform daily tasks, thus empowering them to provide high-quality care for the elderly. Guiding and providing information to family members are among the duties of a nurse, and the role of the family in service systems is also very important. Studies show that it is important to encourage and support relatives to interact with the elderly and nursing staff (Andersen, 1995; Doty, 1986).

2.2 Technology in Sheltered Accommodation

Over the last few decades, technological advances have been made in solutions for intelligent homes, providing a remote monitoring system useful for healthcare. The devices provide surveillance technology to help elderly people live in safety and provide energy efficiency, comfort and automation (Wong et al., 2017). Safe housing has been studied previously, in a case where an intelligent control environment was built in the home of elderly persons. Such technology was placed in each room of the home to monitor the movement of users in the rooms and, if necessary, an alarm can be triggered remotely (Freitas et al., 2015; Klakegg et al., 2017).

The elderly could be supervised by a remote system that collects information about health, activity and safety of the person. Automatically collected data gathers valuable information about their behaviour and potentially their needs to enable prompt decisions and plans for future actions. Devices exported to the home of the elderly should not compromise patient safety and therefore must be as discreet as possible and work under everyday living conditions (Klakegg et al., 2017; Nygård & Starkhammar, 2007).

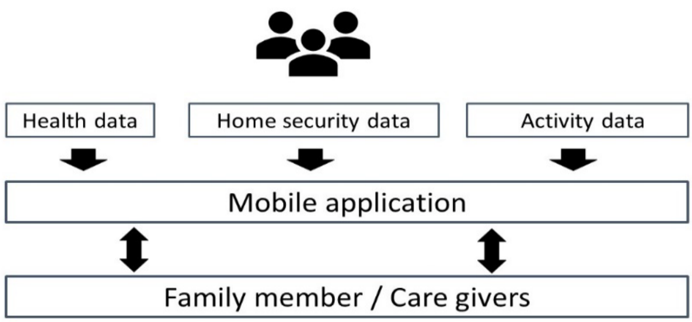

Figure 1: Data flow of mobile applications

Figure 1 illustrates how data can flow between several actors, such as care personnel in the sheltered accommodation and next of kin at their homes who are involved in the communication related to elderly persons' health-related data (Klakegg et al., 2017).

The role of digitalisation will be more visible in future in the form of unobtrusive body area networks (BAN) and PAN sensors in rooms to be applied in healthcare when the requirements of treatment grow worldwide. Sensor networks work together through a wireless network and can identify and achieve numerous opportunities to track and understand the lived phenomena of people (Krishnamachari, 2015: Atzori et al., 2010).

2.3 Healthcare Sensors in Sheltered Accommodation

Internet of things (IoT) refers to devices and items that communicate between each other and are located around us, ubiquitously (Atzori, 2010). IoT consists of sensors, net connections and information management. Sensors located in devices are energy efficient, identifiable and safe and include net technology (Gubbi et al., 2013).

Figure 2 illustrates unobtrusive BAN and PAN sensors positioned in sheltered accommodation for the elderly. Sensors attached to the body or clothing form a network in the body area (BAN). The purpose of the body sensors is to measure heart rate, daily rest, sleep quality, activity, mood and stress levels. Sensors attached to a person should be easy to use and unobtrusive so that their existence does not affect the everyday life of the patient or elderly. Movement must also be possible unobstructed (Cavallari et al., 2014). Sensors attached to the environment form a PAN where sensors are located close to the object. Sensors are placed in the home to various devices such as home appliances, bed, walls or smartphones. PAN sensors can measure, for example, movement, sound, air pressure, temperature, humidity and light. Sensors are used to gather required information about the environment of the elderly (Huttunen et al., 2017).

Figure 2: Unobtrusive BAN and PAN sensors

The use of information technology and telecommunications in healthcare provides advanced solutions for nursing staff. In addition, patients can take advantage of technology to support their own care and at the same time increase interaction between their relatives and the nursing staff. Intelligent systems are intended to enhance access to care, to develop nursing workflows and to reduce bottlenecks that occur in nursing. By first identifying nursing processes, the quality of healthcare services can be improved (Faertes, 2015; Huttunen et al., 2017).

Pervasive healthcare is considered to be one of the solutions to support the future of high-quality care. Healthcare should be available to anyone, anywhere, anytime. The purpose of pervasive healthcare is to eliminate time and place limitations in healthcare. The definition includes short-term and long-term prevention, maintenance and patient controls. Medical equipment that monitors patients' vital functions, movements, quality of life and activity are provided to support patients' care at home or at sheltered housing (Varshney, 2005; Huttunen & Halonen, 2018).

Healthcare professionals are encouraged to use more and more handheld devices to obtain patient information. In elderly care, relatives can receive information about the client's status, reminders about treatment and medication changes or write prescriptions electronically. Healthcare staff rarely have training in intelligent applications, so patients and their relatives should be trained in hospitals in the use of the information and communications technology (ICT)-enabled applications (Varshney, 2005). Handheld devices and personal digital assistants (PDAs) can also detect and monitor patients' vital functions and send alarm messages to hospitals, ambulances or patients' relatives for emergency services. Alarm messages can also support patients' own care, leading to early detection of symptoms and timely taking of medication (Varshney, 2005; Huttunen & Halonen, 2018).

3 Research Approach

Our study focused on understanding a limited group of people in their real environment (see Myers & Avison, 2002; Larsson & Sjöblom, 2010). In the study, qualitative theme-based and open interviews and observation were applied.

The study was carried out among visiting next of kin of people who were being cared for at Comfort. The empirical material was collected in two phases. In the first phase, the participants were asked to fill out a semi-structured questionnaire that consisted of 19 questions. The questions included three main questions and their sub-questions. The main questions were about the background information of the informants, care activities in Comfort and using smart technology that could transfer information about the health status of the occupants to their next of kin. In the second phase, a face-to-face interview was carried out, guided by the information from the semi-structured questionnaires.

The interviews, which lasted from 45 minutes to 90 minutes, were completed in two days. In total, eight family members were interviewed in March 2018. The questions in the questionnaires allowed freedom for the informants to describe their experiences about the interaction between them and the caretakers.

The interviews were transcribed, and the questionnaires were analysed with the help of content analysis (see Myers, 1997). Earlier studies were also noted in the analysis phase. The questionnaire included both open and closed questions, and they were answered by numerals, words or 'yes/no' responses. Eight people participated in both questionnaires and interviews, all of whom were appropriate for the research.

The background information was sorted based on sex, age, relationship with the occupant, distance of home, frequency and duration of stay in Comfort, length of care, frequency of change of care staff during occupancy and whether the next of kin experienced any lack of information related to the care given in Comfort.

Related to participating in the giving of care in Comfort, the resources of the family members were classified. In addition, the ways of participating in care, how personnel encourage participating in care and which tasks in care the informant would like more information about were analysed. Further, the preparedness of the family members to apply smart technology in interacting with care personnel were analysed, mirroring it with earlier research.

4 Findings

Our eight participants consisted of five men and three women. They were three sons, three daughters, one living partner and one other relative. Their age varied between 46 and 85 years, and their homes were situated at the distance from 1 to 230 km. The informants were also asked how often they visited their elderly (see Table 1).

Table 1: Family members as visitors

Frequency of visiting Comfort	Age	Kinship	Distance to home
Daily	85	Spouse	1km
A few times per week	60	Daughter	3km
A few times per week	56	Son	2km
Once a week	58	Daughter	10km
Once a week	69	Son	3km
A few times per month	64	Son	110km
A few times per month	47	Son	2km
A few times per month	46	Other relative	230km

Table 1 reveals that one of the relatives visited the elderly every day, two a few times a week and another two persons once a week. Families that visited often lived near, but the respondents who lived far away visited only a few times a month, except one son who despite the short distance visited a few times per month.

Most of the respondents felt that the information was not always delivered to the family quickly enough and that the information was not explicit enough. Some nurses provided information without asking, but most nurses responded only 'I don't know' when information was requested because they were not named as personal nurses for those elderly. Some relatives also felt that nurses gave loose answers. One of the respondents stated there was a flaw in the information flow between nurses and relatives in the service unit. One of them was very annoyed as the nurses did not note any informed observations about the elderly, who had a urinary tract infection and subsequently had to be treated in hospital.

Eight respondents stated that they didn't get enough information about the care related to their elderly. Most of them also experienced that information is not transferred quickly enough and that the information is inconsistent and changing. In general, the family members felt that the nurses give somewhat vague reports about the daily tasks of their elderly. One of the family members gave a thorough opinion about the issues related to communication between the caregivers and family members as follows:

> *During my visits there has never been a nurse at work who could have known about the wellbeing of my next of kin and if it has changed in a way or other during the past month. When I visit, I ask the nurse on shift how my uncle is. The nurse is not able or cannot say other but what has happened during her shift. If there had been a responsible nurse on shift, she could tell accurately because a trained nurse must be aware of all the clients and their wellbeing. For instance, the influence of medication, injections, starting new medication, results of laboratory tests and their effect on the wellbeing of the client. In addition, the nurse should be responsible for all changes in health status, medication and prescriptions and healthcare actions according to the health reports and examinations and the vital functions of the client.*

Also, the family members were asked for their opinions about their resources to participate in the care in Comfort. Most of them were ready to help the elderly in Comfort as a support for the nurses. They reported that they can offer a lot of support by helping their elderly in getting dressed, going out, discussing, giving information about happenings outside of Comfort, taking care of tasks, listening, comforting, calming and cheering up the elderly and participating in the physician's visit together with the care personnel. We also asked how much the family members had been involved in planning and evaluating the care of their relative before the client arrives in the sheltered accommodation and during the housing. Most of the respondents had been involved in the planning of their elderly person's care, but a few of them had not been able to be give input on the treatment planning. 'I haven't participated due to the long distance. It could have been possible with a video call, but it was not available in the service room at that time.' One person mentioned in the interview that he was involved in a health meeting where they went through his relative's health, hobbies, interests and background information. These biographical items were written on a card where the nurses can check client information. One person also mentioned that she was involved in planning care at the beginning, but afterwards did not get enough information about her relative. *'We did a care plan with the nursing assistant when we arrived to Comfort. After that, perhaps little evaluation took place, but not collectively.'*

Eight of the informants suggested that the smart application should not automatically report about the status of the elderly, daily activities and prescriptions. Rather, the nurse should forward the information to the family member via the application and, in case of need, the family member can contact the elderly via the application. The application should also have a direct messaging functionality to inform the care personnel.

After receiving the background information, the interviewers asked if the respondent was willing to use intelligent technology for interaction between nursing staff and relatives. All eight respondents informed that they desired day-to-day communication through intelligent technology. Relatives would quickly know about changes in health and overall health. The smartphone application would replace the notebook where a family member writes while visiting his or her relative. The answer would be in real time. Family members living far away would get more information and would then be more aware of their elderly's behaviour and change in health status, and the flow of information would be facilitated. The respondents did not find it necessary to get information updates daily. However, one family member considered the smartphone application as a communication tool, defining it as *'Seeing the daily report, current medicines and doses. Despite the long distance I could experience that the distance is not that long and that I am better informed about how my uncle manages.'*.

5 Discussion

This study focused on the family members of elderly living in a sheltered accommodation called Comfort and their willingness to use assistive healthcare if offered by a mobile phone application designed for caregivers.

In Comfort, each client had an individual treatment plan, which supported high-quality care in sheltered accommodation and at the same time acted as a tool for nursing staff. The treatment plans were collaborated with the care unit, occupants and relatives. The need for care of the occupant, the goal of the treatment, the implementation of the treatment and the means were recorded in the treatment plan (see Russello et al., 2008; Schenk et al., 2013).

Guiding family members was one of the nursing staff tasks, and the role of the family was very important. An active role of family members (elderly's spouse, a child or other relative) in the care of the elderly brings substance, continuity and importance to the lives of the elderly. It is important to encourage and support relatives to interact with the elderly and nursing staff (Andersen, 1995; Doty, 1986).

The current study showed that family members *need support for elderly care*. They are *unsure of what's happening* in the nursing home, and they want intelligent technology to support communication. The family members would like *to know that the nurses at the sheltered accommodation can, if necessary, quickly provide topical information* through phone apps to family members.

Family members should also be *offered an opportunity to ask questions about the elderly* from the nursing staff. Intelligent systems allow information sharing between several stakeholders, such as medical staff and nursing staff (Freitas et al., 2015; Klakegg et al., 2017). Our study proposes that the means of pervasive systems are used to inform family members about the status of the elderly.

By adding technology to support nurses' workflows, it is possible to reduce bottlenecks from nursing work and to increase patient safety in sheltered accommodation. (Huttunen et al., 2018). Our study assumes that there are *family members who have resources to support care of the elderly and can thus reduce the care work* of nursing staff. The interaction between nursing staff and family members should be enhanced by using intelligent technology to allow *prompt informing when necessary*.

Available intelligent solutions have been developed to provide remote monitoring systems for healthcare. The devices provide intelligent technology for surveillance of the elderly in housing security, comfort and automation (Wong et al., 2017). Current knowledge and technology already enable pervasive systems (Medjahed et al., 2011; Faertes, 2015; Klakegg et al., 2017). Healthcare mobile devices enable more efficient patient care, and sensors can be used to allow collecting and evaluating physiological data from the elderly (Cavallari et al., 2014).

The current study proposes that the communication between nurses and the family members should be enabled and improved via a mobile device, which could *facilitate and increase the awareness of family members about the care and status of their relatives* in sheltered accommodation. The application should inform about *facilities in use, safety of the elderly, e.g. risk of falling when standing up, duration of living in Comfort and mood of the elderly.*

6 Conclusion

To conclude, the family members strongly wanted to apply assistive technology to ease and reduce uncertainty related to the wellbeing of their elderly. Fixed and wearable sensors offer practical means to collect physical, mental and social information about the wellbeing of people. The fixed sensors collect accurate information about the location and safety of the participants. Sensor-based data can be transferred to the mobile application to be used by the care personnel, who can share information with the family members when appropriate.

By identifying the worries and troubles raised by family members when they visit sheltered accommodation, one can reduce the bottlenecks from communication between family members and nursing staff. With the help of applications, the nursing staff can include the occupants' relatives in different stages of the care to bring the nursing staff and family members closer to the elderly's everyday care during the service life. In case of unexpected issues, the family could be informed about any incidents. However, the family members also pointed out that the final decisions should be made by them, not automatically by 'the computer software'.

There are many kinds of sensors on the market that can improve people's lives. There are sensors both inside the body and wearables but also set in the environment (Klakegg et al., 2017). In Comfort, sensor information could facilitate communication between the patient and the nursing staff, as well as between relatives and caregivers.

In healthcare, the use of technical aids is seen as a key means of facilitating interaction between nursing staff, patients/clients and their relatives. Pervasive healthcare is largely based on the use of technical aids and the continuous availability of healthcare to the patient. The goal of pervasive healthcare is to turn healthcare from doctor-centred care to patient-centred care. Pervasive healthcare aims to guide patients/clients to prevent the emergence of acute illnesses and to respond more quickly to their own care (Varshney, 2005; Klakegg et al., 2017; Huttunen & Halonen, 2018). In our study, the nursing staff benefits from continuous automated data collection for a single patient, and in the current study also all family members were willing to accept new technology in caring activities for their elderly. With automation it will be possible to help and respond faster to changes in patient status.

Automation can help improve access to care (Wong et al., 2017), but the technology and security of sensors need to be improved continuously to allow patients/clients to safely use sensors to identify diseases and change lifestyles. In future, the security of tools developed for communication between nursing staff, patients and relatives to improve communication should also be investigated in order not to compromise privacy.

So far, there have been only few studies on communication between relatives and nursing staff to support elderly care. More research is needed in the future to find out how family members of the elderly experience the use of assistive technology in communication when interacting with caregivers in sheltered accommodation. The interaction should be enhanced by using intelligent technology as desired by the next of kin.

The next phase will focus on the application and communication that could extend between the relevant healthcare providers. The current study offers constructive observations and informative points to build a prototype for the mobile application.

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Unlocking the Smart Home: An Examination of Factors Influencing Smart Lock Adoption Intention

STANISLAV MAMONOV & RAQUEL BENBUNAN-FICH

Abstract Smart home technologies are a growing trend, yet little is known about factors that drive their adoption, given the spectrum of potential functional, experiential and esthetic benefits they offer. To address this gap in research, we explore the factorial structure of salient perceived benefits and concerns associated with smart locks, and we examine the effects of the emergent factors on the adoption intention. We find that while potential adopters express a broad range of perceived benefits and concerns associated with smart locks, only the perceived relative advantage of smart locks vis-a-vis conventional locks in providing safety and security is significantly correlated with adoption intention. Our results indicate that this perceived relative advantage is a critical consideration in the adoption of smart home technologies that replace existing solutions.

Keywords: • Smart home technology • Adoption intention • Security • Privacy • Influencing factors •

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1 Introduction

Continued advances in information and communication technologies have led to the introduction of an array of devices seeking to make our homes smarter. Smart Home Technologies (SHTs) span a very broad range of innovative products that can provide security and access controls, home healthcare, smart kitchen and home appliances, and self-regulating heating and cooling systems, among others (Markets and Markets, 2017). Despite the practical importance of this market, there has been relatively little academic research on the factors that influence SHT adoption. In the SHTs ecosystem, smart locks are an important device to study because they not just improve the individual experience with home access control, but also enable new forms of services, e.g. in-home delivery (Amazon, 2018). The commercial market for smart locks is expected to reach $24.4 billion by 2024 (Grand View Research, 2018).

Smart home technologies promise to offer a unique combination of potential functional, experiential, and esthetic benefits to prospective owners. This breadth of benefits is unlikely to be captured by traditional technology adoption models that evolved primarily in the organizational context. These models may also omit key factors affecting the adoption of SHTs. To address this gap, and in recognition of recent calls for context-specific theory development (Hong, Chan, Thong, Chasalow, & Dhillon, 2013), we conduct a three-stage study on user adoption of SHTs by focusing on smart locks. Our research progresses through 1) the elicitation of salient perceived benefits and concerns associated with smart locks, 2) exploratory factor analysis (EFA) of the elicited perceived benefits and concerns, and 3) confirmatory factor analysis (CFA) within a broader nomological network, where we evaluate the effects of the emergent constructs on the smart lock adoption intention.

We find that perceptions related to functional performance (perceived usefulness), which is traditionally emphasized in information technology adoption research (Venkatesh, Thong, & Xu, 2016), has no statistically significant effect on the adoption intention of smart locks. Similarly, effort expectancy (perceived ease of use) is not among the salient considerations voiced by the prospective adopters. We also find that while the prospective smart lock users indicate that specific functional benefits as well as privacy and security concerns may affect the adoption intention, none of these factors had a statistically significant effect on the adoption intention when we examined them within a broader nomological network. Our results reveal that perceived relative advantage of smart locks vis-a-vis traditional locks in assuring security and safety of a home is the most important factor that influences the smart lock adoption intention.

Our study makes several contributions to theory and practice. First, to the best of our knowledge, this study is among the first to develop a comprehensive, context-specific model of factors that influence smart home technology adoption. The results reveal that the constructs traditionally emphasized in technology adoption research (perceived usefulness and perceived ease of use) are not the key salient factors that influence the adoption intention of such technologies. Our findings emphasize that perceived relative advantage compared to installed technology is the key consideration that is predictive of the adoption intention. This finding has important practical implications in that novel features and functions offered by smart locks may do little to promote their adoption, unless the prospective users are convinced that smart locks perform better on the basic functions afforded by the existing technology - assuring security and protection of a home.

2 Theoretical background

Our review of the literature identified two relevant research streams for our study: smart home studies and technology adoption research. A full review of these streams is beyond the scope of the present manuscript. Below we highlight the key studies within each stream that are related to our work.

2.1 Smart home related research

A smart home is defined as "a residence equipped with computing and information technology which anticipates and responds to the needs of the occupants, working to promote their comfort, convenience, security, and entertainment through the management of technology within the home and connections to the world beyond" (Aldrich, 2003). Smart home technologies include sensors, monitors, interfaces, appliances, and other types of connected devices.

Much of the research on the adoption of SHTs has focused on home healthcare applications for the elderly. A number of studies conducted focus groups and surveys with older adult samples to assess the perceived benefits and concerns associated with in-home monitoring technologies: portable blood pressure monitors, fall sensors, cameras, etc. (Coughlin, D'Ambrosio, Reimer, & Pratt, 2007; Courtney, 2008; Demiris, Hensel, Skubic, & Rantz, 2008; Townsend, Knoefel, & Goubran, 2011). The consensus emerging from these studies is that older adults generally view their homes as sanctuaries and they are concerned about the loss of autonomy that may result from the installation of monitoring technologies (Ziefle, Röcker, & Holzinger, 2011). Although the elderly appreciate the potential benefits offered by in-home monitoring technologies, they generally express concern over the loss of privacy associated with the monitoring technology use (Liu, Stroulia, Nikolaidis, Miguel-Cruz, & Rincon, 2016).

Security and privacy concerns have been repeatedly raised in relation to smart technology adoption (Efthymiou & Kalogridis, 2010; Sankar, Rajagopalan, & Mohajer, 2013). For example, an engineering analysis of smart meters revealed that it is possible to infer appliance usage patterns even without knowing the content of the encrypted communications (McKenna, Richardson, & Thomson, 2012).

In summary, much of the prior research on SHTs has been narrowly focused on in-home monitoring devices for the elderly and electric smart meters. The common observations across these contexts suggest that SHT adoption involves weighing perceived functional benefits against the potential loss of privacy and possibly a sense of autonomy. In the next section, we review the key research studies on technology adoption across a broader set of contexts.

2.2 Technology adoption

Factors influencing technology adoption are a central theme in Information Systems research (Venkatesh, Thong, & Xu, 2012; Venkatesh et al., 2016). The Unified Technology Acceptance and Use Theory (UTAUT) elaborates on the Technology Acceptance Model (Davis, 1989) by adding social influence, facilitating conditions, hedonic motivation and price value perceptions as additional constructs that can help explain technology adoption intention in voluntary contexts (Venkatesh et al., 2012).

Although TAM and UTAUT have proven their value across different technology adoption domains (Taiwo & Downe, 2013; Venkatesh et al., 2016), a number of studies have demonstrated that alternative theoretic perspectives are better at uncovering the key factors that influence technology acceptance in specific contexts. For example, Lee & Larsen (2009) revealed that perceived severity of the threat and perceived response self-efficacy were the key determinants of the intention to install anti-malware software. Hsiao (2003) showed that fear and distrust were the key factors that helped explain the adoption intention in an e-marketplace. Baird et al. (2012) demonstrated that a complex set of contingencies influenced the adoption of electronic patient portals by healthcare providers. In summary, although TAM and its successor, UTAUT, offer general frameworks encompassing factors influencing technology adoption intention, research within specific contexts has found that context-specific factors afford a better, more contextualized, understanding of the phenomenological drivers in the respective contexts.

The novelty of smart home technologies may pose challenges for generic theoretical models as they might be unable to capture key contextual factors for technology adoption in this domain. This recognition has prompted recent calls for context-focused research in information systems (Hong et al., 2013). Consequently we draw on the theory of reasoned action as the overarching theoretical framework and we conduct a multi-stage study to develop a comprehensive model of factors that influence smart lock adoption.

3 Methodology

Our study progresses through three stages. First, we elicit salient perceived benefits and concerns. Second, we conduct an exploratory factor analysis to inductively identify the latent constructs that capture the diverse set of beliefs and concerns elicited in the first stage. Third, we conduct a confirmatory factor analysis, wherein we also evaluate the effects of the emergent constructs on the smart lock adoption intention..

For each stage of the study, we recruited a new set of participants using Amazon's Mechanical Turk (AMT). AMT is an online labor market for micro tasks that has received support as a valuable source of research participants in Information Systems (Lowry, D'Arcy, Hammer, & Moody, 2016; Steelman, Hammer, &

Limayem, 2014) and other disciplines (Buhrmester, Kwang, & Gosling, 2011; Holden, Dennie, & Hicks, 2013). To avoid potential cross-cultural effects, we limited the participation to AMT "workers" from the United States. We also restricted the participation in the study to AMT Masters. AMT "grants the Masters Qualification based on statistical models that analyze Worker performance based on several Requester-provided and marketplace data points" (AMT 2018). We relied on Qualtrics, a commercial survey platform, to capture the participants' responses to our surveys in each stage of the study.

For Stage 1, we recruited 24 participants from AMT. We collected basic demographic data and we asked the participants to indicate ownership of different smart home technologies. Since this was a study on adoption intention of smart locks, it was important that all subjects did not already own smart locks. None of the participants in this stage indicated ownership of a smart lock. We exposed participants to a 5-minute commercially produced video describing smart locks and then asked them to share their opinion on the top 5 potential benefits and top 5 concerns associated with smart locks.

Based on the elicited perceived benefits and concerns, we developed a list of 52 items that reflect commonly stated perceived benefits and concerns. The items included such statements as "Having a smart lock in your home would enable you to verify that your house is locked," "Having a smart lock in your home would enable you to let family in remotely in case of emergency," and "I am concerned that a smart lock may malfunction and lock me out."

For Stage 2, we recruited a new group of 150 participants from AMT. We excluded 2 participants who indicated ownership of a smart lock, since the focus of our study is on the pre-adoption stage. We collected the participants' basic demographic information and we exposed them to the same video describing smart locks. We then asked the participants to indicate their agreement or disagreement with the items generated in Stage 1. We used 7-point Likert scales with "1 = Strongly disagree " and "7 = Strongly agree". We performed an exploratory factor analysis and inductively developed a list of latent constructs that captured the themes that emerged from the analysis. Details of this analysis are provided in the results section.

For Stage 3, we recruited a new group of 574 participants from AMT who did not own a smart lock. We excluded 16 responses because of incorrect responses to attention control questions. We collected basic demographic information and exposed the participants to the video describing smart locks. We surveyed the participants on the constructs that emerged in Stage 2 as well as their adoption intention using the established scale from UTAUT (Venkatesh et al., 2012). We then tested the relationships between all the constructs in a theoretically-based nomological network.

4 Results

With the items generated in Stage 1 and the responses collected from the sample in Stage 2, we conducted an exploratory factor analysis following the recommendations of Muthén & Muthén (1998). We performed a principal axis factor analysis with oblique rotation using Mplus software version 8.1. We chose to use the oblique rotation to allow for potential correlations among the latent constructs reflected in the responses to individual survey items. The results suggested a seven-factor solution shown in Table 1 below. The seven-factor model showed a good fit to the covariance patterns in the data: RMSEA = 0.061, CFI = 0.967, TLI = 0.942, SRMR = 0.016.

Table 1: Exploratory factor analysis – factor loadings

Items	1	3	2	4	5	6	7
B1	0.829	0.28	0.168	0.04	-0.055	-0.007	-0.07
B2	0.771	0.259	0.201	0.149	-0.071	-0.002	-0.093
B15	0.89	0.281	0.196	-0.051	-0.11	-0.127	-0.293
B17	0.864	0.206	0.143	0.086	0.01	0.016	-0.24
B18	0.876	0.237	0.129	0.029	-0.089	-0.063	-0.239
B19	0.77	0.182	0.178	0.096	-0.102	-0.041	-0.213
B20	0.782	0.206	0.103	0.041	-0.034	-0.036	-0.204
B22	0.799	0.248	0.13	0.007	-0.011	-0.016	-0.202
B9	0.355	0.882	0.313	-0.287	-0.305	-0.279	-0.224
B11	0.247	0.869	0.324	-0.265	-0.287	-0.267	-0.17
B14	0.278	0.937	0.256	-0.236	-0.291	-0.237	-0.05
B6	0.199	0.305	1.01	-0.092	-0.105	-0.186	0.035
B16	0.223	0.347	0.817	-0.178	-0.165	-0.311	-0.008
C01	0.034	-0.299	-0.075	0.933	0.515	0.667	0.396
C02	-0.035	-0.293	-0.1	0.945	0.541	0.7	0.382
C04	-0.046	-0.327	-0.148	0.931	0.611	0.677	0.376
C05	0.051	-0.24	-0.109	0.868	0.456	0.689	0.258
C06	-0.018	-0.331	-0.116	0.922	0.561	0.689	0.384
C17	-0.061	-0.329	-0.11	0.487	0.871	0.609	0.295
C18	-0.097	-0.236	-0.01	0.489	0.877	0.507	0.291
C19	-0.05	-0.276	-0.091	0.478	0.914	0.522	0.202
C20	-0.076	-0.265	-0.094	0.494	0.95	0.534	0.244
C21	-0.153	-0.321	-0.067	0.49	0.72	0.637	0.336
C22	-0.155	-0.322	-0.161	0.524	0.868	0.603	0.241
C23	-0.136	-0.259	-0.07	0.514	0.91	0.563	0.342
C24	-0.07	-0.298	-0.133	0.51	0.948	0.554	0.261
C08	-0.092	-0.239	-0.125	0.638	0.5	0.806	0.306
C09	-0.11	-0.283	-0.198	0.621	0.62	0.89	0.212
C11	-0.084	-0.306	-0.225	0.685	0.609	0.864	0.275
C12	0.06	-0.33	-0.15	0.683	0.675	0.785	0.232
C13	-0.151	-0.36	-0.246	0.623	0.556	0.826	0.343
C25	-0.205	-0.275	-0.042	0.507	0.453	0.408	0.727
C27	-0.16	-0.239	-0.006	0.443	0.35	0.375	0.762

Following the recommendations of Fabrigar et al., (1999), we examined the content of individual constructs to develop a theoretical foundation for the latent factors that can affect the adoption of smart thermostats. The first factor that emerges from the analysis captures statements related to perceived usefulness reflected in the specific functional affordances of the smart locks. Perceived usefulness is a firmly established factor in the technology adoption research (Venkatesh et al., 2016), however it is notable that the participants in our study focus on the specific affordances of the technology rather than general perceptions of usefulness.

The second factor that emerges from the analysis reflects the perceived relative advantage of smart locks compared to the traditional locks. Relative advantage is a core construct in the Rogers technology diffusion model (Rogers, 2010), however this construct has been generally overlooked in the analysis of factors affecting individual technology adoption intention (Venkatesh et al., 2016).

The third factor captures perceptions related to the specific perceived novel benefits afforded by the smart locks. Among other functions, smart locks can enable remote video monitoring either as a part of the device itself or as an add-on. It is noteworthy that the prospective users appear to be separately evaluating novel benefits of the smart technology independently from the more general perceived usefulness of the locks.

The fourth factor captures user technology malfunction concerns. Smart locks control access to people's homes. Hence, the possibility of a person being locked out because of a smart lock malfunction can be an important consideration. The fifth factor captures privacy related concerns, ranging from personal information collection, e.g. I am concerned that a smart lock would be collecting data about my habits, to unauthorized commercial appropriation of the collected information – I am concerned that data collected by the smart lock may be sold. Information privacy concerns are well established in IS research and research has found that they can impede technology adoption (Hong & Thong, 2013).

The sixth factor captures concerns about the potential weaknesses of smart locks that may expose the owner to additional physical security threats. These concerns span a broad range of potential causes from hardwiring to hacking. The seventh factor captures concerns related to the potential negative effect of technology on others. While technology usefulness for others has been noted previously in the technology adoption research (Brown & Venkatesh, 2005), negative effect of technology on others that could result from one's adoption of technology represents a novel construct. Table 2 summarizes these factors and the corresponding items.

Table 2: EFA results summary

Factor 1: Perceived Usefulness	
B1	Having a smart lock in your home would enable you to let family in remotely in case of emergency
B2	Having a smart lock in your home would enable you to let in service people when you are at work
B15	Having a smart lock in your home would allow you to verify that your house is locked
B17	Having a smart lock in your home would enable you to check the status of the lock
B18	Having a smart lock in your home would enable you to lock the home while away
B19	Having a smart lock in your home would enable you to make sure kids have door locked
B20	Having a smart lock in your home would enable you to lock the door even if you forgot about it
B22	Having a smart lock in your home would enable you to lock the doors far away from home
Factor 2: Perceived Relative Advantage	
B9	Having a smart lock in your home would offer better protection versus conventional locks
B11	Having a smart lock in your home would make you feel safer compared to conventional locks
B14	Having a smart lock in your home would increase the overall security of your home compared to conventional locks
Factor 3: Perceived Novel Benefits	
B6	Having a smart lock in your home would enable you to see who’s at the door
B16	Having a smart lock in your home would enable you to see who enters and leaves

Factor 4: Technology Malfunction Concerns	
C01	I am concerned that a smart lock may not work and I would be locked out
C02	I am concerned that a smart lock may malfunction and lock me out
C04	I am concerned that a smart lock may fail and lock everyone out
C05	I am concerned that a smart lock may stop working and make it impossible to lock the door
C06	I am concerned that a smart lock may refuse to open
Factor 5: Privacy-Related Concerns	
C17	I am concerned that a smart lock may be storing my personal information
C18	I am concerned that a smart lock would be knowing too much about our comings and goings
C19	I am concerned that a smart lock would be collecting data about my habits
C20	I am concerned that data collected by the smart lock may be sold
C21	I am concerned that a smart lock may make it possible to predict hours when people are home or not
C22	I am concerned that a smart lock can lead to information being stolen
C23	I am concerned that a smart lock may lead to sale of information about my location
C24	I am concerned that a smart lock may lead to sale of information about when I am at home
Factor 6: Physical Security Threats	
C08	I am concerned that someone can hardwire a smart lock somehow
C09	I am concerned that a smart lock can give unauthorized access to my house
C11	I am concerned that a smart lock might have security flaws
C12	I am concerned that a smart lock might get hacked
C13	I am concerned that a smart lock can allow someone to break into my house
Factor 7: Negative Effect of Technology on Others	
C25	I am concerned that a smart lock would make it difficult for guests to figure out the temporary keys and be locked out
C27	I am concerned that a smart lock might be hard to use for some people

The factor structure emerging from Stage 2 provided the foundation to test the constructs in a nomological network in Stage 3. Due to space constraints, we are only reporting key information from this analysis. Based on the results from the sample recruited for stage 3 (558 responses, 574 participants recruited minus 16 who failed attention control questions in the questionnaired).

The measurement model showed a good fit: RMSEA = 0.052, CFI = 0.957, TLI = 0.953, SRMR = 0.046. The specified structural model similarly showed a good fit: RMSEA = 0.048, CFI = 0.963, TLI = 0.960, SRMR = 0.041. Figure 1 below summarizes the results of the path analysis in the model.

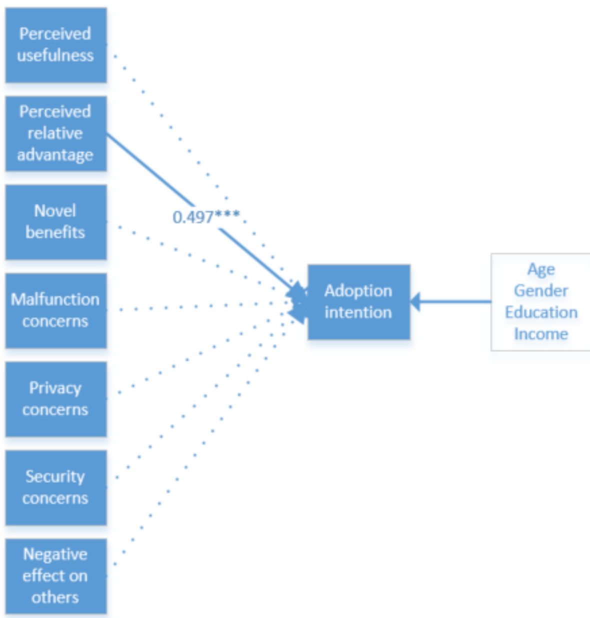

Figure 1 – Structural path model analysis summary

5 Discussion

Smart home technologies represent a diverse set of innovations that promise to transform the experience within our homes, yet relatively little is known about the factors that may influence the adoption of such technologies. Responding to recent calls for context-specific theory development (Hong et al., 2013), we conducted a three-stage study focusing on the perceptions that can affect the adoption of smart locks. In stage 1, we elicited smart lock related perceived benefits and concerns. In stage 2, we conducted exploratory factor analysis to gain insight into the key latent factors that may affect smart lock adoption. In stage 3, we evaluated the effects of the factors identified in stage 2 on the smart lock adoption intention.

In stage 2, we identified the following key factors that can potentially impact the smart lock adoption intention: *perceived usefulness, perceived relative advantage, novel benefits, malfunction concerns, privacy concerns, security concerns, and negative effect of technology on others.* Only one of these factors – *perceived usefulness* – appears in the UTAUT model that is the dominant theoretical perspective in technology adoption research (Venkatesh et al., 2016). *Perceived ease of use*, which is a core construct in the UTAUT model was not among the salient considerations voiced by the participants in our study. These results suggest that generic models developed in the organizational context may offer limited insight into the salient factors that affect the adoption of novel smart home technologies.

Our analysis of the effects of the identified factors (*perceived usefulness, perceived relative advantage, novel benefits, malfunction concerns, privacy concerns, security concerns, and negative effect of technology on others*) on the smart lock adoption intention revealed an unexpected result. We found no statistically significant effect for *perceived usefulness*, and the only factor that had a statistically significant effect on the adoption intention was the *perceived relative advantage*. This construct reflects the beliefs that smart locks would offer greater safety and security vis-à-vis conventional locks.

Perceived relative advantage construct that emerged in our analysis is distinct from the *relative advantage* that is a part of the Rogers model of innovation diffusion in one important respect. Rogers defines relative advantage as "the degree to which an innovation is perceived as better than the idea it supersedes" (Rogers, 2010). The statements that reflect *perceived relative advantage* in our study focus specifically on the extent to which the new technology (smart locks) delivers on the key benefits compared to the incumbent technology (traditional locks) – assuring safety and security of a person's home. The definition offered by Rogers does not elaborate on what "better" means and this has caused confusion in the past studies that attempted to adopt the construct in information systems (Al-Jabri &

Sohail, 2012). Our results indicate that *perceived relative advantage* can be the singular most important construct in predicting innovative technology adoption in the context where it replaces incumbent technology. Therefore, potentials users need to understand the functionality of these devices to promote its adoption. The *novel benefits* construct in our study arguably makes smart locks "better" by expanding the available functionality. However, novel benefits have no effect on the adoption intention in our study.

In conclusion, our study was motivated by the recent calls for context-specific theory in information systems. Our examination of the salient user beliefs that affect the adoption of smart locks as an example of innovative smart home technologies revealed that the dominant models in information systems are unlikely to capture the key salient user considerations in this context. We find that *perceived relative advantage* of the new technology in relation to the core benefits afforded by the incumbent technology is the singular predictor of the smart lock adoption intention in our study. Notably, *novel benefits* have no effect on the adoption intention.

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From dirty data to multiple versions of truth: How different choices in data cleaning lead to different learning analytics outcomes

JUSTIAN KNOBBOUT, HUUB EVERAERT & ESTHER VAN DER STAPPEN

Abstract Learning analytics is the analysis of student data with the purpose of improving learning. However, the process of data cleaning remains underexposed within learning analytics literature. In this paper, we elaborate on choices made in the cleaning process of student data and their consequences. We illustrate this with a case where data was gathered during six courses taught via Moodle. In this data set, only 21% of the logged activities were linked to a specific course. We illustrate possible choices in dealing with missing data by applying the cleaning process twelve times with different choices on copies of the raw data. Consequently, the analysis of the data shows varying outcomes. As the purpose of learning analytics is to intervene based on analysis and visualizations, it is of utmost importance to be aware of choices made during data cleaning. This paper's main goal is to make stakeholders of (learning) analytics activities aware of the fact that choices are made during data cleaning have consequences on the outcomes. We believe that there should be transparency to the users of these outcomes and give them a detailed report of the decisions made.

Keywords: • Data Cleaning • Learning Analytics • Student Data • Moodle Data • Outcomes •

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1 Introduction

Virtual Learning Environments (VLEs) are digital learning platforms where students can interact with course materials (presentations, digital readers, instructional video's et cetera), can test their knowledge via quizzes, and can interact with each other and instructors via e.g., the discussion board. They support learning and simultaneously enable the collection of data on learner behavior in the system. Data from virtual learning environments are used for learning analytics activities, cf. Agudo-Peregrina, Iglesias-Pradas, Conde-González, & Hernández-García (2014); Conijn, Snijders, Kleingeld, & Matzat (2016); Rienties, Toetenel, & Bryan (2015); Romero, Ventura, & García (2008). Objectives of learning analytics vary but often involve student behavior modelling, prediction of performance and increase in (self) reflection and (self) awareness (Papamitsiou & Economides, 2014).

Importantly, raw data exported from virtual learning environments need to be cleaned and transformed before it is of any use to educators and students. In general, data cleaning takes up to 80% of analytical time (Brink, Richards, & Fetherolf, 2016). However, in the current learning analytics field, details about cleaning and transforming are often overlooked or, at best, not described and discussed in literature. For example, searching the terms *data cleaning* or *data preprocessing* in the Learning Analytics & Knowledge conference proceedings 2011 till 2018 (n = 438) only yield 17 papers describing either cleaning or preprocessing of learner data before analyzing the data. To make matters even more complex, full-scale and multimodal learning analytics require aggregated data from multiple sources, amplifying the effects of data cleaning on the analysis' outcomes. As we will show in this paper, data cleaning is problematic as (unspoken) choices can lead to a wide variety of outcomes and, subsequently, pedagogical interventions. Using a raw data set with VLE data, we will construct twelve different, cleaned sets and use these to calculate the time-spent-on the online part of six courses. With these data sets, we can provide an answer to our research question: *"What are the effects of (unspoken) choices made during the cleaning process of student data on the outcomes when these data are in turn used for learning analytics?"*.

The remainder of this paper is structured as follows. First, an in-depth description of learning analytics and data cleaning is given based on existing literature. Then, the research question and method are described, followed by the presentation of our results. Finally, we provide five recommendations based on the outcomes of our study, as well as directions for future work.

2 Related work

In this section, we will present existing literature related to our study. First, we will provide a definition of learning analytics and an overview of the learning analytics process. Next, a thorough description of data cleaning and its implications is given.

2.1 Learning analytics

Learning analytics is "the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environment in which it occurs" (Siemens et al., 2011). Learning analytics aim to improve learning processes at the level of students and teachers (Siemens & Long, 2011) and is, for example, used to analyze student behavior within digital learning environments, monitor the usage of course material, and predict whether students will fail a certain course or drop out entirely. The process of learning analytics consists of four steps: 1) learners generate learning data, 2) these data are captured, collected and stored, 3) analysis and visualization are performed, and 4) the design and use of data-driven pedagogical interventions (Clow, 2012) – see also Figure 1. Consequently, when the data is incorrect or incomplete, the analysis and subsequent interventions may be sub-optimal or even completely erroneous.

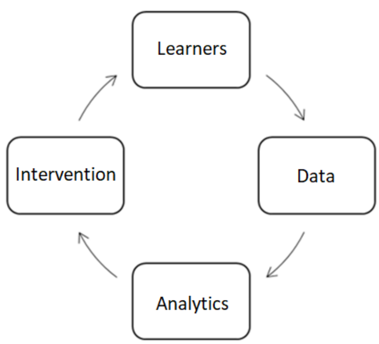

Figure 1: Learning Analytics Cycle (Clow, 2012).

2.2 Time-on-task

Study-time is the time students spend on studying learning materials, using (metacognitive) tools, solving questions etcerera and can be used as measure of affected learning (Knobbout & van der Stappen, 2018). In several studies, a positive correlation between study-time and achievements of students has been found, cf. Marzano (2003); Scheerens & Bosker (1997)). Estimating 'time-on-task' in the 'traditional' classroom is based on estimates by students and/or observations in classrooms. In a virtual learning environment (VLE), on the other hand, it is common to use the number of clicks (Wolff, Zdrahal, Nikolov, & Pantucek, 2013) or the time between certain clicks as measure for time-on-task (Kovanović et al., 2015).

Wolff et al. (Wolff et al., 2013) showed that "even fairly coarse grain data about students' activities" is useful in predicting retention (p. 148). Unfortunately, it is not perfectly clear what part of the clicks were used "[w]hile the issue of data cleaning for all data within the [Open University] was not resolved, it was possible to gain enough knowledge about the data […] to start building models" (p. 146). From their point of view, it is import to note that in predicting failing students, changes in the student's own VLE activity, compared to their previous activity, are indicative. A relative reduction of clicks hints an failing student. Kovanović et al. (2015) deal explicitly and extensively with the thorny methodological issues of estimating time-on-task in VLE's. Their primary goal is "to raise awareness of the issue of accuracy and appropriateness surrounding time-estimation within the broader learning analytics community, and to initiate a debate about the challenges of this process" (p. 184). It is regarded good practice in different academic fields to discuss methodological issues and learning analytics should not become an exception to this rule. In this study, we extent the work of Kovanović et al. by estimating time-on-task for multiple parallel courses and by showing different options to handle missing data, i.e., records of events unlinked to any of the courses in the dataset.

2.3 Data cleaning

Data cleaning is an important part of the ETL (Extraction, Transformation and Load) process. According to VanderPlas (2016) the majority of the work in data science often "comprises cleaning and munging real-world data" (p. 188). Brink, Richards, and Fetherolf (2016) underline five common tasks, of which two - transforming original data to the target and create features that are more easily interpreted – are core business in working with large computer generated data files. Müller and Guido (2016) state that "in the real world, inconsistencies in the data and unexpected measurements are very common" (p. 19). Brink, Richards & Fetherolf (2016) estimate researchers are spending about 80% of their research time to munging, wrangling, combining or reshaping data. Special attention is given to utilizing expert knowledge. Although machine learning can reduce the need to create a set of expert-designed rules, that does not mean that prior knowledge of the application or domain should be discarded. Domain experts can help to identifying useful features that are more informative than the initial representation of the data (Müller & Guido, 2016).

2.4 Missing data

In (social sciences) papers and articles an often-subordinated subject is missing data. One of the most frequent and most ignored sources of bias is missing data (Baguley, 2012). Missing data is a stubborn problem in data analyses and, in general, we have to consider two issues: how much is missing and why it is missing. Thanks to eloquently written textbooks like 'Applied missing data analysis' (Enders, 2010), solutions to deal with missing data mechanisms are nowadays within reach for social researchers. In an overview of traditional techniques, Enders (2010) describes (listwise/pairwise) deletion, several imputation methods, averaging items in Likert scales, or last observation carried forward to address the problem and concludes that "most single case imputation methods produce biased estimates, even with Missing Completely at Random (MCAR) data. Stochastic regression imputation is the one exception and is the only traditional approach that yields unbiased estimates under a Missing At Random (MAR) mechanism" (p. 54). He demonstrates benefits of modern methods like maximum likelihood approaches and multiple imputation. Even in MCAR – which occurrence can hardly be safely assumed – the problems of missing data may become more serious if more cases are missing. "Unfortunately, there are as yet no firm guidelines for how much missing data can be tolerated for a sample of a given size" (Tabachnick & Fidell, 2007) (p. 63). Indirectly, Tabachnick & Fidell (2007) seem to consider about 5% missing or less of the sample size as 'manageable' in some way or the other. It also depends on the pattern of missing data. Choosing among different techniques for dealing with missing data may also depend on knowledge, confidence, and familiarity with the subject matter on part of the researcher. Van Belle (2011) among others advocates sensitivity analysis as a good idea based on "a thorough understanding of the subject matter" (p. 186).

It does not matter whether the above mentioned authors are working in the different fields varying form social or educational sciences, general data sciences to hard core machine learning and it seems fair to conclude that working with data is time consuming and in general comes with trouble, caveats or thorny issues. Fortunately, at the end of the process we will rely on some technical solutions, but working the data is in itself a muddy experience in which the data scientist/researcher has to rely on (several) subjective views and or decisions.

Educators are in the midst of a transition from learning analysis to learning analytics. The analysis of classical test scores is not enough. The availability of VLEs and the tracking of student behavior gives both students and educators much more opportunities to follow the learning of students in real–time and opportunities to intervene if necessary. At the same time, the upper limits of learning analytics are not well defined. Techniques borrowed from educational data mining, data science and machine learning combined with data from social-media become more and more intertwined (Daniel, 2017; Gibson & Ifenthaler, 2017). Technical solutions by themselves are not sufficient for successful use of educational data, as "[d]ata do not exist independently of the ideas, instruments, contexts and knowledge used to generate, process and analyze them" (Kitchin, 2014) (p. 2) thereby (implicitly) suggesting that data scientist are not aware of the pitfalls of data construction. As we will later show in this paper, most data scientists are aware of the true nature of data, that is, data are not neutral, objective and pre-analytic in nature. What often lacks is a thorough discussion of the possible solutions and consequences of a technical data issue, which is a major motive to conduct the study at hand.

3 Research method

The choices made in the cleaning of student data extracted from VLEs has effect on the outcome of this process – the dataset which is used for analysis and visualization of learning. However, not much is written about this effect and, consequently, the differences between outcomes based on the assumptions and choices made by the people responsible for the cleaning of the raw data are also underexposed. This study's aim is to fill this gap in the current learning analytics knowledge based on answering the following research question: *"What are the effects of (unspoken) choices made during the cleaning process of student data on the outcomes when these data are in turn used for learning analytics?"*. As we will research how the made choices affect analytical outcomes of contemporary events whilst we do not have control over these events, a case study is a suitable research method for our study (Yin, 2014).

3.1 Case description

In this single case study, we analyze data from an international minor program. Students (n = 34) from the Netherlands, Finland, Spain, United Kingdom, Mexico, and Germany all participate in six blended courses (in this study named A to F), offered in 'traditional' classrooms, at an external workplace, as well as online via Moodle – a well-known VLE. In this study, we focus on data obtained from the latter.

Log files from Moodle are collected by exporting them via the administrator dashboard. This dashboard allows administrators to download all logs in comma separated value (.csv) format, which in turn can be processed in more specialized statistical software or learning analytics tools – in this study, we used IBM SPPS Statistics 24. The data are aggregated by us, i.e., events from all six courses are combined in one dataset. In compliance with the ethical procedures and guidelines that were applicable at the time the research was conducted, students were asked to give passive informed consent and all data were after collection immediately anonymized. Initially, the dataset comprises the variables as shown in Table 1 and Figure 2.

Table 1: Variables extracted from Moodle.

Variable	Description
Date	Date of the event taking place
Time	Time, in HH:MM-format, of the event taking place
User id	Moodle id of the user
Event context	Page of the VLE where event takes place
Component	Whether it involves an assignment or not
Event name	Name of the activity
Description	Description of the event, including course and user(s) id
Origin	Whether website or app is used
IP-address	IP-address from where Moodle is accessed
Id of affected user	In case of e.g., message sent or discussion board reaction

Date	Time	ID	Event context	Component	Event name	Description	Origir	IP addre
6-9-2016	14:14	141	Assignment: Task 2)	Assignment	The status of the su	The user with id '141' has viewed the submission status page for the as:	web	145.89.118.'
6-9-2016	14:14	141	Course: Introductory	System	Course viewed	The user with id '141' viewed the course with id '16'.	web	145.89.118.'
6-9-2016	14:11	118	Course: Introductory	System	Course viewed	The user with id '118' viewed the course with id '16'.	web	145.89.164.
6-9-2016	14:11	33	Course: The Project -	System	Course viewed	The user with id '33' viewed the course with id '17'.	web	145.89.64.1
6-9-2016	14:08	118	Assignment: Task 0b	Assignment	The status of the su	The user with id '118' has viewed the submission status page for the as:	web	145.89.164.
6-9-2016	14:08	118	Assignment: Task 0b	Assignment	A submission has l	The user with id '118' has submitted the submission with id '580' for the	web	145.89.164.
6-9-2016	14:08	44	User:	System	Message viewed	The user with id '44' read a message from the user with id '118'.	web	145.89.164.
6-9-2016	14:08	118	System	System	Message sent	The user with id '118' sent a message to the user with id '44'.	web	145.89.164.
6-9-2016	14:08	38	User:	System	Message viewed	The user with id '38' read a message from the user with id '118'.	web	145.89.164.
6-9-2016	14:08	118	System	System	Message sent	The user with id '118' sent a message to the user with id '38'.	web	145.89.164.
6-9-2016	14:08	46	User:	System	Message viewed	The user with id '46' read a message from the user with id '118'.	web	145.89.164.

Figure 2: Snippet of raw data set.

As a case for our study, we want to determine for each individual student how much time is spent on each of the six courses of the minor program and the underlying learning activities. This means we have to structure the data in such way that we can estimate the time-on-task for all events in the data set. We elaborate on this process and its results in the next section.

3.2 Cleaning of the data

Our focus in the ETL process of the Moodle data is on cleaning and transforming the data by deriving new calculated variables and values by splitting a column (existing variable) into multiple columns (new variables) and so disaggregating the data. Our VLE data records user id, event description and timing of an event. The variable Description (including the user id and course id) is split in different variables to identify the course the student is working on. We are willing to assume that a student's action in the VLE and thus creating an event in the data set is synonymous with studying. Therefore, we have to assume that opening of a second event implies the end of the first event and the time-spent-on the first event T1 amounts to t2 minus t1 – see Figure 3. Unfortunately, closing of the event is normally not registered in the VLE. Consequently, time-spent-on the last event in a session (T4 in Figure 3) cannot reliably be calculated.

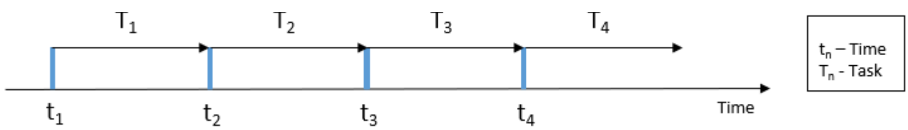

Figure 3: Calculation of time-spent-on task by using the start of new event.

Another issue is missing data: many events are not linked to a specific course. For example, when a student sends a message to another student, Moodle does not know to what course (if any at all) the message relates and therefore omits the inclusion of a course id in the event description. This proves problematic when calculating the total-time-spent-on a course. In Figure 4 we see that a student is working on course D at t2. Later, at t5, he is involved in course C. In order to link the other events (t1, t3, t4, t6, and t7) to a specific course to compute total-time-spent-on a course, we must make some assumptions.

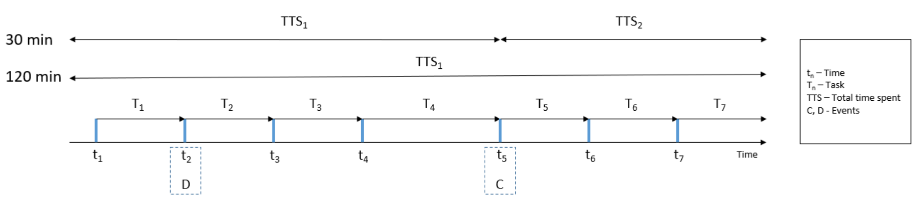

Figure 4: Total-time-spent on different courses, based on varying session times.

First, we must decide whether the event on t_4 is to be associated with a session in which the student is working on course C or course D. In the literature, a session or study-period often ends 30 minutes after the last click (see discussion and overview of time-on-task in (Kovanović et al., 2015)). Moodle's default setting, however, automatically ends sessions after 120 minutes. That are two main versions we worked with in this study, but there is no logical reason to limit ourselves to these options – why not 60 or 90 minutes? By deciding to end a session after 30 minutes of inactivity, we also assumed that the course worked on in the 30 minutes version is D at t_1, t_2, t_3 and t_4, while the student started with course C at t_5. We can now calculate the total-time-spent (TTS) during this session by adding all T_x within the session. In the default Moodle version, on the other hand, the timing between all events is smaller than the 120 minutes cut-off time. In such a study period (see Figure 4), we can calculate the total-time-spent during the session but do not know to what (portion of a) course to assign it. It can be DDDDCCC, but also DDCCCCC or whatever permutation possible. Obliviously, this is of influence when computing total-time-spent-on a course.

To deal with the problem of events not linked to courses – which is essentially a missing data issue – we defined six scenarios:

- In the first scenario (strict) we disregarded sessions with events not referring to any course. This way, we do not have to make assumptions to what course a session relates. The downside, however, is that we lose sessions and, thus, information.
- In the second scenario (wide 1), we filled out the missing values by carrying the last observation forward till the next observed course or the end of the study session.
- In the third scenario (wide 2), we simply relied on the most frequent course in a study period as the one and only; overwriting missing values in that particular time frame.

In the other three scenarios, we imputed the missing values with randomly assigned courses weighted by the number of known courses worked on:

- In the fourth scenario (wide 3), the weight was based on the number of all courses observed on a weekly basis of all students together and all missing values of a single student in a particular time frame got the same random course assigned (for instance, AAA or BBB)
- In the fifth scenario (wide 4), the same is done as in wide 3 but several missing values in a particular computed study-period were independently randomized (for instance, DBA, or CAC or just FFF).

- In the final scenario (wide 5), the weight is computed by the number of courses directly chosen by an individual student on a weekly basis and missing values were imputed as in wide 4.

We just want to show that all scenarios are plausible in one way or the other, and indeed, we could have chosen other ways to deal with missing values. At this point we are not interested in the stability of the different approaches. In order to compute the total-time-spent-on a course (TTS_A, TTS_B et cetera) in the different versions and session, we recomputed the study sessions by taking t-last minus t-first of a row of equal courses in order to estimate time-spent-on a course. See Figure 5 for a schematic representation of some of the scenarios.

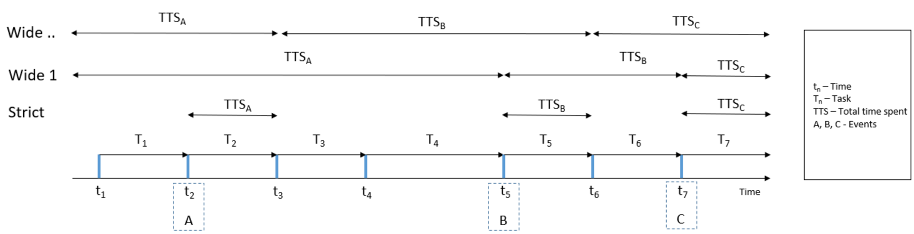

Figure 5: Schematic representation of scenarios Strict, Wide 1 and one of the other Wides.

3.3 Data processing

In line with our own recommendations (see section 5.1), we provide a summary of assumptions and decisions made in the processing of our data:

- Events related to accessing the VLE with phones or mobile apps creates records without any information other than that a mobile device is used and can be removed from the dataset;
- Activities as changing passwords or failed login attempts are not related to learning and thus can be removed from the dataset;
- Our research focusses on learners so event caused by other users (teachers, administrators etcetera) can be removed from the dataset;
- All remaining events in the dataset represent learning activities in the VLE;

- Learning sessions end either 30 or 120 minutes after the start of the last event in said session;

Data is cleaned by applying one of the six methods described in section 3.2.

4 Results

Now we have 12 different data sets – the six scenarios how to deal with missing data and two different sessions times (30 versus 120 minutes). With these data sets, we now calculate the time-spent-on the six courses of the minor program.

4.1 Identifying events and courses

In total, our raw dataset comprised 148,285 events. After removing events related to accessing the VLE with phones or mobile apps removing non-learning activities, and limiting ourselves to student users, we end up with 57,811 events. Of all these events, just 12,334 events (21% of relevant events) are directly linked to a course – see Figure 6. This leaves 45,477 events (79%) unaccounted for and the only way to link the registered student activity to a course is within a study session based on the Moodle default of 120 minutes or the 30 minutes often used in academic studies.

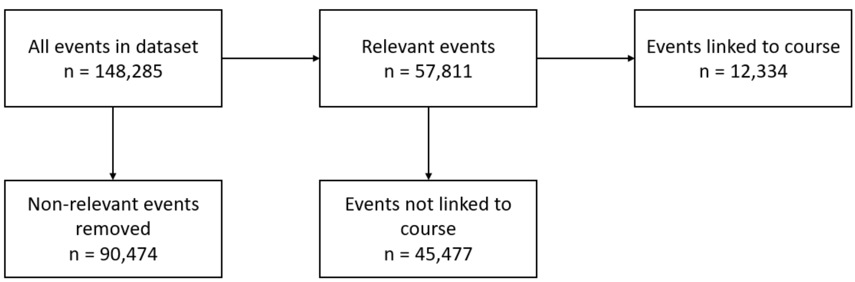

Figure 6: Number of events during and after data processing.

As a result of the option between 30 and 120 minutes, we see in Table 2 that in the 120 minute default 3,832 events take place within study periods in which there is no link to any course at all. Just by shortening the end of the study session to 30 minutes, the number of not directly identifiable events more than doubles to 8,546 events. Shorter periods in the 30 minutes version leads to more unequivocally identifiable events; all known events in these periods belong to one and the same course. In the 120-minute default, it is just the opposite: the number of events pertaining to two or more different courses within a study period nearly doubles compared to the 30 minutes variant. Independent of the selected version, there are 137 not directly identifiable events we could not solve by carrying the last observation forward till the next observed (wide 1) or just taking the most frequent course in a study session (wide 2).

Table 2: Assigning events to courses in order to estimate time-spent-on course.

Moodle default: 120 minutes

Decision		Unidentified	A	B	C	D	E	F	Total events
Raw data									148,285
Evens relating to courses	Unidentified	**3,832**	0	0	0	0	0	0	3,832
	Unequivocally identified	0	15,125	6,005	3,651	1,126	1,943	5,744	33,594
	Two or more options		7,407	8,182	6,563	8,127	9,624	9,425	
Versions	Strict	3,832	18,315	10,112	5,944	3,971	5,115	10,522	53,979
	Wide 1	137	19,058	10,552	6,329	4,514	5,701	11,520	57,674
	Wide 2	137	19,117	10,788	6,175	4,126	5,387	12,081	57,674
	Wide 3	0	18,902	10,768	6,242	4,303	5,620	11,976	57,811
	Wide 4	0	18,885	10,784	6,239	4,314	5,621	11,968	57,811
	Wide 5	0	19,017	10,653	6,277	4,409	5,635	11,820	57,811

Theoretical standard/advise: 30 minutes

Decision		Unidentified	A	B	C	D	E	F	Total events
Raw data									148,285
Evens relating to courses	Unidentified	**8,546**	0	0	0	0	0	0	8,546
	Unequivocally identified	0	15,560	7,080	4,005	2,009	2,970	7,285	38,909
	Two or more options		4,641	4,371	3,862	4,075	3,984	3,529	
Versions	Strict	8,546	17,584	9,663	5,276	3,430	4,624	8,688	49,265
	Wide 1	137	19,051	10,562	6,351	4,513	5,718	11,479	57,674
	Wide 2	137	19,116	10,827	6,143	4,357	5,758	11,473	57,674
	Wide 3	0	18,784	11,068	6,207	4,227	5,616	11,909	57,811
	Wide 4	0	18,827	11,138	6,145	4,148	5,782	11,771	57,811
	Wide 5	0	18,989	10,963	6,221	4,316	5,669	11,653	57,811

4.2 Identifying time-spent-on tasks and courses

After cleaning the data and imputing the missing values, we have 12 datasets and can calculate the number of activities on each course based on the various data sets. At first glance it seems that only differences between the strict and the wide scenarios are noteworthy. The solutions within the five wide approaches do not differ that much. That is erroneous: the number of events in Table 2 are presented over all students together. What we really want to know is the number of events – and more importantly – time-spent-on by each individual student. Both measures vary enormously according to the chosen dataset. We can now also calculate the time-spent-on each course by each individual student as shown in Table 3 for just four students.

Table 3: Relative amount of time spent on courses for four different students.

		Moodle default: 120 minutes							Theoretical standard/advise: 30 minutes						
User id	Scenario	A	B	C	D	E	F	Total time (minutes)	A	B	C	D	E	F	Total time (minutes)
128	Strict	16%	26%	18%	13%	10%	17%	14.173	23%	28%	21%	11%	5%	11%	3.439
	Wide1	15%	24%	16%	12%	9%	24%	15.921	21%	26%	20%	10%	5%	19%	3.999
	Wide2	13%	26%	13%	12%	6%	30%	17.261	19%	28%	17%	12%	4%	19%	4.116
	Wide3	15%	27%	16%	12%	11%	20%	15.921	20%	28%	19%	12%	6%	15%	3.999
	Wide4	15%	25%	16%	12%	9%	23%	15.397	22%	27%	21%	11%	5%	15%	3.747
	Wide5	14%	24%	15%	13%	11%	23%	16.224	21%	28%	21%	10%	5%	15%	3.982
132	Strict	28%	13%	18%	7%	9%	26%	6.466	44%	9%	10%	4%	12%	20%	1.447
	Wide1	22%	18%	13%	8%	7%	32%	9.142	32%	7%	8%	12%	10%	32%	2.070
	Wide2	21%	17%	12%	10%	9%	30%	9.618	32%	7%	8%	11%	11%	32%	2.105
	Wide3	22%	13%	13%	8%	11%	32%	9.142	32%	14%	8%	8%	9%	29%	2.070
	Wide4	25%	13%	15%	7%	9%	32%	8.017	37%	8%	9%	5%	11%	30%	1.795
	Wide5	19%	10%	12%	7%	20%	33%	10.387	33%	7%	8%	5%	21%	27%	2.106
138	Strict	26%	21%	13%	3%	11%	27%	5.385	45%	11%	5%	3%	7%	29%	1.424
	Wide1	20%	22%	13%	4%	11%	31%	7.008	32%	11%	13%	2%	8%	34%	2.011
	Wide2	21%	20%	13%	6%	6%	34%	7.157	35%	11%	10%	3%	8%	34%	2.035
	Wide3	20%	22%	11%	2%	13%	32%	7.008	34%	11%	11%	5%	7%	32%	2.011
	Wide4	22%	25%	12%	2%	9%	29%	6.226	36%	13%	10%	2%	5%	33%	1.804
	Wide5	21%	27%	14%	3%	10%	25%	6.658	28%	23%	10%	3%	5%	31%	2.325
144	Strict	44%	6%	7%	9%	13%	22%	4.577	45%	10%	12%	9%	1%	23%	1.336
	Wide1	29%	8%	9%	23%	8%	23%	7.759	36%	8%	11%	24%	0%	21%	1.802
	Wide2	26%	6%	9%	8%	26%	25%	8.166	34%	10%	10%	24%	1%	21%	1.829
	Wide3	27%	6%	6%	10%	10%	41%	7.759	36%	9%	9%	9%	5%	32%	1.802
	Wide4	31%	5%	7%	7%	16%	34%	6.674	41%	9%	11%	7%	1%	31%	1.580
	Wide5	37%	8%	4%	7%	15%	29%	6.787	42%	10%	12%	8%	1%	28%	1.526

Compared to the theoretical standard/advise of 30 minutes, students spend about 3 to 4 times as much time on the total of six courses under the Moodle default of 120 minutes. Considering Moodle's default session ending time of 120 minutes, students spent about 3 to 4 times as much time on their courses compared to the total time-on-task when using the theoratical standard ending time of 30 minutes. This is in line with the assumptions used – 120 minutes is four times as long as 30 minutes. However, if we look at the relative time students spent on specific courses between the two versions or within the used scenarios of a version, the link between assumptions used and relative time becomes foggy and blurred.

In the 30 minutes version, all students seem to spend relatively more time on course A and less on course B, compared to the Moodle default of 120 minutes. However, student 144 spends also relatively less time on course E. If we compare over the scenarios within the separate versions, we sometimes see huge differences between strict and several wide scenarios. For instance, in the 30 minutes version, student 138 spends 45% of his time in the strict version to course A, in wide 5 this is reduced to a mere 28%. In the Moodle default, the relative time-spent-on in these sets is more or less the same (26% versus 21%).

As our results show, it is difficult to see a common pattern in these figures, indicating different assumptions lead to different dashboard figures. Concluding, we observe that time-spent-on as a key variable for the quality of learning stays without reach for teachers as a basis to act upon and interfere with a particular student: it just depends and variates with the assumptions made and the truth is hard to find.

5 Discussion and conclusion

In this paper, we have shown that the choices made during the cleaning process of student data can have large impact on the outcome of the subsequent analysis. Estimating time-on-task is one example of a learning (outcome) measure which is affected by data cleaning, but also other metrics used in learning analytics research might be influenced, e.g., the use of (metacognitive) tools or the number of discussion board postings. With the emerge of full-scale and multimodal learning analytics – requiring the aggregation of data from multiple sources –the effects of data cleaning on the analysis' outcomes are even more amplified. We are not in search of a holy grail for student data cleaning (which probably does not exist at all), but the goal of this study is to make both practitioners and academics aware of these - often unspoken - choices and their effect.

5.1 Recommendations

Based on our research, we present the following recommendations: (1) provide users of learning analytics tools (students, teachers et cetera) with the insight what assumptions and corresponding choices were made during the data cleaning process. This helps them to better understand the results and visualizations of the data analysis; (2) provide users with the opportunity to see other versions based on different assumptions of the data set as well; (3) to make scientific work better reproducible and comparable, researchers should elaborate on the cleaning of their data. In the current literature, researchers often almost immediately jump from raw data to results without saying anything on the choices made, although some exceptions exist, cf. Bos & Brand-Gruwel (2016); Chen, Chen, & Xing (2015); Kovanović et al. (2016); (4) involve domain experts in the cleaning process. Data experts working on the data sets without knowing the exact context the data was collected in, might use erroneous assumptions to clean the data. By consulting domain experts before the data handling, the resulting data might be better suit the learning context (Müller & Guido, 2016); (5) stakeholders should feel responsible, support the choices made, and be transparent about them.

If we want students, colleagues and other professionals to work with our analysis, results or dashboard functionality, we should be open and give them a detailed report of the decisions made. As a rule of thumb, we should state and explain explicitly how we have dealt with the issues at hand in such way the user can understand it (Van Belle, 2011).

5.2 Future work

Now we have different data sets, we might want to research in what ways to inform end users about the data cleaning process. That is, how can we inform users – students, teachers et cetera – what assumptions were made, what steps were taken, what user preferences are, and what the effects on the analysis outcome are. We propose the use of focus groups to identify (critical) success factors for awareness creation about data cleaning and its consequences.

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Twitter at the Hands of the Church

SOILE KARJALAINEN & RAIJA HALONEN

Abstract This qualitative study analysed how the Church utilised Twitter. The empirical material consisted of 937 individual tweets published in early 2017 and classified into three categories: tweets published by the Church, tweets published by other organisations and tweets published by individual persons. The latter two groups were re-tweeted by the Church reasoning their role as empirical research material. At the time of the study, the most topical issues were asylum seekers, equal-marriage laws and human rights. Qualitative content analysis was performed following a step-by-step approach. Networking was identified as the strategy for utilising social media. The results also showed that the way the Church acted in social media was interactive. The Church tweeted openly and encouraged people to join discussions.

Keywords: • Twitter • the Church • Public organisation • Religious • Content analysis • Social media •

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1 Introduction

The current study analysed how a public organisation utilised social media as a tool. The study was conducted as a case study in the Finnish Evangelical Lutheran Church (hereinafter the Church). The social media studied was limited to Twitter, and the empirical research material consisted of tweets made over January–April 2017 from the Twitter account owned by the Church and managed by the Church Council.

Social media has become an essential part of everyday of people, and it is integrated into daily life. The popularity of social media is increasing, and many enterprises have adopted social media among their practices to contact people regardless of place or time. Recently, public organisations have significantly increased their use of social media, being more achievable than before (Mergel, 2013; Simon, Goldberg & Adini, 2015). Also journalists report about incidents via Twitter, increasing openness, and share content produced by actors other than themselves (Vis, 2013).

Many public organisations, actively use Twitter (Lovejoy, Waters & Saxton, 2012), and one of them is the Church. Like any public service provider (see Serrat, 2017), also the Church has faced the need to more flexibly utilise media to enable inclusive, participative, and responsive communication. So far, however, Twitter-related studies have not focused on churches, although Cheong (2014) analysed tweets by one pastor. The Church wanted to reach people, so it was activated in the same forum were people are. The Church had accounts in Facebook, Instagram, YouTube and Twitter. However, despite the active use of social media and especially the use of Twitter in the hands of the Church, the way how Twitter was used had not been analysed so far.

This study focused on the research question: How does the Church utilise the microblog service Twitter in interactions with its members? The research question was investigated in a case study with inductive content analysis (Krippendorff, 2013). A framework with seven steps (Mayring, 2014) was applied. The study was mainly qualitative (Kaplan & Maxwell, 2005) in nature, with some numerical facts included to add value to the interpretations.

According to the analysis, the Church utilised Twitter to spread Christianity and mostly tweeted about religious topics but also about refugees, equal marriage and human rights. The language used showed that the Church could express its views in humorous ways and sought to spur active interactions.

2 Literature Review

Social media can be defined as a group of Internet-based applications that are built on Web 2.0 and that enable users to produce and share content. In general, social media enables reaching many people in real time (Serrat, 2017).

For governments, social media offers possibilities to capture messages and opinions from citizens and use that information to build processes, increase openness and develop solutions for governmental problems (Mergel, 2013). Companies need to make intentional decisions to adopt social media, build social communities and gain skills to learn from the content produced by customers (Culnan, McHugh & Zubillaga, 2010). Companies can learn which of their registered users follow other registered users, thus building networks that organisations can use (Debreceny, 2015).

Due to its non-anonymous nature social media appeals more people with extraversion and openness to experiences than introverts (Correa, Hinsley & De Zuniga, 2010). Most often reasons for social media usage are related to having fun and providing updates of it, or content-specific and information seeking (Luchman, Bergstrom & Krulikowski, 2014). Social media also enables forming common understanding with stakeholders and offers an important link between government and citizens (Mergel, 2013).

One of the most popular social networking sites is Facebook, which has more than 1.15 billion monthly active users (Debreceny, 2015). Among the other social media sites (e.g. Sixdegrees, Hi5, MySpace, YouTube and Flickr), Twitter, founded in 2006, has grown rapidly in recent years, and its popularity is expected to continue to grow in the future (Gerstein, 2011). Twitter allows 140-character messages to be sent to and seen by people not known to the sender (Kietzmann, Hermkens, McCarthy & Silvestre, 2011). Twitter users can make status updates, have conversations and share news and knowledge. Twitter can be valuable for both leisure and professional pursuits, such as sharing sources and coordinate projects (Lux Wigand, 2010; van Dijck, 2011). Twitter has developed the use of hashtags (#) to inform other users about the content of messages (Naaman, Becker & Gravano, 2011).

Twitter serves as a formal communication channel for various authorities, including government agencies (Mergel, 2013). Twitter has a growing role at the governmental level and has introduced a new way to have discussions with stakeholders (van Dijk, 2011). Twitter use even proved to be crucial in the United States presidential campaign in 2016 (Enli, 2017). Government Public Relations can benefit from the low-cost nature of Twitter and reach large audience if the citizens engage in dialogue with information, questions and ideas as encouraged by the officials (Farhatiningsih & Salamah, 2018).

Enterprises utilise Twitter primarily to inform and promote their relationships and advertising activities (Waters, Burnett, Lamm & Lucas, 2009). Public organisations similarly use Twitter for information sharing, a type of communication that emphasises publishing facts (Waters & Williams, 2011). Twitter acts as a marketing tool, enables amateurism, challenges professionalisation and serves as a tool to set new agendas for institutions and other actors that tweet (Enli, 2017). Institutions with open Twitter accounts actively use the site to share information and facts publicly and quickly in real time and to increase confidence in their administration and operations (Waters & Williams, 2011).

Twitter also enables two-way interactions that offer new possibilities for businesses' social-media use (Briones, Kuch, Liu & Jin, 2011). Twitter-based internal communication opens an informal way to disseminate and discuss topics that would not necessarily be raised in traditional channels. Twitter improves collaboration in work environments by making information sharing easier and faster and increasing the community spirit among colleagues. (Zhao & Rosson, 2009).

The integration of social media tools into citizens' everyday life has enabled utilisation of social media during crises. Especially during catastrophes, social media plays a significant role as other communication systems, such as phone lines, can become overloaded. Twitter can be used to share information about personal circumstances and coordinate assistance, first aid and evacuations. (Macnamara & Zerfass, 2012; Ludwig, Reuter & Pipek, 2015).

Although Twitter has grown into a leading media tool in organising political campaigns (Enli, 2017), its role in communication between organisations and stakeholders has not yet been established (Lovejoy et al., 2012). Furthermore, many organisations have not developed guidelines or strategies for social media use. Only 20% of Australian organisations and 23% of European organisations have created overall social media strategies, and organisations often have insufficient skills to utilise social media. (Macnamara & Zerfass, 2012).

In all, Twitter seems to be used to serve in versatile purposes related to such as adding communication among different crowds, advertising and marketing, sharing governmental information, influencing public opinion and pushing political or administrative goals forward.

However, Church as the tweeter has not gained much attention, with the exception of a single priest in a large church as the tweeter (Cheong, 2014), and new empirical findings were expected to increase knowledge about Twitter in the hands of a significant religious organisation.

3 Empirical Context

The Evangelical Lutheran Church (the Church) is the largest religious community in Finland. In 2017, the Church had about four million individual members, amounting to 71.9% of citizens. Founded in 1809, the Church has a tradition of established practices. The Church was separated from the state in 1870, when significant responsibilities for education, healthcare and care for the poor were also transferred to municipalities. The Church's central administration body is the Church Council.

At the time of the study, the Church had adopted use of social media and frequently updated its social media accounts. The online Church offered ongoing services and hours of prayer, and praying online. The Church also had Facebook, Instagram, Twitter and YouTube accounts and encouraged its parishes to build their own social media accounts and to be visible also in internet. In addition, there were several prominent persons in the Church who made their contributions via their private social media accounts.

At the time of the study, the Church's Facebook site had 54,874 'likers' and 51,780 'followers'. The Church published one to three postings daily and shared posts by its partners and other individuals. On YouTube, the Church published several video shots weekly. One of its newest online products was 'One-Minute Devotions' on diverse topics, and some of these video shots had gained thousands of views. The Church's social media sites were managed by a special team of persons hired for that. The team included priests, diaconal workers, youth workers and informatics.

4 Research Approach

The research was conducted as a qualitative case study that investigated the phenomenon in its real-life context – discussion forum of the Church outlined by four months (see Yin, 2003). Qualitative research methods are mostly inductive in nature and are used to collect data from observations, interviews and documents (Kaplan & Maxwell, 2005). Using a case study is reasonable when the goal is to add understanding about a phenomenon that earlier has received little, if any, scientific interest (Gable, 1994). A case study approach can be applied both for a qualitative and a quantitative study, and it allows simple and complicated research settings (Baxter & Jack, 2008). Qualitative data analysis is about understanding and interpreting qualitative research material such as especially text (Lacity & Janson, 1994).

The empirical research material consisted of tweets published over January–April 2017. The research material was analysed with the help of a content analysis, which aims to find conclusion from the data analysed (see Krippendorff, 2013). Content analysis consists of conventional, directive and summative approaches (Hsieh & Shannon, 2005), and the categories formed should be exclusive to ensure that all the content fits into only one category (Krippendorff, 2013).

In this study, the tweets were analysed carefully in seven steps: formulating a concrete research question, linking the research question to theory, deciding the research design, defining the material and the sampling strategy, selecting the data collection and analysis methods, processing the study, presenting the results and discussing the quality of the study (see Mayring, 2014). The concrete research question of 'How does the Church utilise the microblog service Twitter in interactions with its members?' was answered through formulating two sub-questions: What does the Church tweet about? How can its tweets be categorised?

5 Empirical analysis of the Twitter tweets of the Church

The empirical research material consisting of 937 individual tweets from the Twitter account of the Church were downloaded. This amount included also tweets originally created by the Church and re-tweeted by individual parishes and vice versa.

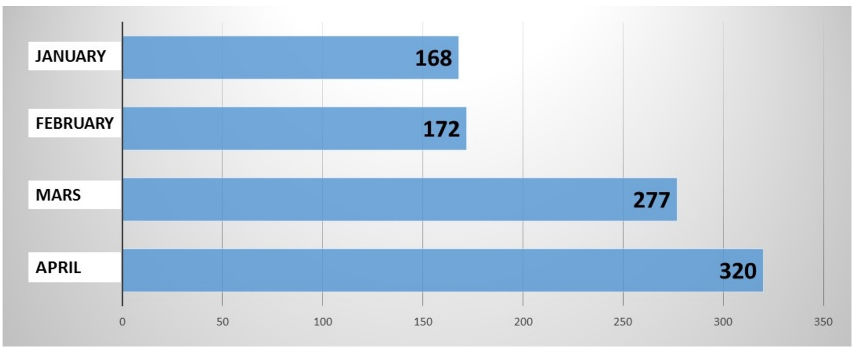

Figure 1: Number of tweets per month.

The study period started on the beginning of the year, not tied with any religious calendar. Figure 1 reveals that during January the number of tweets was the smallest (168), increasing towards the end of the study period.

Preliminary categories were formed based on a review of the tweets, and after thorough familiarisation with the material, they were then refined into eight categories: religious, marketing, declaration, information, answer, aid-and-mission, sharing news and other tweet. Every tweet published during January–April was placed in one category. The religious tweets were separated at the beginning of the analysis, and all tweets that in some way emphasised religion, for example, through Bible verses, prayers and religious-themed pictures were included in that category.

Figure 2: Religious tweet.

Figure 2 gives an example of a tweet classified as 'religious'. The tweet was originally sent by a parish and then re-tweeted by the Church. At the time, ice hockey was a hot topic in the town. The tweet includes a modified quotation ('Thy will be done on ice as it is heaven') of the Lord's Prayer but also references topical issues and displays the Church's humorous style of religious allusions in its tweets. At the time of study, this tweet had been liked by 186 users and re-tweeted 76 times.

'Marketing' category and 'informing' category were separate, although it was challenging to determine to which category some tweets belonged. 'Marketing' category included all the tweets that advertised different events, camps, or radio and television programs of the Church. 'Information' category consisted of tweets that were purely factual or informative in nature. Such tweets included information about negotiation of cooperation procedure in the Church, office premises, and other factual tweets. For example, one tweet pushed for more energy efficiency in the offices, and another tweet informed about the General Synod's discussion on caring for the terminally ill.

As another example of classification, one priest responsible for work with deaf parishioners tweeted to advertise her reception hours on Skype, which was classified as 'marketing'. In several other tweets, she advertised YouTube videos of sermons, psalms and prayers in sign language. Another tweet advertising a mass was sent by a bishop who welcomed a popular band to the city but informed that he cannot attend the rock concert because he was proclaiming *"Christ is risen!"* with the congregation attending the service. His tweet had received 61 likes and was re-tweeted 12 times at the time of the study.

'Declarations' consisted of tweets discussing topical national and global issues, such as asylum seekers, marriage, unemployment and equality. In addition, topics related to euthanasia, human rights, human trafficking, climate change and future bishop elections raised discussion. As well, tweets advertising events where negative decisions for asylum seekers were read aloud were classified as 'declarations'. One tweet announced that Jesus was a refugee in reference to Trump's refugee policy. Despite the mention of Jesus, the tweet was classified as declarative based on its message.

The 'answer' category included all tweets responding to questions posed to the Church. Some questions were provocative, such as *'When will you ask for forgiveness for pressuring the Sami people to change their official nationality from the right stakeholders?'*. The Church answered, *'What do you mean?'*, and the tweeter replied, *'The church forced the Lappish people to change their language from the devil's language to the majority's language. Nobody has apologised for this'*. The conversation on this sensitive, delicate discussion had not been continued in the tweets at the time of the study. However, most questions were related to religious concepts, holy days and the Church's views on issues and events. In general, tweets classified as 'answers' addressed a wide range of topics, such as statistics, parishioners' attendance and taxes paid by the Church. In total, 105 tweets were classified as 'answers' in the study.

The 'aid-and-mission' category consisted of 15 tweets related to relief work performed by the Church nationally and internationally. The 'sharing-news' category had only seven tweets. The 'other' category included 47 tweets that did not belong in any other named category. The largest category was 'religious', with its 238 tweets, accounting for one fourth of the tweets. The second-largest category was 'marketing', with 229 tweets, also nearly a quarter of all.

There were also dialogues that consisted of several tweets. For instance, a tweeter asked if the next version of the Bible would include hashtags. The tweeter received an answer directly quoting the Bible (*'Matthew 23:5: They do all their deeds to be seen by others'*). This dialogue was classified as 'religious' due to the biblical quotation. The discussion in Twitter was active as there were always people at work in the social media team to monitor the tweets.

The analysis also explored what the Church intended to communicate when re-tweeting. The research material included 558 tweets (59.5%) published by the Church, 214 tweets (22.8%) by individual persons and 165 tweets (17.6%) by other organisations. The individual tweeters, particularly their Twitter accounts and the details of their posts, were analysed carefully. The analysis revealed that some non-Church employees tweeted, but many were priests, youth workers and other Church employees. Only one, with four tweets at the time of the study, was identified as a spokesperson. The organisations were classified as religious and non-religious organisations.

Due to the limited number of characters (140), the tweets often included pictures, especially for informational campaigns. For instance, the '101 reasons to belong to the Church' campaign featured 101 pictures. The Church also used tweets to apologise for failed communication efforts. At the time of the study, the Church had run an unsuccessful advertisement related to a nation-level meeting. The advertisement featured a young woman in underwear (Fig. 3) and was widely seen on big billboards along the roads and on the walls of large buildings.

Figure 3: Failed advertisement

The Church tweeted: *'We failed. Choosing that picture was completely unsuccessful. We apologise for that, and we will remove the picture from that advertising campaign'*. The Church thus asked for forgiveness from people in general, not only those who might have been offended. Although the archbishop tried to cool the atmosphere after the communication fault, the discussion on the controversy continued and was also raised in the print media.

The four months studied (January–April) included Easter, the Church's oldest and most important feast, which was evident in the empirical material. Most tweets were published in April (320 tweets), while in January, only 168 tweets were published.

Overall, the analysis of 937 tweets from the Church's Twitter account shows that most tweets (238, 25.4%) were religious in nature. The second-largest category was marketing (229, 24.4%). The tweets classified as declarations (177, 18.9%) addressed topics such as marriage, refugees, human rights and racism. Informing was the fourth-largest category, with 119 (12.7%) tweets. The answers category included 105 (11.2%) tweets, the aid-and-mission category 15 tweets (1.6%), and, finally, the sharing-news category seven (0.75%) tweets.

6 Discussion

The current study analysed how the Church as a public organisation utilises Twitter. The research data was collected from the Twitter account of the Church, and all tweets (937) during January - April in 2017 were included. The tweets were analysed in seven steps and were carefully read one at a time in a chronological order, starting from January 2017.

In general, social media and online tools are valued and discussed in several countries, and among private and public organisations. Twitter is an open forum where members can easily comment and share opinions. As a cross-platform application, Twitter enables marketing, promotion, discussion and other types of communication. Twitter offers a new way to communicate, and at the same time it enables and supports parties to build relationships, to be present together, discussion, reporting news, information sharing and coordinating projects (Lux Wigand, 2010). The research material revealed that communication, discussion and social presence were visible in the tweets. The Church participated in several discussions with its followers, and occasionally the discussions seemed sensitive and personal. The Church's followers adopted this new tool to communicate with it, and the Church could communicate in real time as it continuously monitored its account and swiftly posted responses.

The Church had deployed an innovative tactic by utilising Twitter and engaging interactively with followers (see Culnan et al., 2010). The analysis revealed that having a person monitoring the Church's tweets added interaction between the Church and its members. For the Church, active communication with its followers was valuable. The numbers of 'likes' in the tweets revealed that the Church had succeeded with many of its tweets (see Fig. 2).

Management commitment is important when adopting social media (Mergel, 2013). The leading persons such as bishops and other higher officers had active roles in tweeting. The person (usually a priest) in charge of monitoring the tweets answered questions, described and explained terms and concepts related to the Church's calendar, and re-tweeted posts and statements written by other people.

The Church had three goals: to promote openness, participation and collaboration. Similarly, the challenges of Serrat (2017) were realised in the topics of emerging global issues and rising citizen expectations. The tweets were open in nature, and discussion was going on about sensitive and challenging topics such as refugees, immigration, racism and unique marriage law. The tweets encouraged discussion and interaction and included declarations made without additional passion or antagonism. Politics were raised, particularly in relation to topical subjects such as bishop elections and subjects in the General Synod. The Church encouraged discussions by tweeting thoughts and offering new topics for tweets. Participation was promoted, for instance, through tweets inviting people to attend events and vote in elections.

The analysis of the research material lead to identify eight categories of tweets: religious, marketing, declaration, information, answer, aid-and-mission, sharing news and other. The categories were defined paying attention to their exclusive nature (see Krippendorff, 2013), and no changes were made during the analysis.

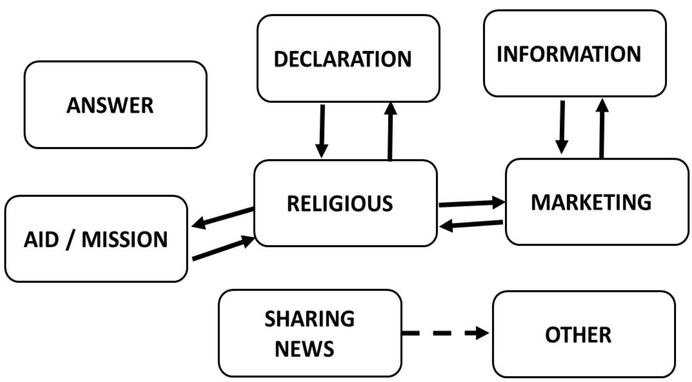

Figure 4: Proposed categories and their relations

Figure 4 illustrates the relationships among the categories. The arrows depict the challenges to decide which category a tweet was to be classified in. Some tweets required more analysis and consideration than others. The 'religious' category appeared to be a category that was a near category to more than the others. As seen in Figure 4, the 'answer' category was not related to any other as its tweets were identified explicitly as answers. Another observation was related to the 'sharing news' and 'other' categories, which were related only to each other. However, 'sharing news' had a low number of tweets (seven), and it could be included in the 'other' category.

Overall, one can assume that religious topics form the core of communication in the Church. This could be seen in the research material as well, as most of the tweets were classified as 'religious'. The second-largest category, 'marketing', included mostly advertising messages about events and happenings in the Church. Besides pure religious topics, also other topics were widely seen in the tweets, as immigration and human rights were visible in the research material as well. The Church, therefore, appeared to be an active part of the society and wants to participate in contemporary discussions.

7 Conclusion

This study focused on e the topics the Church tweeted about and the ways in which it utilised Twitter. The subject was fresh and topical as, at the time of the study, there was little no prior knowledge about the use of Twitter. A qualitative study (Kaplan & Maxwell, 2005) was an appropriate choice in this case. This study did not open the strategy related to utilising social media, and it would be interesting to know how the strategy was formed and whether it was planned or ad hoc. More knowledge about the role of social media in communication by large organisations such as churches and cities is needed.

Of the Church's 937 tweets over January–April 2017, most were 'religious' in nature, accounting for 25.4% (238) of the sample of tweets. The next-largest category of 'marketing' had almost as many tweets (229, 24.4%). The third-largest category of 'declarations' had 177 tweets, while the 'informing' category had 119 tweets. In addition, 105 tweets were classified as 'answers', 15 as 'aid-and-mission', and seven as 'sharing news'.

The study was first of its kind about utilising Twitter in the Church in Finland. The literature review did not find much relevant knowledge from scientific studies on Twitter use in other countries with similar environments. This scant knowledge suggests that the findings presented in the paper will also have interest for international audiences. The current study was limited to tweets from the Church's account, and future studies will be extended to include other public agencies. Moreover, extending the study to churches in other countries could add new knowledge about new ways to use Twitter, particularly at the hands of religious organisations.

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Real-time Prediction of the Risk of Hospital Readmissions

NILMINI WICKRAMASINGHE, DAY MANUET DELGANO & STEVEN MCCONCHIE

Abstract This study aims to identify predictors for patients likely to be readmitted to a hospital within 28 days of discharge and to develop and validate a prediction model for identifying patients at a high risk of readmission. Numerous attempts have been made to build similar predictive models. However, the majority of existing models suffer from at least one of the following shortcomings: the model is not based on Australian Health Data; the model uses insurance claim data, which would not be available in a real-time clinical setting; the model does not consider socio-demographic determinants of health, which have been demonstrated to be predictive of readmission risk; or the model is limited to a particular medical condition and is thus limited in scope. To address these shortcomings, we built several models to predict all-cause 28-day readmission risk and included Socio-economic Indexes for Areas (SEIFA) data as proxies for socio-demographic determinants of health. Additionally, instead of using insurance claims data, which could require several weeks to process, we built our models using data that is readily available during the inpatient stay or at the time of discharge. The set of default prediction models that were examined include logistic regression, elastic net, random forest and adaptive boosting (Ada Boost). This study examined A not for profit tertiary healthcare organisation from fiscal year 2012-2013 through fiscal year 2017-2018. The out-of-sample results show that all of the models performed similarly and adequately to predict readmission risk.

Keywords: • Risk prediction • Machine learning • Hospital readmission, • length of stay • Real-time prediction •

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1 Introduction

Like all OECD countries, Australia is also facing cost pressure regarding delivering high quality care. In the private healthcare sector in Australia unplanned readmissions are 3.1 typically requires the joint analysis of multiple sources of data [2]. However, this can be challenging as data is often incomplete, fragmented and/or consists of misaligned information [3]. This limitation in data quality in turn has hindered epidemiologists to extrapolate demographic information to within plausible limits [4]. Additionally, fragmented data spread across multiple sources makes it difficult for policymakers to compare the relative cost-effectiveness of different interventions [5]. Thus, measuring, gauging and creating benchmarks for unplanned readmission is difficult and yet trying to solve this problem, as is the goal of this research, will have many far reaching consequences.

2 Literature Review and Background

Recent developments in the fields of data warehousing and data science have enabled researchers to contribute to a growing body of knowledge in predictive analytics [3]. In particular, the building, training and application of predictive models to stratify patients into various risk groups based on information from administrative, insurance,
clinical, and government registry sources is becoming a key focus [5]. Such studies are aimed at first aligning complex and sensitive information across multiple sources [6]. This information is then used to identify patients in need of additional healthcare resources by means of various intervention methods [6].

The preponderance of research on predicting unplanned readmissions applies logistic regression models using dichotomous dependent variables [5,8,9,10,11,12,13,14] and occasionally linear regressions [14,11]. Although the variable to be explained is dichotomous, logistic regression can additionally determine the probability of belonging to a certain group, for example, whether a patient is cost intensive (i.e. a likely unplanned readmission or high risk patient) or not (a relatively healthy patient unlikely to have complications) [15]. Compared to logistic regression, the scale level of the dependent variable in linear regression is metric [15]. On the one hand, the use a dichotomous dependent variable with a well-defined threshold allows for a better comparability. However, the dichotomous dependent variable has the disadvantage that potential cost savings can not directly be assigned [9]. In addition to regression models, classification models such as Support Vector Machine (SVM) and Decision Tree (DT) methods can be applied [16,17,18]. Classification is the assignment of data objects to a suitable class, whereby, for example, the minimization of the classification error or the maximization of the degree of affiliation are used as performance evaluation criteria [19]. In SVMs, data objects are represented as vectors in a ddimensional data space. An SVM looks for a boundary where the objects with different class affiliation are separated as distinctively as possible. This limit is represented by so-called support vectors. In case of more than two attributes, the separating boundary corresponds to a hyperplane [19]. Drosou and Koukouvinos [16] use SVM to find an optimal hyperplane that separates cost-intensive from "regular" patients. However, comparing different classification and predictive models, Moturu, Johnson, and Liu [17] show that SVM have the lowest performance. In their study, Bertsimas et al. [18] utilize DT to classify high-cost patients. The advantage of decision trees lies in the ability to be easily interpreted, where the importance of an attribute is reflected by its proximity to the root node. However, especially for data sets with many attributes, the danger of overfitting occurs [19]. In this case, very large decision trees are created. Although a large decision tree leads to a high classification accuracy on the training data, it does not necessarily lead to a high classification accuracy on the test data [19]. Since the mentioned classification models have not shown a sufficient performance in literature and logistic regression has the advantage of generating probabilities as well, this method is chosen for the predictive analysis. In order to evaluate whether overfitting occurs when learning a classifier, cross-validation of the models is applied.

There are a variety of different influencing factors in literature that increase the likelihood of becoming a costintensive patient. Especially demographic variables are often used as the first factor in predictive analysis, where aspects such as age and gender are known to be reliable predictors [17, 3]. Bertakis and Azari [14] intensively examine the influence of gender in their study and confirm that women are associated with higher costs. Chechulin et al. [3] further verify that good estimates of future costs can be made based on a person's age. Although pure predictive demographic models perform worse in terms of prognosis quality compared to models with clinical variables, they provide meaningful predictions for the small amount of information available. This allows for categorization at a time when no other information is given [17]. Other important indicators are clinical variables based on the ICD9 and ICD-10 diagnostic codes [3]. Cucciare and O'Donohue [20] further suggest that predictions that include diagnoses show very accurate results. Here, certain chronic diseases, such as diabetes, chronic heart failure (CHF) and chronic obstructive pulmonary disease (COPD), should be studied separately, as these have a major impact on the resulting costs [3]. Hartmann et al. [9] identify accordingly that the metabolic system, especially diabetes, is a trigger for a high number of other diseases and may have long-term effects. Snider et al. [13] support this finding by identifying obesity as an important indicator in their study. This is also related to the body mass index (BMI), sociodemographic variables and other comorbidities. Additionally, people who suffer from a CHF tend to become cost-intensive because they tend to use more healthcare resources of all kinds [21]. Lee et al. [13], define different levels of care, showing that patients with regular care needs are characterized, among other things, by COPD and asthma. In general, diseases can also be summarized in co-morbidity indices and incorporated into the modeling as a predictor [23]. An example is the Charlson Comorbidity Index, which includes diagnoses based on ICD-10 codes [12, 25]. Other relevant predictors include the self-assessment of one's own health status [12, 23], previous healthcare costs [27, 26], resource demands such as number of hospitalizations and number of visits [3, 25], and medication [24, 23]. In the current study we built several models to predict allcause 28-day readmission risk and included Socio-economic Indexes for Areas (SEIFA) data as proxies for sociodemographic determinants of health. Additionally, instead of using insurance claims data, which could require several weeks to process, we focussed on building our own models using data that is readily available during the inpatient stay or at the time of discharge, as the following presents.

3 Methodology

One of the primary objectives of this study is to accurately predict, (ultimately) in real time, the risk of hospital readmission within 28 days of discharge. The following sections describe the underlying data constructions and assumptions that were built into our models.

3.1 Data Preparation

Before developing prediction models, the data set has to be cleaned and prepared. First, variables that have more than 90% missing values or have a constant value over all cases are excluded. Due to input errors in the data set, cases showing inconsistencies across multiple attributes are removed.

3.2 Dataset

The developed models of readmission risk utilised hospital activity, patient characteristics and clinical data, which were derived from six years of admitted patient episode care data, from fiscal year 2012-2013 through fiscal year 2017-2018. These datasets contained episode level information regarding hospital activity, patient characteristics, procedures performed and diagnoses. A separate dataset containing information regarding the specialist, including specialist identification, name and age, was also utilised to develop the model. Eight different SEIFA 2016 scores at a postal code level were incorporated as proxies for socio-demographic determinants of health. This initial dataset contained 202 variables across 926,778 episodes.

4 Outcome Variable

A not for profit tertiary healthcare organisation counts readmissions at the episode level. For the purposes of this study, readmissions were considered for any patient that was readmitted under the following conditions:

- Readmission occurred within 1 to 28 whole days following discharge; and
- readmission occurred for a unique episode; and

- The readmission sequence was discarded.
- Episodes were excluded from the outcome variable for the following reasons:
- Patients were readmitted at a rehabilitation facility; or
- Patients were readmitted at cancelled or hold wards; or
- Patients were readmitted with dialysis or oncology codes; or
- Patients were readmitted with same day mental health treatment; or
- Patients were readmitted with electroconvulsive therapy (ECT) treatment.

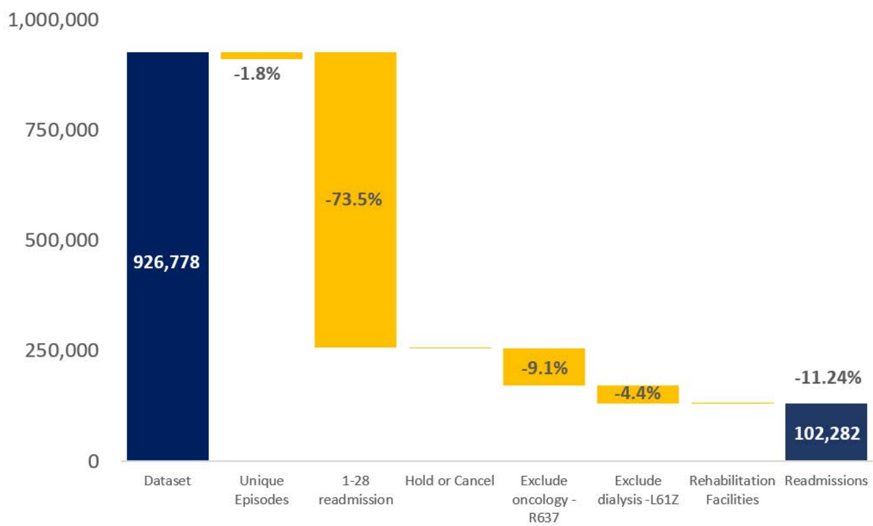

Figure 1. Readmission building block

Of the 926,778 episodes in the initial dataset, 102,282 are identified as readmissions, which represents a readmission rate of 11.24%.

It is important to note that the readmission rate is not included in our model as the dependent (outcome) variable, as a readmission is the final consequence. Because our goal is to predict the risk of readmissions prior to the discharge on the first instance, we instead used the readmission index. The readmission index considers the admission immediately preceding the readmission episode, as quantifying the risks of readmissions prior to discharge from the initial episode can allow clinicians to identify patients who might benefit from more intensive pre-discharge care.

The readmission variable was calculated according to the formula described in section IV.1.2. Then the index readmission was derived and validated to predict the risk of readmissions within 28 days after discharge from this not for profit tertiary healthcare organisation.

Figure 2. Index – Readmission Concept

4.1 Data Cleaning

To further refine the variables used in the model, we excluded or transformed factors based on the following reasons:

4.2 Unrelated Variables

An extensive consultation process was undertaken with the Clinical Outcomes and Analytics team, the Chair of Health Information Management for a not for profit tertiary healthcare organisation, and external consultants to determine the potential risk factors for readmissions. Empirical evidence suggested that the following variables do not have significant impacts on the risk that a particular patient will be readmitted to the hospital within 28 days of discharge: the division type, the care type, the number of noncertified days of stay, the number of private bed days, the conversion from outpatient to inpatient stays, the conversion from inpatient stays to outpatient stays, the rehabilitation episode type, death after discharge, fund diagnosis related group (DRG) version, hospital DRG version, principal Commonwealth Medicare Benefits Schedule (CMBS) date and principal CMBS banding.

4.3 Missing feature values

An important number of variables did not include complete records. Careful consideration of methods for dealing with missing data was performed, as failure to appropriately consider missing data can lead to biased results. Variables were generally treated with one of the following methods:

4.4 Elimination

When the missing data represented more than 10% of the total records, the variable was excluded from the modelling dataset. Eliminated variables included the following: unplanned admissions to the ICU, referred by doctor, referred by specialty doctor, referred by doctor at a clinical institute, referred to doctor, referred to specialty doctor, principal shared care doctor clinical institute, miscellaneous code 1, miscellaneous code 2, miscellaneous code 3, miscellaneous code 4, miscellaneous code 5, miscellaneous code 6, miscellaneous code 7, miscellaneous code 8, miscellaneous code 9, miscellaneous code 10, the Australian national subacute and non-acute patient (An-Snap) classification, Snap version, assessment only indicator, date of discharge plan, usual accommodation prior to admission, living arrangement prior to admission, employment status, existing comorbidity, emergency department treating doc 2, emergency department treating doc 3, emergency department treating doc 4, emergency department waiting, emergency department time, triage category, emergency department provisional dx code, emergency department provisional dx, discharge to usual accommodation, policy type and admission patient classification.

4.5 Mean substitution

For continuous variables that contained a low percentage of missing variables, such as the age of the practitioner, the mean value was computed from available cases and was used to replace the missing data values for the remaining cases.

Method of treating missing feature values as special values.

For categorical variables that contained a low percentage of missing variables, such as the insurer group model and SEIFA 2016 factors, the missing variables were treated as new values.

4.6 Inaccuracies

After careful quality inspection of the data, we eliminated the values of discharge age, readmission within 28 days, readmission days, readmission option, height and weight, as these variables were identified as having formulation problems, making their calculations inaccurate.

4.7 Descriptive data

While descriptive data is important for the team to understand the data, these variables were not important for modelling purposes and were therefore excluded: fund DRG description, CMBS description 1, CMBS description 2, CMBS description 3, CMBS description 4, CMBS description 5, CMBS description 6, CMBS description 7, CMBS description 8, CMBS description 9, CMBS description 10, principal diagnosis description, principal coding onset code description, diagnosis coding onset code description 2, diagnosis coding onset code description 3, diagnosis coding onset code description 4, diagnosis coding onset code description 5, diagnosis coding onset code description 6, diagnosis coding onset code description 7, diagnosis coding onset code description 8, diagnosis coding onset code description 9, diagnosis coding onset code description 10, and principal procedure description.

4.8 Insurance claim data

Our primary objective is to develop a model that can be employed in hospital settings to support data-driven discharge interventions to mitigate the risks of hospital readmissions. Thus, we excluded insurance claims data, which could take several weeks to process, as our models requires data that is available during the inpatient stay or at the time of discharge. The variables that fall into this category are the following: fund DRG code, principal diagnosis code, diagnosis code 2, diagnosis code 3, diagnosis code 4, diagnosis code 5, diagnosis code 6, diagnosis code 7, diagnosis code 8, diagnosis code 9, diagnosis code 10, principal procedure code, procedure code 2, procedure code 3, procedure code 4, procedure code 5, procedure code 6, procedure code 7, procedure code 8, procedure code 9, and procedure code 10.

4.9 Redundant data

The following variables overlap with other relevant factors and were therefore excluded: discharge destination, Local Government Areas (LGA) code, discharge patient classification, ICU hours, discharge doctor clinical institute, reference to doctor clinical institute, principal procedural doctor clinical institute, CMBS code 2, CMBS code 3, CMBS code 4, CMBS code 5, CMBS code 6, CMBS code 7, CMBS code 8, CMBS code 9, and CMBS code 10.

4.10 Feature construction/Transformation

Based on our previous experience, the discovery of meaningful features contributes to a better understanding of the underlying causes of readmissions. Thus, after another extensive consultation process with the Clinical Outcomes and Analytics team, the Chair of Health Information Management for a not for profit tertiary healthcare organisation and external consultants, the following features were derived and/or transformed: admission patient, insurer identifier grouping, marital status, language, age of admitting doctor, age of discharge doctor, age of procedural doctor, age of anaesthetic doctor, indicator of emergency admission, number of emergency procedures, number of procedure codes used, admission month, admission year, discharge year, discharge month, patient age at discharge, number of previous admissions, and number of previous readmissions within 180 days.

4.11 Normalization

As part of our normalization process, we performed discretization on some continuous variables, such as previous readmissions within 180 days. We also attempted to normalize the remaining continuous variables; however, this approach did not improve modelling performance. Therefore, we did not normalize continuous variables in the final dataset.

4.12 De-identification

A crypto-graphical hash function was applied to the following sensitive variables: patient identification, episode identification, insurer group, doctor identification, and patient date of birth. The variables were internally serialized, and we implemented a cyclic redundancy check (CRC) hash function algorithm to compute a compact digest of the serialized object.

5 Patients

To develop a robust risk prediction model, a number of records were removed based on characteristics related to the episode of care. These records were removed to ensure that their inclusion in the modelling dataset did not reduce the robustness of the risk prediction model. These trimmed records generally fell into one of three categories.

The first category included episodes that were considered to be outliers, as their inclusion would disproportionately skew the risk prediction model. These episodes included the following:

- The number of wards for patients that had visited more than four wards;
- The number of anaesthetic doctors for patients with more than three anaesthetic doctors;
- Patients with negative lengths of stay or lengths of stay greater than 41 days for a single episode;
- Patients that spent more than 300 minutes in the operating theatre;
- Patients that visited more than 7 operating theatres for a single episode;
- Patients over 100 years old; and

- Patients that have visited A not for profit tertiary healthcare organisation more than 95 times.

The total number of episodes considered to be outliers represented 5% of the dataset.

The second category included episodes that were removed on the advice of the Clinical Outcomes and Analytics team, as having admission characteristics could not lead to readmission or being generally unrepresentative for the purposes of determining the probability of readmission. This category included the following:

- Episodes related to rehabilitation health admissions in Brighton, Richmond and the Transitional Living Centre.

The final category was related to decisions regarding which episodes were considered out-of-scope or not representative of the patient population. These episodes were trimmed if they included the following characteristics:

- Duplicate episodes; and
- Intersex or indeterminate patients (2 patients in the whole dataset).

6 Modelling

6.1 Feature selection

Feature subset selection is the process of identifying and removing variables that do not have significant impacts on the risk of a particular patient being readmitted to the hospital within 28 days of discharge. We conducted a univariate logistic regression to identify relevant variables.

6.2 Univariate variable selection

This step identified the top-ranked attributes. For categorical variables, the significance of the correlation between each variable and the index readmission was determined using the likelihood ratio test (LRT), using the p values of the fitted logistic regression. In addition, the prevalence, the chi-squared test and the odds ratio were also considered. For continuous variables, the significants of the correlation between each variable and the readmission outcome index was determined using the LRT, using the p values of the fitted logistic regression. In addition, the odds ratio was considered. For all variables, the response factor was the index readmission, and the explanatory factor was the tested variable. Attributes with significance levels of $p<0.01$ in the univariate analyses were retained for further analyses. In addition, all factors and conditions with prevalence values of less than 1% within the population of patients were excluded from further analyses. The following features were excluded at this stage: ICU days, language v1, language v2, discharge method, admission shift, urgency of admission, discharge month, admission month, discharge day, unplanned theatre visit during episode, admission day, robot use and same-day or overnight stay indicator.

At this stage, the socioeconomic attribute (Decile Index of Relative Socio-economic Advantage and Disadvantage (IRSAD) that most correlated with the index readmission outcome was selected among the following eight variables: Rank IRSAD, Rank Index of Education and Occupation (IEO), Rank Index of Relative Socio-economic Disadvantage (IRSD), Rank Index of Economic Resources (IER), Decile IRSAD, Decile IEO, Decile IRSD and Decile IER, based on the lowest univariate AIC value.

6.3 Correlated variables

Correlation coefficients were obtained among all of the continuous variables A consultation process with the Clinical Outcomes and Analytics team was undertaken to select the most representative variables among heavily correlated variables (<0.30).

- The total number of beds and the total number of wards exhibited a correlation of 0.83. The total number of wards was selected.
- The total number of anaesthetic doctors and the total number of procedure doctors exhibited a correlation of 0.38. The total number of anaesthetic doctors was selected.

- The length of stay and the total number of procedure doctors exhibited a correlation of 0.31. The length of stay was selected.
- The total number of procedures codes and the total number of procedure doctors exhibited a correlation of 0.78. The total number of procedures codes was selected.
- The length of stay and the total number of beds exhibit a correlation of 0.30. The length of stay was selected.
- The admitting doctor age and the discharge doctor age exhibit a correlation of 0.99. The discharge doctor age was selected.

Variables related to the admitting doctor and the discharge doctor were heavily correlated; thus, it was decided that variables related to the discharge doctor should be retained for further analyses.

6.4 Training, testing and validation datasets

A training dataset composed of 80% of the total sample was used to train the models. A validation dataset composed of 20% of the total sample data was used for the unbiased evaluation of suitable models. A testing dataset composed of 10% of the total sample data was used to provide an unbiased evaluation of a final model fit to ensure that the model did not overfit the data.

We ensured that the three datasets followed the same probability distributions among key variables, such as the index readmission.

6.5 Unbalance Dataset

For machine learning problems, differences in prior class probabilities and class imbalances have been reported to hinder the performance of classification algorithms. To account for these potential issues, we tested several resampling techniques, such as under-sampling the majority (normal) class, over-sampling the minority (abnormal) class, random over-sampling examples (ROSE), and synthetic minority oversampling (SMOTE), which have previously been proposed to address class imbalance problems, and compared their effectiveness. The performance of these techniques was measure by the receiver operating characteristic curve (ROC) method. In previous studies, the results obtained by using similar methods on artificial domains have been linked to the results obtained in real-world domains.

6.6 Classification algorithms

Initially, we experimented with several classic and modern classifiers, including logistic regression, elastic net and random forests. In each case, a 5-fold cross validation was performed.

7 Discussion and Conclusions

This exploratory study served to identify key steps when analysing large healthcare data sets including: defining the index, managing imbalanced data using various techniques and yet achieving a reasonable ROC and assessing various classification algorithms. Crucial insights include the need to focus on index so as to assess ahead of time likelihood of readmission, gender did not play a key role but being alone at home did appear to have an impact.

There were also aspects that might be addressed due to more focussed patient education in some procedures so that bleeding/pain does not automatically mean the need to return to hospital or the emergency department.

While it is exploratory in nature, this study has several contributions to both theory and practice. As noted above we have been able to provide insights into strategies to adopt in order to develop reasonably reliable predictive models using unbalanced data as well as assess the merits of different classification algorithms in the context of data analytics in healthcare. From the perspective of practice, given that today private healthcare organisations in Australia are facing increasing pressures around reducing unplanned readmissions, a necessary first step is to be able to develop robust strategies to best predict likely readmissions at the time of the initial admission and then implement appropriate risk mitigation strategies to avoid the likely unplanned readmissions. Our results have enabled us to progress with this approach for the specific healthcare organisations data and patient population; however, we believe are findings have wider implications and benefits given the move to value-based care in many healthcare systems globally and thereby the need to manage problematic unplanned readmissions in a systematic and critical fashion. To date, while the need for data analysis, machine learning and deep leaning in the context of healthcare is recognised as important, key findings, algorithms, models and solutions are still not well developed. This study has served to try to assist in this regard. The developed models will now be tested in a large not for profit tertiary healthcare organisation to assess their predictive powers.

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Stakeholder Relationships within Educational Ecosystems – a Literature Review

MARIA KARALASH & ULRIKE BAUMÖL

Abstract The ongoing societal and technological changes make it necessary for universities to modify their teaching and learning programs. Regarding the cooperation with stakeholders that have influence on how it could be designed can serve as a basis. With this article we examine the recent contributions in the field of cooperation of higher education (HE) institutions by conducting a structured literature review. A close regard in particular are the interdependences between stakeholders in order to build a basis for future curricula developments. For our conceptualization, we use the quadruple helix model to analyse the educational ecosystems. Therefore in particular the term "educational ecosystem" is taken into account. The results show that evenso that the term is used there is a lack of suitable definitions in this context. So based on the analysis of the recent literature, a definition of educational ecosystem was introduced and the quintuple helix model, which was constructed for the conceptualization of the topic, was extended by further important aspects – knowledge transfer and adaptivity.

Keywords: • Educational ecosystem • E-learning • Quadruple helix • Third mission Bled • eConference • Knowledge transfer • Adaptivity •

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1 Introduction

The digital society is driven by Information Technology (IT) based transformations in social organization and structure. This shift can be illustrated e.g. by the steadily increasing access to the internet for an ever-increasing number of people as well as by the ongoing implementation of web-based technologies into our lives. In 2018, about 55% of the current world population had access to the World Wide Web (Statista, 2018). In the workplace the use of digital technologies is also increasing, at the same time the employers expect the employees to have several skills, among them digital skills and competencies. As a result, these ongoing technological and social changes force universities to respond to new accrued challenges by introducing new study programs, realizing content modifications as well as incorporating new research focus into their portfolio. Nevertheless, according to the official data of European Commission, almost 50% of the human population have insufficient digital competencies (European Commission, 2014). Therefore, not only the industry sector but also the students have advanced requirements on the curriculum content and design. These challenges inevitable require modifications with regard to the educational structure, the learning environment and the whole business models which universities constitute in general.

The higher education (HE) paradigm shift driven by political and social requirements leads to the emergence of reconceptualization of the teaching and research process. In this regard, higher education institutions (HEIs) are faced with requirements of several stakeholders like government, industry and students. The Bologna-Process, for instance, intends the establishment of homogeneous European HE standards (BMBF, 2018). Furthermore, students have expectations of the curriculum to be as individual as possible and to be flexible concerning time and location. The industry sector expects future employees to have certain competencies, which should have been taught by the university previously. Finally, HEIs also have standards they want to keep, so compromises need to be made. To understand how such compromises can look like and how future curriculum and learning environment can be designed a foundation should be created. As a first step, we suggest looking at the interrelationships between the stakeholders by using the ecosystem approach, as it examines the different components of an interacting system separately as well as the dynamic interactions between them. Because an ecosystem is an open boundary system, it allows adding further components or processes and therefore is well suited to represent the relations in the educational context.

The objective of the article is to provide an overview of the interrelationships of the stakeholder within the ecosystem and to develop a definition of the term "educational ecosystem", which contains all involved parties and necessary aspects. Therefore, the following research questions were developed: Which relationships exist between the stakeholders within the educational ecosystem? Is there a common understanding of the term "ecosystem" in the educational context?

This article is structured as follows: first, we specify the methodology by defining the review scope, which is based on the taxonomy of Cooper (1988). Subsequently, we layout the concept of a quadruple helix model in conformity with the ecosystem approach. We complete the chapter with a detailed documentation of the literature review. Further, we present and discuss the analysis and synthesis of the regarded literature. We finally finish the article with a conclusion and suggestions for further research.

2 Methodology

In this section the review scope of the literature review is defined and the conceptualization of the article is constructed followed by a detailed description of the literature search process.

2.1 Review Scope

In order to explore the recent research field on the term of educational ecosystems, a structured literature review was conducted. To achieve maximum transparency, the review was related to the guideline for literature reviews by vom Brocke et al. (2009). The individual steps lead to a systematically procedure, which is presented in the following.

The taxonomy of Cooper was applied to define the scope of a literature review (Cooper, 1988). As shown in the taxonomy (Figure 1), the study´s review scope focuses on the research outcomes, as the recent contributions according to the research focus will be considered and analysed to serve as a basis for an own definition of educational ecosystem. The goals are firstly to synthesize past literature, which is related to common issues, and secondly to identify central issues to the field of educational ecosystem. The neutral perspective shall enable a representative coverage focused on peer reviewed journals and selected conferences, which are important in the subject of information systems (IS) research. The present literature results are organized in a conceptual way. The audience addressed by the review consists of general scholars as well as practitioners.

Characteristic	Categories			
focus	research outcomes	research methods	theories	practices or applications
goal	integration	criticism	identification of central issues	
perspective	neutral representation		espousal of position	
coverage	exhaustive	exhaustive with selective citation	representative	central or pivotal
organization	historical	conceptual	methodological	
Audience	Specialized scholars	General scholars	Practitioners or policy makers	General public

Figure 1: Taxonomy of the recent article (Cooper, 1988)

2.2 Conceptualization

The classic role of the university was extended to the third mission, which is about breaking boundaries of internal organizational actions. The third mission approach describes all societal interactions with the environment (Würmseer, 2016) consisting of all the external influences. In this regard, external influences can be other stakeholders, e.g. politicians, companies and individuals, as they also affect the teaching design and learning content. To understand and to map the relationships and interdependences between the stakeholders, we suggest the ecosystem approach, as it examines the different components of an interacting system separately as well as the dynamic interactions between them. Because an ecosystem is an open boundary system, it allows adding further components or processes and therefore has an appropriate design for the educational treatment. To make sure that an ecosystem can represent the required aspects, we want to look at existing definitions of an ecosystem first.

The term ecosystem originally refers to the ecological research field. The traditional term and concept were originally proposed by the English botanist Arthur Tansley, who describes it as *"a particular category among the physical systems that make up the universe. In an ecosystem the organisms and the inorganic factors alike are components which are in relatively stable dynamic equilibrium" (Tansley, 1935). Whereas Adner defines an ecosystem as the "the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize" (Adner, 2017).*

Pearce and McCoy describe the term "educational ecosystem" as the intersection of the domains education/learning, research/discovery and outreach/engagement, "where assets and interests of all stakeholders (faculty, students, industry, community) combine to achieve synergistic results that benefit all" (Pearce & McCoy, 2007). Chen et al. focus on an education ecosystem in the context of big data, which "can be represented as educational conformity of resources, user precise localization, educational flexible cooperation, novel service mode, data value excavation and complicated educational environment" (Chen, Zhang, Huang, & Chen, 2016). As the definitions differ in their content, we develop a more general definition based on the findings of this literature review.

Based on the previous findings we suggest the following definition: *"educational ecosystem is an interactional system of an educational community, its environment and stakeholders (university, government, industry and students) as well as the interdependency and mutual requirements of the stakeholders."*

According to previous explanations regarding the ecosystem concept, the conceptualization of the article leans on a model, which represents the stakeholders and their relationships in the educational context. The concept of the triple helix was initiated by Etzkowitz and Levdesdorff and concentrates on the relationships between university, industry and government (1998). Caraynnis and Campbell suggest a quadruple Helix model by developing the forth helix identified as the media- and culture-based public (2009). Following the recent knowledge of Carayannis et al. (2018) the conceptualization is constructed twofold, it combines the ecosystem approach and the quadruple/quintuple Helix approach. The fourth helix has been modified into the term "students" as shown in figure 2 in order to serve as a suitable basis for the structure, as in the educational context we solely regard the education consumer. We added the learning environment in the middle of the helixes because of the interaction of the stakeholders, as it is of great importance to get an insight view of possible future curricula design.

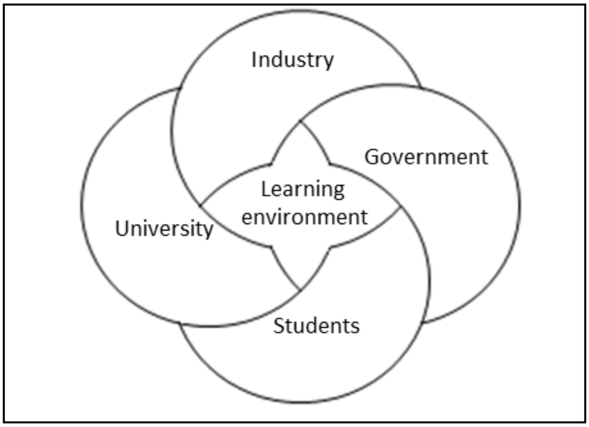

Figure 2: Conceptualization as a quintuple helix model in an ecosystem context

The configuration is alluded on the "balanced" configuration presented by Etzkowitz and Ranga (2013). In accordance to the authors, this configuration allows the most important insights for innovation as all stakeholders act in partnership and create favourable environment for innovation, which here represents the novel education program. Each helix implies requirements of the respective part, whereas the overlapping part in the middle represents the learning environment, where all parts exert influence regarding content and the environment. The single components are characterized as follows:

1. The government implies guidelines and policies, like e.g. legal conditions, university law, and data protection law. The helix also includes requirements regarding the innovation, such internalization, HE reforms, e.g. Bologna-Reform, and research and knowledge transfer.
2. The industry sector implies requirements of the employers on future employees with respect to expected qualifications and competencies, which are changing over time.
3. The students sector represents the requirements of education consumer.

4. The university is the place, where all the requirements come together and must be transformed into curriculum, simultaneously trying to satisfy the needs of every part.
5. The overlapping part in the middle of the four helixes represents the learning environment, where all parts exert influence regarding content and the environment.

2.3 Literature search process

According to the conceptualization above, the keywords were defined and combined to a full search term: ((“higher education” OR “third mission” OR “e-learning”) AND ecosystem) OR (“education* ecosystem”)).

The combination of the terms “higher education” and “ecosystem”, as well as “educational ecosystem” are the main search phrases. Third mission implicates activities of HEIs, which exceed the traditional areas of responsibility research and teaching (Henke & Schmid, 2017). and is about augmenting the knowledge with societal practice knowledge, creating transdisciplinary research fields (Schneidewind, 2016). The term “e-learning” is taken into consideration in order to find out, whether the cooperation of the different stakeholders within the learning field represents a research focus or not and to examine how the future learning environment is influenced by the different parties.

In order to cover all relevant sources in the field of IS different databases are taken into account. Following search fields were limited in Ebscohost database: Applied Science & Technology Source, Business Source Ultimate, EconLit with Full Text, Library, and Information Science & Technology Abstracts. Further quality assurance was made by only considering peer-reviewed literature in the period from 01.01.2015 to 31.12.2018. The Association for Computing Machinery (ACM) Digital Library also refers to the field of computing and information technology and was searched under the same restrictions.

Conferences play an important role in the IS field, according to this the Institute of Electrical and IEEE Xplore Digital Library and Association for IS (AIS) Digital Library were explored. As Hawaii International Conference on System Sciences (HICCS) articles are not listed in the described databases after 2017, the proceedings on the website were separately taken into account. As the search options do not allow simultaneously searching of all terms, they were searched individually and the results were proofed for redundancy. Table 1 below shows the results of considered databases.

Table 1: Results of the literature search

Database	Result all fields	Results title	Results abstract	Results full text
Ebscohost	105	17	10	7
AISeLibrary	57	15	2	0
ACM Digital Library	103	15	10	6
IEEE Digital Library	55	21	13	7
HICSS	14	6	3	2
Wirtschaftsinformatik(WI) conference	3	1	1	0
Total	337	75	39	22

The column "result all fields" shows the number of results in total after making search limitations. In the next step, all titles were regarded and articles sorted out due to topic relevance. Subsequently the abstracts of the remaining articles were perused. Finally, 22 articles were read. Worth mentioning is the fact, that many articles were sorted out, as the term "ecosystem" was only represented in the abstract. In the next chapter, the found articles are structured according the previous determined conceptualization.

3 Analysis and Discussion

This section presents the findings of the previous literature search, which are categorized as shown in table 2: first the single relationships (university-industry, university-government, university-students) are taken into account followed by insights concerning learning environment. The second part deals with triple and quadruple helix relationships.

Table 2: Concept matrix

<table>
<tr><th></th><th>HEI</th><th>Government</th><th>Industry</th><th>Society/user</th><th>Learning environment</th></tr>
<tr><td></td><td colspan="3">Triple helix 9</td><td></td><td></td></tr>
<tr><td></td><td colspan="4">Quadruple helix 10</td><td></td></tr>
<tr><td>(Barokas and Barth 2018)</td><td>x</td><td></td><td>x</td><td></td><td></td></tr>
<tr><td>(Rustam and van der Weide 2016)</td><td></td><td>x</td><td></td><td></td><td>x</td></tr>
<tr><td>(Vorvoreanu et al. 2015)</td><td></td><td></td><td></td><td>x</td><td>x</td></tr>
<tr><td>(Juvonen and Kurvinen 2017)</td><td>x</td><td></td><td>x</td><td></td><td></td></tr>
<tr><td>(Hajikhani et al. 2018)</td><td>x</td><td></td><td>x</td><td></td><td>x</td></tr>
<tr><td>(Moreira et al. 2017)</td><td></td><td>x</td><td></td><td></td><td>x</td></tr>
<tr><td>(Mulhanga et al. 2016)</td><td>x</td><td>x</td><td></td><td></td><td></td></tr>
<tr><td>(García-Peñalvo et al. 2015)</td><td>x</td><td></td><td></td><td>x</td><td>x</td></tr>
<tr><td>(Sein-Echaluce et al. 2015)</td><td></td><td></td><td></td><td></td><td>x</td></tr>
<tr><td>(Ortega-Mohedano and Rodríguez-Conde 2018)</td><td>x</td><td></td><td></td><td>x</td><td></td></tr>
<tr><td>(Marques et al. 2015)</td><td colspan="3">x</td><td></td><td></td></tr>
<tr><td>(Birkner et al. 2017)</td><td colspan="3">x</td><td>x</td><td></td></tr>
<tr><td>(Sicilia et al. 2018)</td><td>x</td><td></td><td>x</td><td>x</td><td></td></tr>
<tr><td>(Miller et al. 2016)</td><td colspan="4">x</td><td></td></tr>
<tr><td>(Bazhal 2015)</td><td colspan="3">x</td><td></td><td></td></tr>
<tr><td>(Chen et al. 2016)</td><td>x</td><td></td><td></td><td>x</td><td></td></tr>
<tr><td>(Rothe and Steier 2017)</td><td>x</td><td></td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>(Galán-Muros et al. 2017)</td><td>x</td><td></td><td></td><td>x</td><td></td></tr>
<tr><td>(Amorim Silva and Braga 2018)</td><td>x</td><td></td><td></td><td>x</td><td></td></tr>
<tr><td>(Donald et al. 2018)</td><td colspan="4">x</td><td></td></tr>
<tr><td>(Miller et al. 2018)</td><td colspan="4">x</td><td></td></tr>
</table>

3.1 Single relationships of the stakeholders and learning environment

Barokas and Barth start by introducing the original term of ecosystem (2018). The projects pursue the objective of a tight cooperation between the educational and industrial sector, which results in academic courses, a training course for high school teachers and a course, developed by industry to train purposes. Based on the findings, the authors provide guidelines for creating future educational ecosystems and develop prerequisites for these. Juvonen and Kurvinen also focus on university-business collaboration by proposing collaboration with start-ups and small and medium enterprises, fostering learning through real business cases.

Thereby companies can directly participate via education activities or shared customer projects, and be used as trainers, sources of projects and tasks and as employers during students practice training (Juvonen & Kurvinen, 2018). Hajikhani et al. distinguish platforms and ecosystems and describe their similarities such as interdependence and network effects. Further, they present a platform as a "focal factor" within the ecosystem, which increases the system value by increasing number of participants and derived necessary conditions for such cooperation. The platform shall support the multi-disciplinary discovery relationships and explore the positive impact of innovative use of communication technologies on human experience (Hajikhani, Russell, Alexanyan, Young, & Wilmot, 2018). In order to explore the perceptions concerning the importance of digital competences and teaching progress in HEIs, Sicilia et al. conduct a study. According to other studies on digital competences the authors point out that the measurement of achieved level on digital skills is still insufficient from the employers view. The HEI focus group stresses that there is a lack of a systematic curricular approach on digital competences. In this regard, situated learning, which takes place in the context of real setting, plays an important role. So an approach with workplace is needed to develop a systematic training in the curriculum. Rothe and Steier present Udacity as a case study and example of collaboration between business and students, where MOOC platforms with lectures from private companies disrupt boundaries of conventional education (2017). The cooperation between the educational and industrial sector is of high importance, as it allows the students to encounter and to confront concerns, which are relevant in practice. Such cooperation is profitable for both parts, as the industry sector, as the future employer, can influence the teaching content to form their future employees. Students can gain industrial experience via internships and be more prepared before starting their careers. In keeping with Sicilia et al. universities should invest more in teaching digital competences, due to an increasing demand by industry. The platform concept proposed by Hajikhani et al. (2018)can serve as a suitable medium to facilitate knowledge transfer and knowledge sharing.

Even the university-government cooperation is not treated extensive, Mulhanga et al. point out some important issues concerning the government role in the ecosystem. Of particular note are the government strategies for science and their implementations, financial resources as well as national and international science developing programs (Mulhanga, Lima, & Massingue, 2016). Since there are many political pressure and structure guidelines the university has to comply; the government should also be regarded as an important stakeholder within the educational ecosystem.

The article of García-Peñalvo et al. deals with the integration of students into the creation process of learning environments. Having an individual learning environment, students can use tools, which are more suitable for them and they can learn independent of the institutional location or period of time (García-Peñalvo et al., 2015). In this regard, the authors utter that the current learning management system (LMS) as only part of the educational and technological innovation strategy is not valid any more, since the limitations are almost known and seem not to be attractive for the user. Learning analytics is necessary to foster the adaptive knowledge management systems. Hereby, adaptability can e.g. be accumulated with gamification aspects to engage the students in the learning process. In order to solve the problem, the authors propose the technological learning ecosystem as a framework, which supports renewed educational processes and must comply with the knowledge management strategy and contain a series of interoperable key elements (García-Peñalvo et al., 2015). Based on a literature study, Ortega-Mohedano and Rodríges-Conde define education as a service in economical context considering students as clients, who are participated in the production (co-producer). Amorim Silva and Braga design a "system of systems" to support the interaction between the core elements of an educational Internet of Everything ecosystem (Amorim Silva & Braga, 2018). There is an agreement in the recent research concerning necessity to involve the user in the production process, as students have to participate in the construction of their learning environment. Gamification aspects can be used to foster the perception of progress. The data about the preferences and learning habits of the students in turn can be used to improve the curriculum. Insofar, the students represent an indispensable component in the educational ecosystem, as they shall participate in the design of the learning environment. Consistent with the third mission approach, the university has to open boundaries and cooperate with the other stakeholders to improve the study offer and the quality of the curriculum thus strengthens the competitiveness.

Taking for granted the phenomenon of the transformation to a digital society, in particular e-learning was examined in the ecosystem context. The majority of the articles examine the digital learning environment, e.g. in the form of MOOCs.

Rustam and van der Weide propose an IT platform, where courses from different universities and MOOCs are jointed together with the goal to offer suitable courses for students independent of the physical location of the university. Furthermore in this way, universities can share their knowledge country-wide, which still can be controlled by the government (Rustam & van der Weide, 2016). García-Peñalvo et al. also emphasize the importance of the possibility to learn independent of the institutional location or period of time. As mentioned in the prior section, the authors propose the use of learning analytics to improve adaptive knowledge management systems (García-Peñalvo et al., 2015). Moreira et al. underline the importance of using data from online courses, social platforms and other LMS in order to improve teaching and implement adaptive teaching (Moreira, Gonçalves, Martins, Branco, & Au-Yong-Oliveira, 2017). Keeping it with the previous authors, Sein-Echaluce et al. also examine adaptive learning at HE, particularly the adaptivity in MOOCs and moodle courses regarding the adjustment of teams, which perform work . Finally, Rothe and Steier claim that MOOC platforms are about to disrupt university boundaries and may pose a risk for HEIs (2017).

3.2 Triple helix and quadruple helix relationships

The articles from Bazhal and Marques et al. deal with the cooperation and interaction between HEIs, government and business. Bazhal uses the triple helix model to improve the development of innovation activities in an Ukrainian university (Bazhal, 2015) whereas Marques et al. focus on creating synergies between the stakeholders in an entrepreneurial context. The authors emphasize that HEIs play an important role in developing student skills in order to promote their employability. They also stress that the enterprises by collaborating with HEIs maximize the development of their employees, increase the competitive advantage, and introduce a project to point out the importance of non-formal and informal entrepreneurial learning in the academic context in Portugal (Marques, Moreira, & Ramos, 2015).

McAdam et al. consider university incubation models in the quadruple helix context. University incubation can be seen as an interactive process, which shall integrate mentoring and knowledge exchange between the stakeholders (2016). In keeping with Carayannis and Rakhmatullin (2014), the authors suggest an extension of the triple helix model by introducing innovation users as a forth helix. Miller et al. define the fourth helix in form of the "societal based innovation users", as further stakeholder with committed involvement, participation and influence throughout the university technology transfer (UTT) process (2018). In this regard following aspects could be identified as relevant: paying attention to tensions between the various stakeholders, developing stakeholder relationships, the "soft infrastructures" like networking, knowledge transfer; the difficulties in UTT performance measurements; the need of an open organizational structure, which allows knowledge transfer and exchange. Birkner et al. also expand the triple helix model with a further helix underlining the role of the civil society and fifth helix emphasizing the ecological aspect. The authors utter that universities are permanently under pressure by involved parties for satisfying their needs and demands. On the one hand, the universities seem to adopt a third mission apart from research and education and on the other hand, universities benefit from the cooperation, as industrial research leads the way for academic research. Insofar it is possible to adjust the learning materials beforehand to meet the demands of industry (Birkner, Máhr, & Berkes, 2017). Donald et al. examine students' perception of benefits from HE on future employability as well as the perception of future university and careers preparedness for entering the global labor market. Therefore, the authors examine the perceived use of career services. Findings are: perceived employability improvement and life aspirations due to HE, benefits highlighted were personal development, future career and life aspiration. Lecturers could be identified as key players providing career advice; a need for greater collaboration between universities and employers was also identified. Therefore, the authors constructed a career advised model to show the complexity and interrelations between stakeholders. Furthermore, the authors found out that it is important for the government to work together with organizations in order to address the market requirements and create new jobs (Donald, Ashleigh, & Baruch, 2018).

The literature review shows that a general definition of the term "ecosystem" in the educational context does not exist, even though the term is used in this research field. Pilinkienė and Mačiulis compare different ecosystem analogies in the economical context (2014). The authors identify several analogies e.g. "industrial ecosystem" or "innovation ecosystem" and others, but the analogy of "educational ecosystem" is missing. Regarding this point, the literature review reveals the necessity for an ecosystem definition in the educational context. Therefore we suggest the following ecosystem definition based on the insights of the articles: *an ecosystem is an interactional system of an educational community, its environment and stakeholders (university, government, industry and students) as well as the interdependency and mutual requirements of the stakeholders.*

The discussed dependences show that just considering the triple helix relationship is insufficient. At least the stakeholders of the quadruple helix and their relationships should be taken into account in educational context. The quadruple helix perspective shows that an open organization structure is needed to allow knowledge exchange and knowledge sharing between the stakeholders. The second important point is the necessity of adaptive aspects by designing the learning environment (adaptive gamification, adaptive knowledge management system, etc.). In this regard, the initial conceptualization needs to be extended to these important characteristics "knowledge transfer" and "adaptivity" (Figure 3). The arrows in figure 3 represent the ongoing interaction between the stakeholders, which builds the fundament for the knowledge transfer and possibility to adapt new content. The dashed line represents the open blundered environment, which allows extending the model with new components.

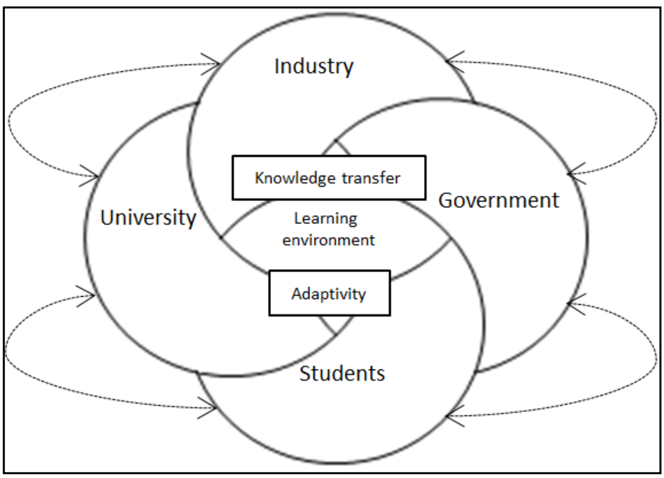

Figure 3: Modified conceptualization

By means of the literature review the learning environment could be augmented with two important processes which need to be taken into account by constructing novel curriculum designs. Adaptivity shall improve the efficiency of educational ecosystems, where social and technical aspects come together. Based on the different backgrounds, abilities and habits of the students adaptive mechanisms can provide personalized features of the curriculum design (Morrison, Balasubramaniam, & Falkner, 2008). Optimizing knowledge transfer strategies between the stakeholders but also within universities can lead to improvements in knowledge involved processes.

4 Conclusion and further research

With the literature review we examined the relationships between the stakeholders of the quadruple helix model and whether there is a common understanding of the term "educational ecosystem" in the field of IS. The analysis shows that mostly single relationships between two stakeholders are regarded. Only in the quadruple helix perspective, all four parties are considered together. Relationships between the university and the industry are e.g. the technology transfer from the university on the one hand and coaching from industry practitioners or the possibility for internships, on the other hand. The relationship between the university and the government is characterized by legal guidelines and international research partnerships. Finally, comprehensive teaching and research identify the university-students relationship. However, all relationships have the necessity of knowledge transfer in common otherwise no relationship could exist. In addition, we could identify "adaptivity" as an important aspect for developing the learning environment. Therefore, the initial conceptualization was modified and extended with these findings.

Furthermore, the results show that even if the regarded articles include the term "ecosystem" in the abstract or full text, mostly neither the definition of ecosystem was introduced nor the approach has been consistently pursued. Although the ecosystem approach seems to be well suited to map the relationships between the stakeholders of the ecosystem and its environment, the use of the approach is insufficient in this research field. In conclusion, we suggest a definition of "educational ecosystem", which in our opinion can serve as a fundament for further research.

With regard to the limitations of this approach, we firstly have to mention that the literature search was limited towards articles, which deal with education in the context of ecosystem, by excluding all of them, which do not contain the term "ecosystem". Therefore, it is possible that there are articles describing the relationships between the previously mentioned stakeholders, which were not taken into account. Secondly, we use the term "e-learning" to examine possible future learning environment(s) without considering other learning alternatives as we claim that traditional learning becomes less important in the future of digital society.

Future research in the context of educational ecosystems should focus on clearly defining the stakeholders of the ecosystem and their interrelationships. Therefore, an ontology could be constructed. Such an ontology can be seen as a specification of an abstract worldview describing and defining the elements of a particular area and their relations (Dong & Hussain, 2007). Another important research focus should be the examination of knowledge sharing and knowledge transfer since there is a flood of information, which has to be managed between the stakeholders and within the particular environments. Furthermore, the integration of adaptivity aspects in the learning environment can be analysed from a socio-technical system perspective. Finally, in the next step a comprehensive educational ecosystem can be modelled.

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Beyond De-Identification Record Falsification to Disarm Expropriated Data-Sets

ROGER CLARKE

Abstract The wild enthusiasm for big data and open data has brought with it the assumptions that the utility of data-sets is what matters, and that privacy interests are to be sacrificed for the greater good. As a result, techniques have been devised to reduce the identifiability of expropriated data-records, on the assumption that privacy is to be compromised to the extent necessary. This paper argues for and adopts data privacy as the objective, and treats data utility for secondary purposes as the constraint. The inadequacies of both the concept and the implementation of de-identification are underlined. Synthetic data and Known Irreversible Record Falsification (KIRF) are identified as the appropriate techniques to protect against harm arising from expropriated data-sets.

Keywords: • Big Data • Data Analytics • Privacy • Re-Identification • Record Falsification •

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1 Introduction

During the early decades of administrative computing, roughly 1950-1980, personal data was collected for a purpose, used for that purpose, and confined to 'silos'. Only in particular circumstances did it escape beyond its original context, and become subjected to 're-purposing', and combination with data from other sources. From the 1970s onwards, however, there was growth in the financial services sector's sharing of data about consumers' creditworthiness (Furletti 2002), and in data matching by government agencies (Clarke 1994c).

Over the last few decades, these, initially exceptional, secondary uses of personal data have changed from a dribble to a haemorrhage, supported by advances in the technical capabilities necessary to handle large volumes of data. The notions of 'data warehousing' (Inmon 1992) and 'data mining' (Fayyad et al. 1996) emerged. After early disappointments, these ideas have recently resurged with the new marketing tags of 'big data', 'open data', 'data analytics' and 'data science'.

During the early decades of data protection law, the fundamental principle was that use and disclosure beyond the original purpose of collection had to be based on consent or authority of law (OECD Use Limitation Principle, OECD 1980). The protection that this Principle was meant to afford has since been torn asunder by exemptions, exceptions and long lists of legal authorisations.

In this paper, the short-form term 'expropriation' is adopted to refer to the kinds of secondary use that are common with big data / open data. These enthusiastic movements are based on the application of data for purposes beyond the aims for which it was collected and is authorised by the individual to be used.
In the public sector, governments around the world appear to have been inspired by the openness of Danish agencies' databases to secondary uses (e.g. Thygesen et al. 2011). A practice is becoming more widespread in which all personal data that is gathered by government agencies, in many cases under compulsion, is regarded as the property of the State and "a strategic national resource that holds considerable value" (AG 2015). The whole of government is treated as a monolith – thereby breaching the 'data silo' protection mechanism.

In Australia, for example, the Australian Institute of Health and Welfare (AIHW) has pillaged data-sources across the healthcare sectors at national and state and territory levels, and made rich sub-sets available to large numbers of researchers. Further, the Australian Bureau of Statistics (ABS) has a multi-agency data integration program (MADIP) in train with a range of 'partner' agencies. This extracts data gathered for specific administrative purposes and enables its analysis for a wide range of purposes. A great many other such projects are being conducted and proposed under the big data and open data mantras. Justifications for the abuses of data in government and in health-related research emphasise collectivism and de-value individualism.

The private sector is piggybacking on the 'open data' notion (e.g. Deloitte 2012). Corporations are encouraged by governments to treat data about individuals as an exploitable asset, irrespective of its origins, sensitivity and re-identifiability. Assertions of business value, and that such activities are good for the economy, are treated as being of greater importance than human values.

In both sectors, proponents and practitioners make the assumption that such projects are capable of delivering significant benefits, even though tha data has been wrenched far beyond its original context, has been merged with other data with little attention paid to incompatibilities of meaning and quality, and has been analysed for purposes very different from those for which it was collected. Limited attention is paid to data quality audit and even less to testing of the inferences drawn from such data-collections against real-world patterns (Clarke 2016b). Considerable scepticism is necessary about the real effectiveness and social value of these activities.

The doubts extend beyond the activities' justification to the negative impacts on the individuals whose data is expropriated. Proponents of big data do not object to replacing identifiers with pseudonyms; but they do not welcome comprehensive privacy protection: "it is difficult to ensure the dataset does not allow subsequent re-identification of individuals, but ... it is also difficult to de-identify datasets without introducing bias into those sets that can lead to spurious results" (Angiuli et al. 2015). Significantly for the argument pursued in this paper, the position adopted by big-data proponents is that the interests of the individuals to whom the expropriated data relates are secondary, and that such procedures as are applied to reduce the risk of harm to individuals' privacy must be at limited cost to its utility for organisations.

Examples of the claim for supremacy of the data-utility value over the privacy value abound. For example, "we underline the necessity of an appropriate research exemption from consent for the use of sensitive personal data in medical research ..." (Mostert et al. 2016, emphasis added) More generally, "We develop a method that allows the release of [individually identifiable microdata] while minimizing information loss and, at the same time, providing a degree of preventive protection to the data subjects" (Garfinkel et al. 2007, p.23, emphasis added).

The theme for the Bled conference in 2019 is 'Humanising Technology for a Sustainable Society'. This paper addresses that theme by proposing a switch back from the asserted supremacy of data utility to recognition of the primacy of the human right of privacy. It is not argued that data utility should be ignored. The proposition is that, when preparing personal data for disclosure and use beyond its original context, the appropriate value to adopt as the objective is privacy protection. The retention of such utility as the data may have for other purposes is not the objective. It remains, however, an important factor to be considered in the choice among alternative ways of ensuring that harm is precluded from arising from re-identification of the data.

The paper commences with a summary of privacy concerns arising from the expropriation of personal data and its use and disclosure for purposes far beyond the context within which it was collected. The notions of identification, de-identification and re-identification are outlined, and conventional techniques described. This builds on a long series of prior research projects by the author. De-identification is shown to be a seriously inadequate privacy-protection measure. Two appropriate approaches are identified: synthetic data, and Known Irreversible Record Falsification (KIRF).

The paper's contributions are the review of de-identification measures from the perspective of the affected individuals rather than of the expropriating parties, and the specification of falsification as a necessary criterion for plundered data-sets.

2 The Vital Role of Data Privacy

Privacy is a pivotal value, reflected in a dozen Articles of the International Covenant on Civil and Political Rights (ICCPR 1966). It underpins many of the rights that are vital constituents of freedom. Fuller discussion is in Clarke (2014c). Philosophical analyses of privacy are often based on such precepts as human dignity, integrity, individual autonomy and self-determination, and commonly slide into conflicts between the moral and legal notions of 'rights'. Adding to the confusion, legal rights vary significantly across jurisdictions. A practical working definition is as follows (Morison 1973, Clarke 1997):

Privacy *is the interest that individuals have in sustaining 'personal space', free from interference by other people and organisations*

The diversity of contexts within which privacy concerns arise is addressed by typologies that identify dimensions or types of privacy (Clarke 1997, Finn et al. 2013, Koops et al. 2016). The dimensions of privacy of personal data and of personal communications are directly relevant to the present topic. The term 'information privacy' is commonly used to encompass both data at rest and on the move, and is usefully defined as follows:

Information privacy *is the interest that individuals have in controlling, or at least significantly influencing, the handling of data about themselves.*

Protection of information privacy is not only important in its own right. It also provides crucial underpinning for protections of the other three dimensions: privacy of personal behaviour, of personal experience, and of the physical person.

Abuse of the privacy interest results in significant harm to human values. Within communities, psychological harm and negative impacts on social cohesion are associated with loss of control over one's life and image, loss of respect, and devaluation of the individual. Reputational harm inflicted by the disclosure of data about stigmatised behaviours, whether of the individual or of family-members, reduces the pool of people prepared to stand for political office and hence weakens the polity. Profiling, and use of data-collections to discover behaviour-patterns and generate suspicion, lay the foundation for the repression of behaviours that powerful organisations regard as undesirable. This undermines the exposure of wasteful, corrupt and otherwise illegal activities, and reduces the scope for creativity in economic, social, cultural and political contexts. At any given time, a proportion of the population is at risk of being identified and located by a person or organisation that wishes to take revenge against them or exact retribution from them, excite mortal fear in them, or eliminate them.

Behavioural privacy is harmed not only from unjustified collection, use and disclosure of personal data, but also from the knowledge or suspicion that individuals may be watched, that data may be collected, and that their activities may be monitored. This has a 'chilling effect' on group behaviour, whereby intentional acts by one party have a strong deterrent effect on important, positive behaviours of some other party (Schauer 1978). This results in stultification of social and political speech. A society in which non-conformist, inventive and innovative behaviour are stifled risks becoming static and lacking in cultural, economic and scientific change (Kim 2004).

Data sensitivity is relative. Firstly, it depends on the personal values of the individual concerned, which are influenced by such factors as their cultural context, ethnicity, lingual background, family circumstances, wealth, and political roles. Secondly, it depends on the individual's circumstances at any particular point in time, which affects what they want to hide, such as family history, prior misdemeanours, interests, attitudes, life-style, assets, liabilities, or details of their family or family life.

Various aspects of privacy are important, in particular circumstances, for a substantial proportion of the population. Some categories of individual are more highly vulnerable than others. For the large numbers of people who at any given time fall within the many categories of 'persons-at-risk', it is essential to guard against the disclosure of a great deal of data, much of it seemingly innocuous (GFW 2011, Clarke 2014a).

To assist in assessment of the effectiveness of safeguards against harm arising from data expropriation, Table 1 presents a small suite of test-cases that are sufficiently diverse to capture some of the richness of human needs.

Table 1: Six 'Persons-at-Risk' Test-Cases

- **People with outlier, non-conformist or 'deviant' personal profiles**
  Key Data: characteristics of interest to service-providers
  Key Risks: denial of service
  e.g. genetic or medical conditions resulting in discrimination by health insurers, low 'social credit' scores resulting in denial of access to transport
- **Negotiators of corporate mergers and acquisitions**
  Key Data: information-sources, locations, meeting-partners
  Key Risks: breach of corporations law and stock exchange listing rules
- **Candidates for political office**
  Key Data: associations with stigmas such as psychiatric treatment
  Key Risks: unelectability, reduction in the pool of candidates
- **Whistleblowers and media sources**
  Key Data: identity
  Key Risks: retribution, drying-up of informers, unchecked corruption
- **Victims of domestic violence**
  Key Data: location
  Key Risks: physical harm
- **Police informants and protected witnesses**
  Key Data: pseudonym and/or location
  Key Risks: physical harm, loss of witness, loss of future witnesses

This paper's purpose is to switch the focus away from the asserted utility of big and open data for secondary purposes, and back towards the human value of privacy. However, there are further aspects of the conference theme of 'Humanising Technology for a Sustainable Society' that are negatively affected by the prevalence of data expropriation.

Many organisations' operations depend on access to personal data, and on the quality of that data. For an analysis of data quality aspects in big data contexts, see Clarke (2016b). The goodwill of the individuals concerned is very important not only to data access and data quality, but also to the cost incurred in assuring data quality. Extraneous uses of personal data cause a significant decrease in trust by individuals in the organisations that they deal with. The result is that they are much less willing to disclose and much more likely to hide and to obscure data, and much less willing to disclose honestly, and much more likely to disclose selectively, inconsistently, vaguely, inaccurately, misleadingly, imaginatively or fraudulently. There is a great deal of scope for obfuscation and falsification of data (Schneier 2015a, 2015b, Bösch et al. 2016, Clarke 2016a). Widespread exercise of these techniques will have serious negative consequences for the quality of data held by organisations.

Expropriation of data results in the data on which analyses are based bearing a less reliable relationship to the real-world phenomena that they nominally represent. This leads to the inferences that are drawn by medical, criminological and social research in the interests of the public, and by marketing activities in the interests of corporations, being at best misled and misleading, and their use being harmful rather than helpful. This particular form of dehumanising technology, rather than contributing to the sustainability of society, undermines it.

This section has presented the reasons why privacy is a vital human value. The proposal that privacy is the primary objective and data-utility the constraint is therefore of far more than merely academic interest, and is a social and economic need. The following section outlines the relevant aspects of identification, and the conventional mechanisms that have been applied to expropriated data in order to achieve what designers have portrayed as being 'anonymisation' of the data.

3 De- and Re-Identification

This section outlines the notions of identity, nymity and identification, drawing on Clarke (1994b, 2010). It presents the conditions that need to be fulfilled in order that de-identification can be achieved, and re-identification precluded. It then provides an overview of techniques applied to expropriated personal data.

3.1 Concepts

An **entity** is a real-world thing. Rather than artefacts such as tradeable items and mobile phones, this paper is concerned with human beings. An **identity** is an entity of virtual rather than physical form. Each person may present many identities to different people and organisations, and in different contexts, typically associated with roles such as consumer, student, employee, parent and volunteer. During recent decades, organisations have co-opted the term 'identity' to refer to something that they create and that exists in machine-readable storage. Better terms exist to describe that notion, in particular **digital persona** (Clarke 1994a, 2014b). In this paper, the term 'identity' is used only to refer to presentations of an entity, not to digital personae.

The notion of **'nymity'** is concerned with identities that are not associated with an entity. In the case of **anonymity**, the identity cannot be associated with any particular entity, whether from the data itself, or by combining it with other data. On the other hand, **pseudonymity** applies where the identity is not obviously associated with any particular entity, but association may be possible if legal, organisational and technical constraints are overcome (Clarke 1999).

An **identifier** is a data-item or set of data-items that represent attributes that can reliably distinguish an identity from others in the same category. Commonly, a human identity is identified by name (including context-dependent names such as 'Sally' or 'Herbert' at a service-counter or in a call-centre), or by an identifying code that has been assigned by an organisation (such as an employee- or customer-number).

Identification is the process whereby a transaction or a stored data-record is associated with a particular identity. This is achieved by acquiring an identifier, or assigning one, such as a person's name or an identifying code.

De-identification notionally refers to a process whereby a transaction or a stored data-record becomes no longer associable with a particular identity. However, it is in practice subject to a number of interpretations, outlined in Table 2.

Table 2: Alternative Interpretations of 'De-Identification'

1. **The removal of data-items** that are designed to, or are known to, facilitate the association of a record with a real-world identity. This interpretation is the one most commonly apparent in the literature. It satisfies a necessary condition, but falls a long way short of being sufficient
2. **Further adaption and/or 'perturbation' of the data-set in order to address additional association risks**. These are discovered by analysis of the data and its various contexts in order to achieve understanding of the many other ways in which at least some proportion of the records may remain associable with a particular real-world identity. This interpretation is sometimes apparent in the literature
3. **Further processing of the data-set to address the risk of physical or virtual merger, linkage or comparison of that data-set with other data-sets**. This interpretation is seldom apparent in the literature
4. **Demonstration of the reliability of de-identification**, by showing that the records in the data-set cannot be associated with the real-world identity to whom they originally applied. This interpretation is seldom apparent in the literature

De-identification of a data-set is very likely to result in at least some degree of compromise to the data-set's utility for secondary purposes. In Culnane et al. (2017), it is argued that "decreasing the precision of the data, or perturbing it statistically, makes re-identification gradually harder at a substantial cost to utility". It remains an open question as to whether, under what circumstances, and to what extent, the objectives of the two sets of stakeholders can be reconciled. For early examinations of the **trade-off between de-identification and the utility of the data-set**, see Duncan et al. (2001), Brickell & Shmatikov (2009) and Friedman & Schuster (2010). The perception of compromise to data utility appears to be an important reason why the more powerful de-identification techniques in Table 2 are seldom actually applied, or at least not with the enormous care necessary to achieve significant privacy-protection.

In many circumstances, de-identified records are subject to 're-identification', that is to say the re-discovery or inference of an association between a record and a real-world identity, despite prior attempts to de-identify them. This is possible because de-identification is extremely difficult for all but the simplest and least interesting data-sets. It is particularly easy with rich data-sets, such as those whose records contain many data-items, or whose data-items contain unusual values.

Further, a great many of the data-sets that are lifted out of their original context and re-purposed are subsequently merged or linked with other data-sets. This gives rise to two further phenomena, which together greatly increase the risk of inappropriate matches and inappropriate inferences (Clarke 2018):

- combined data-sets generally offer even more opportunities for re-identification than do single-source data-sets; and
- combined data-sets are far more likely than single-source data-sets to lead to faulty inferences being drawn. This is because:
    - the quality of the data in each of the data-sets is often not high and hence comparisons of data-content may be unreliable;
    - the meanings of the data-items in each of the data-sets are often unclear or ambiguous;
    - the definitions of the data-items in each of the data-sets may be inconsistent or otherwise incompatible; and
    - where data scrubbing activities have been undertaken, before and/or after combination of the data-sets, the process(es) of addressing some problems inevitably also create new problems.

The notion of re-identification has attracted considerable attention, particularly since it was demonstrated that "87% ... of the population in the United States had reported characteristics that likely made them unique based only on {5-digit ZIP, gender, date of birth}. About half of the U.S. population ... are likely to be uniquely identified by only {place, gender, date of birth}, where place is basically the city, town, or municipality in which the person resides" (Sweeney 2000).

Narayanan & Shmatikov (2008) presented a general de-anonymization algorithm which they claimed requires "very little background knowledge (as few as 5-10 attributes in our case study). Our de-anonymization algorithm is robust to imprecision of the adversary's background knowledge and to sanitization or perturbation that may have been applied to the data prior to release. It works even if only a subset of the original dataset has been published" (p.2). For fuller discussion of re-identification, see Ohm (2010) and Slee (2011).

3.2 Longstanding De-Identification Techniques

In response to objections to the expropriation of personal data, proponents argue that the records are 'anonymised', can no longer be associated with the individual concerned, can therefore do that individual no harm, and hence the individual should not be concerned about the re-use or disclosure of the data. In order to deliver what they claim to be 'anonymised data', expropriating organisations have applied a variety of techniques.

From the 'data mining' phase (indicatively 1980-2005), a literature exists on **'privacy-preserving data mining'** (PPDM – Denning 1980, Sweeney 1996, Agrawal & Srikant 2000). For a literature review, see Brynielsson et al. (2013). PPDM involves suppressing all identifiers and other data-items likely to enable re-identification ('quasi-identifiers'), and editing and/or statistically randomising (or 'perturbing') the contents of data-items whose content may assist re-identification (e.g. because of unusual values). The declared purpose is to preserve the overall statistical features of the data, while achieving a lower probability of revealing private information.

During the later 'big data' phase (since c. 2010), guidance on forms of data manipulation that are suitable for practical application is provided in particular by UKICO (2012), but see also DHHS (2012). In Slee (2011), a simple set of four categories is suggested: **replacement, suppression, generalisation and perturbation**. Accessible summaries of the challenges and some of the risks involved in the de-identification process are in Garfinkel (2015) and Polonetsky et al. (2016).
The regulatory regime applying to US health records (HIPAA) specifies two alternative approaches for de-identification: The Expert Determination Method and the Safe Harbor method (which is effectively a simplified 'fool's guide').

However, "neither method promises a foolproof method of de-identification with zero risk of re-identification. Instead, the methods are intended to be practical approaches to allow de-identified healthcare information to be created and shared with a low risk of re-identification" (Garfinkel 2015, p. 22).

In D'Acquisto et al. (2015) pp.27-37, it is noted that "most data releasers today (e.g. national statistical offices) tend to adopt the *utility-first approach*, because delivering useful data is their *raison d'etre*" (p.29, emphasis added). A further indication of the strong commitment to data utility is that, although "in Germany, any organizational data accessible to external researchers is required to be de facto anonymized", the bar is set very low, because all that is required is that "the *effort* that is necessary to identify a single unit in the data set is *higher than the actual benefit* the potential intruder would gain by the identification" (Bleninger et al., 2010, emphasis added). This formulation ignores the critical issues that (1) the breach causes harm to the affected individual, and (2) the harm to the affected individual may be far greater than the benefit to the breacher.

Similarly, the de-identification decision-making framework in O'Keefe et al. (2017) remains committed to the utility-first approach, because it applies the threshold test of "when data is *sufficiently de-identified* given [the organisation's] data situation" (p.2, emphasis added).

A further indicator of the inadequacy of the approaches adopted is that 're-identification risk' is regarded as being merely "the percentage of de-identified records that can be re-identified" (Garfinkel 2015, p. 38). If privacy rather than utility is adopted as the objective, then 're-identification risk' is seen to be a much more complex construct, because every breach has to be evaluated according to the potential harm it gives rise to – which can be severe in the case of a wide range of categories of persons-at-risk.

Garfinkel's conclusion was that, "**after more than a decade of research, there is comparatively little known about the underlying science of de-identification**" (2015, p.39). Given the complexities involved in both the problems and the techniques, it is far from clear that any practical solutions will ever emerge that satisfy the privacy-first rather than the utility-first criterion.

3.3 Re-Identification Techniques

The application of de-identification techniques naturally stimulated responses: "it seems that new techniques for de-identifying data have been met with equally innovative attempts at re-identification" (Hardy & Maurushat 2017, p.32). For analyses of techniques for re-identification, see Sweeney (2002), Acquisti & Gross (2009) and Ohm (2010).

In relation to one critical area of concern, the re-identifiability of location and tracking data, Song et al. (2014) showed that "human mobility traces are highly identifiable with only a few spatio-temporal points" (p.19). Further, de De Montjoye et al. (2015) found that credit card records with "four spatiotemporal points are enough to uniquely reidentify 90% of individuals ... [and] knowing the price of a transaction increases the risk of reidentification by 22%" (p. 536). Culnane et al. (2017) and Teague et al. (2017) described successful re-identification of patients in a de-identified open health dataset.

In contesting the De Montjoye et al. findings, Sanchez et al. (2016) provided a complex analysis, concluding that "sound anonymization methodologies exist to produce useful anonymized data that can be safely shared ...". It is inconceivable that the intellectual effort brought to bear by those authors in defending disclosure would or even could ever be applied to the continual, high-volume disclosures that are part-and-parcel of the data expropriation economy: "De-identification is not an exact science and ... you will not be able to avoid the need for complex judgement calls about when data is sufficiently de-identified given your [organisation's] data situation" (O'Keefe et al. 2017, p.2). The practical conclusion is that, at least where privacy is prioritised over data-utility:

Sound anonymization methodologies are so complex and onerous that they cannot be relied upon to produce useful anonymized data that can be safely shared

The re-identification process is easier where:

1. the data-set contains a large number of data-items;
2. there are unique values within individual data-items; and/or
3. there are unique combinations of values across multiple data-items.

A further important consideration is the availability of multiple data-sets that are capable of being compared, which gives rise to greater richness in a combined or merged data-set. An important factor in successful de-identification activities has been the widespread availability of large data-sets, such as electoral rolls, subscription lists, profiles on social networking sites, and the wide range of data broker offerings. In short, **a great many expropriated data-sets satisfy the conditions for easy re-identification of a material proportion of the records they contain.**

3.4 Recent De-Identification Techniques

The D'Acquisto monograph describes more privacy-protective techniques that have been proposed by academics – although most of them appear to be encountering difficulty in escaping the laboratory. The monograph refers to the alternative techniques as 'privacy-first anonymisation', but use of that term is not justified. The formulation is still utility-as-objective and privacy-as-constraint: "a parameter ... guarantees an upper bound on the re-identification disclosure risk and perhaps also on the attribute disclosure risk". Further, even in academic experimentation, the privacy-protectiveness has been set low, due to "*parameter choices relaxing privacy* in order for reasonable utility to be attainable" (p.29, emphasis added).

The D'Acquisto et al. summary of the 'privacy models' underlying these techniques is as follows: "A first family includes k-anonymity and its extensions taking care of attribute disclosure, like p-sensitive k-anonymity, l-diversity, t-closeness, (n,t)-closeness, and others. The second family is built around the notion of differential privacy, along with some variants like crowd-blending privacy or BlowFish" (D'Acquisto et al. 2015, p.30).

The k-anonymity proposition is a framework for quantifying the amount of manipulation required of quasi-identifiers in order to achieve a given level of privacy (Sweeney 2002). A data-set satisfies k-anonymity iff each sequence of values in any quasi-identifier appears with at least k occurrences. Bigger k is better. The technique addresses only some of the threats, and has been subjected to many variants and extensions in an endeavour to address further threats.

Differential privacy is a set of mathematical techniques that reduces the risk of disclosure by adding non-deterministic noise to the results of mathematical operations before the results are reported. An algorithm is differentially private if the probability of a given output is only marginally affected if one record is removed from the dataset (Dwork 2006, 2008).

In both cases, "The goal is to keep the data 'truthful' and thus provide good utility for data-mining applications, while *achieving less than perfect privacy*" (Brickell & Shmatikov 2009, p.8, emphasis added). Further, the techniques depend on assumptions about the data, about other data that may be available, the attacker, the attacker's motivations, and the nature of the attack. Some of the claims made for the techniques have been debunked (e.g. Narayanan & Shmatikov 2010, Zang & Bolot 2011, Narayanan & Felten 2016, Zook et al. 2017, Ashgar & Kaafar 2019), and a range of statistical attacks is feasible (O'Keefe & Chipperfield 2013, pp. 441-451). **All k-anonymity and differential privacy techniques provide very limited protection.**

Even if these highly complex techniques did prove to satisfy the privacy-first criterion, the excitement that they have given rise to in some academic circles has not been matched in the real world of data expropriation, and it appears unlikely that they ever would be. None of the techniques, nor even combinations of multiples of them, actually achieve the objective of privacy-protection – not least because their aim is the retention of the data's utility. The highest standard achieved within the data-utility-first tradition, even in the more advanced, but seldom implemented forms, might be reasonably described as 'mostly de-identified' or 'moderately perturbed'.

The data-utility-first approach, and the de-identification techniques that it has spawned, cannot deliver adequate privacy protection. The expropriation of personal data gives rise to harm to people generally, and is particularly threatening to person-at-risk such as the small suite of test-cases in Table 1. Addressing their needs requires another approach entirely.

4 Privacy-First Disarming of Expropriated Data-Sets

This section considers ways in which privacy can be prioritised, but, within that constraint, such utility as is feasible can be rescued from data-sets. Although it is unusual for researchers to treat privacy as the objective and economic benefits as the constraint, it is not unknown. For example, in Li & Sarkar (2007), "The proposed method attempts to preserve the statistical properties of the data based on privacy protection parameters specified by the organization" (p.254). Privacy is thereby defined as the objective, and the statistical value of the data the constraint ("attempts to preserve").

In another approach, Jändel (2014) describes a process for analysing the risk of re-identification, and determining whether a given threshold ("the largest acceptable de-anonymisation probability for the attack scenario") is exceeded. When the safety of victims of domestic violence and protected witnesses is taken into account, that threshold has to be formulated at the level of impossibility of discovery of the person's identity and/or location. It is therefore reasonable to treat Jändel's extreme case as being privacy-protective.

In order to provide adequate protection against privacy breaches arising from expropriated data-sets even after de-identification, two approaches are possible:

1. Avoid the risks, by not using empirical data, but instead generating synthetic data
2. Prevent the risks arising, by ensuring that, even where individual records are re-identified, the data is unusable because it has been falsified in ways the specifics of which are unknowable, and which are irreversible

The remainder of this section considers those two approaches.

4.1 Synthetic Data

The most obvious way in which privacy can be protected is by not expropriating data, and hence avoiding use and disclosure for secondary purposes. This need not deny the extraction of utility from the data. Under a variety of circumstances, it is feasible to create 'synthetic data' that does not disclose data that relates to any individual, but that has "characteristics that are similar to real-world data

[with] frequency and error distributions of values [that] follow real-world distributions, and dependencies between attributes [that are] modelled accurately" (Christen & Pudjijono 2009. p.507).

This has been argued by some to be an effective solution to the problem: "empirically, it is difficult to find a database table on which sanitization permits both privacy and utility. Any incremental utility gained by non-trivial sanitization (as opposed to simply removing quasi-identifiers or sensitive attributes) is more than offset by a decrease in privacy, measured as the adversarial sensitive attribute disclosure. It is possible, however, to construct an artificial database, for which sanitization provides both complete utility and complete privacy, even for the strongest definition of privacy ..." (Brickell & Shmatikov 2009, p.7).

To date, there appears to have been very little take-up of this approach. As abuses of personal data, and harm arising from them, become increasingly apparent to the public, the assumed power of national statistical and other government agencies and large corporations may be shaken, and the generation of synthetic data may become much more attractive.

4.2 Empirical Data, De-Fanged

In this case, the proposition is that no data-set can be expropriated beyond its original context unless it has been first rendered valueless for any purpose relating to the administration of relationships between organisations and particular individuals. One way of achieving this is to convert all record-level data that was once empirical – in the sense of being drawn from and reflecting attributes of real-world phenomena – into synthetic data that represents a plausible phenomenon, but not a real one.

The underlying data-set is of course not affected, and remains in the hands of the organisation that manages it. The underlying data-set is the appropriate basis for administering the relationships between organisations and particular individuals; whereas expropriated data-sets are not.

The process must also be irreversible, at the level of each individual data record.

Further, **the fact of processing (as distinct from the details), and the standards achieved:**

- **must be known by organisations that do or may gain access to the expropriated data-sets.** This ensures that they are aware that the record-level data, whether or not it can be associated with any particular person, is unusable for any purpose related to the individual; and
- **must be known by affected individuals, and by advocacy organisations for their interests.** This ensures confidence in the process, and avoids motivating people to obfuscate or falsify data about themselves

Combining these properties, this mechanism is usefully described as **Known Irreversible Record Falsification (KIRF)**.

The possibility exists that the characteristics of some data-sets, or of some records within them, may resist falsification to the point of unusability. In that case, the records in question are unsuitable for expropriation, and no empirical derivative of them may be disclosed. If those records constitute a sufficient proportion of the data-set as a whole, then the data-set as a whole cannot be disclosed.

Examples of data-sets that may contain records that are too rich to be effectively falsified include the combination of psychological and social data with stigmatised medical conditions, and data about undercover operatives in national security and law enforcement contexts. (This of course does not necessarily preclude the use of statistical distributions derived from such data-sets as a basis for generating synthetic data that has comparable overall characteristics).

A corollary of the privacy-first approach is that the utility of the data-set is a constraint, not an objective. This might seem to rob the expropriated data-set of a great deal of value. Intuitively, it would appear unlikely that any single process could achieve both the standard of 'irreversibly falsified records' and preservation of the original data-set's overall statistical features. On the other hand, for any given use to which the expropriated data-set is to be put, different falsification processes could be applied, in order to produce a data-set that preserves the particular statistical features that are critical for that particular analysis.

In most circumstances, it would appear likely that changes can be made to data in order to satisfy the criteria, while sustaining at least a moderate level of utility for particular purposes. This is an empirical question that cannot be determined in the abstract, but requires detailed analysis in each specific context of data-set and purpose.

A less stringent approach could be considered, whereby the 'every record' requirement is relaxed, in favour of 'enough records'. However, because many records are not falsified, the data-set's utility for making decisions about individuals is not undermined and hence adversaries are motivated to conduct attacks. Individuals whose records are not falsified are subject to compromise. This is a serious matter, because inevitably some of them would be among the categories of persons-at-risk. The inadequacy extends further, however, because the interests of all individuals are compromised. Records that have been falsified are also likely to be used to generate inferences – and, due to the falsification steps, the inferences that are drawn are unreliable, and potentially harmful.

The less stringent arrangement would fail to curb the eagerness of organisations to exploit the expropriated data-set, and would fail to earn the trust of the affected individuals. Even if the application of a particular record's content to a particular individual were to be precluded by law, the scope for unregulated abuse of the provision is too high. The Known Irreversible Falsification criterion needs to be applied to all records, not merely to some or even most records.

5 Towards an Evaluation Process for the Privacy-First Approach

The purpose of this paper has been to argue for a privacy-first approach to the preparation of data-sets for expropriation to secondary purposes, and to develop an operational definition of what that involves. This section provides some preliminary suggestions as to the steps necessary to apply the principles, operationalise the process, and assess its effectiveness.

The term 'privacy-first' is of recent origin, and its first use in D'Acquisto et al. (2015, p.29) was in any case a false start. The sense in which it is proposed in this paper is so far outside the present mainstream as to be arguably deviant. Searches for existing literature on data perturbation undertaken to satisfy the requirement of falsification have not located a literature on the topic, or even individual instances that adopt the approach. Further, in the absence of theoretical discussions, it is not likely that exemplars and testbeds can be readily found.

On the other hand, some prior work is very likely to have relevance, in the sense of being capable of adaptation to the privacy-first criterion. A simple example of this would be a model in which a parameterisation mechanism enables the privacy weighting to be set at 1, but that nonetheless delivers non-zero utility, or at least information or insights. An approach to generating action in this field would be to expose these ideas in workshops that focus on de-identification and re-identification topics.

It is also feasible for projects to be undertaken that commence with existing guidelines on data perturbation, apply the Known Irreversible Record Falsification (KIRF) principle, and test the results by considering the 6 test-cases in Table 1. Initial projects might use data-sets of convenience. More serious studies would then be needed on mainstream, rich data-sets, such as those in the Census, social data and health care fields that are commonly subjected to expropriation.

Once the point has been reached that multiple approaches have been specified that satisfy the requirement, further rounds of research are needed in order to establish principles and practical guidance in relation to the retention of maximal utility, while still satisfying the requirement of known irreversible falsification for all individual records.

6 Conclusion

This paper's purposes have been:

- to abandon the utility-first approach;
- to adopt privacy as the objective and relegate data-utility to the level of a constraint;
- to argue for data-expropriation beyond its original context to be contingent on the prior application of techniques that fulfil that requirement; and
- to identify and articulate specific ways in which this can be done.

The analysis of alternative criteria for achieving privacy-first disarming of data-sets identified two contenders. The first possibility is the use only of synthentic data. This avoids the disclosure of any personal data, by creating and disclosing data whose distribution has usefully close approximations to the original data, but without any scope for disclosure of any personal data relating to any actual identity.
The second possibility applies the Known Irreversible Record Falsification (KIRF) criterion, in order to achieve similar properties in a released data-set to those of synthetic data. This achieves privacy protection by ensuring that all records are unusable for any purpose that relates to any specific individual. KIRF will, however, have impacts on the utility of data-sets. These impacts may be modest, but will often be significant, and in some circumstances will render the data-set unusable for data analytics purposes.

An implication of this conclusion is that research into de-identification processes needs to shift away from the approaches adopted over the last 15 years, such as k-anonymity and differential privacy, which prioritise utility at the expense of privacy. Instead, **the need is for a focus on ways to minimise the harm to the utility of data-sets, given that every record has to be falsified in such a manner that it is unusable for determinations about individuals, and is known to be so.**

If data-expropriating organisations fail to switch their approach in this way, it will be increasingly apparent to the public that their personal data is being expropriated and exploited by organisations without meaningful regard for either the rights of individuals or the harm that may arise from re-identification. As one research team in the re-identification area put it, "The ... government holds vast quantities of information about [individuals]. It is not really 'government data'. It is data about people, entrusted to the government's care" (Culnane et al. 2017).

A proportion of the population will neither know nor care. A further proportion will know, and care, but feel themselves to be technically incapable and/or powerless to do anything about it, sullenly accept the situation, and trust organisations as little as possible. The remainder will take action in order to deny the use of their data. Many techniques are already been demonstrated whereby individuals can resist abuse of their data, and moderate numbers of tools for obfuscation and falsification are available for deployment.

Over the last 50 years, organisations' data-gathering techniques have migrated from manual capture by employees to a combination of manual capture by the individuals to whom the data relates and automated capture as a byproduct of transactional activities. There is increasing incidence of autonomous creation of data by equipment that individuals are not aware are monitoring their behaviour. Obfuscation and falsification are easiest in relation to the long-standing forms of data capture. There are interesting challenges aplenty in devising ways to avoid, subvert and defeat byproduct and autonomous data capture. The expertise of many capable individuals will be attracted to the endeavour.

If this scenario unfolds, the quality of data that is in the expropriated collections will diminish below its present mediocre level. This will have serious implications for the validity, and for the business and policy value, of inferences drawn from data analytics activities. The benefits to economies and societies arising from this scenario will be significantly less than what would be achieved if instead the privacy-first approaches advocated above are adopted. This paper thereby contributes to the aim of humanising technologies for sustainable society.

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Gratifications and Credibility Judgment of Online Information for Task Completion – A Comparison of Students and Workers

MATHUPAYAS THONGMAK

Abstract This study aims to examine the impact of U&G determinants on intention to search online information and to investigate the effect of the intention to intention to evaluate quality of information and its corresponding behaviour between two user groups: students and workers who use the Internet information to complete their tasks. Structural equation modeling is utilized to assess the research model. Findings reveal U&G factors that are important to full-time students and full-time employees. The results also show the differences between the two groups in terms of the effect of a U&G factor and intention to search on its tentative dependent factor. The comparison between students and employees, the exploration of nascent dimensions of U&G theory, and the focus of the task-fulfillment purpose provide insights to educators, managers, and policy makers on how to enhance the credibility of information used in school or office works.

Keywords: • Internet Information Credibility • Uses and Gratifications • Theory of Planned Behaviour • Behavioural Intention • Credibility Judgment •

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1 Introduction

Information technology (IT) such as the Internet could improve both internal efficiency and personal productivity for a company (Antonelli, Almeida, Espejo, & Longhi, 2013). The Internet is not only used for work but is also used in school practices since it changes both formal and informal educational opportunities for students by providing greater autonomy in their learning tasks (Quintana, Pujol, & Romaní, 2012). Information seeking is a purposive searching for information to satisfy some goals (Rieh & Hilligoss, 2008). Everyone has to understand how to search and apply relevant information for problem solving and decision making (Lu & Lee, 2012). For instance, students generally used the Internet largely for school purposes (Metzger, Flanagin, & Zwarun, 2003). Workers search and analyse information from multiple sources and use information to make decisions or generate new ideas (Silva, 2009). The Internet is a valuable e-resource for students as well as employees in their information seeking due to an abundance of information available online (Catalano, 2013; Shanahan, 2008). It is also a medium for course delivery to students and workers in need of lifelong learning (Cereijo, 2006). However, not all information on the web is high quality and the quality control of web content is generally insufficient. Thus, web credibility has drawn more attention from researchers (Liao & Fu, 2014; Quintana et al., 2012; Shanahan, 2008; Tanaka et al., 2010).

Individuals try to achieve efficient and effective performance in information seeking, according to information-foraging theory (Sharit, Taha, Berkowsky, Profita, & Czaja, 2015). But individuals with different backgrounds and intention use various approaches to interact with the web and face different problems in information seeking (Athukorala, Głowacka, Jacucci, Oulasvirta, & Vreeken, 2016; Zhou, 2014). For example, students' ability to search and retrieve information are varied widely (Zhou, 2014). They sometimes lack of ability to distinguish inaccurate or biased information from other credible sources (Metzger et al., 2003). People in Generation Y have high capabilities in technology, but have poor capacity to judge the credibility of Internet information (White & Kiegaldie, 2011). Young users frequently fail to express their needs of information and experience the difficulty in credibility judgment of Internet information (Rieh & Hilligoss, 2008). Older adults face difficulties in verifying the website credibility and recalling its source (Robertson-Lang, Major, & Hemming, 2011). Therefore, understanding online information behaviour, particularly search and verification behaviour is important (Flanagin & Metzger, 2007; Metzger et al., 2003). Katz, Haras, and Blaszczynski (2010) also point that information literacy of college students and workers should be assessed to help instructors identify learners' information literacy need.

Information behavior is a set of activities engaged by a person when identifying the need of information, searching for information and using or transferring information (Catalano, 2013). Online information search process consists of identifying search goals, locating suitable information sources, selecting relevant information, and synthesizing information from multiple sources (Zhou, 2014). The Uses and Gratifications (U&G) theory explain the reasons that individuals choose a particular medium such as virtual community, e-book, and social network sites over others (Ifinedo, 2016; Liu, Cheung, & Lee, 2010; Shin, 2011). Uses and gratifications are appropriate to help understanding relationships between users and technologies, especially the Internet, because web users are goal-directed and are aware of the needs they trying to satisfy (Kaye & Johnson, 2004; Papacharissi & Rubin, 2000). Various components of the Internet such as bulletin boards, e-mail, and websites are functionally different from each other. Therefore, people's needs and gratifications of these components may be different (Ifinedo, 2016; Kaye & Johnson, 2004).

Although a number of studies in the literature have examined the U&G, recent adoption of U&G research to the Internet are incomplete, for instance, lacking of the exploration of an individual's perception of Internet information and credibility judgment across diverse information tasks. In addition, little prior research has investigated the information seeking and credibility judgment of young people (Rieh & Hilligoss, 2008). Only few studies have paid attention to credibility evaluation in the information-seeking process (Metzger et al., 2003; Rieh & Hilligoss, 2008). None of them has focused on the perceptions among different user groups or students in particular (Metzger et al., 2003). In addition, only four to five research has examined Thai people's behaviour on internet-related topics (Panjakajornsak et al., 2017). Therefore, this study explores the different aspects of the U&G framework with an important information seeking purpose: searching online information for task completion and tries to answer these research questions.

RQ1: How strongly do motivational constructs according to the uses and gratifications theory impact the information-searching intention of students and workers?,
RQ2: Do intention to search for Internet information directly and indirectly predict the students' and workers' credibility judgement behaviour (through information-judgment intention)?, and
RQ3: Do these key factors differently affect students' behaviours and workers' behaviours?

2 Related Research

Niehaves and Plattfaut (2014) studied elderly people's intention to use the Internet and its influencing factors using two alternative theories: the Unified Theory of Acceptance and Use of Technology (UTAUT) and the Model of Adoption of Technology in Households (MATH). Findings revealed that constructs from both theories could explain more than 70 percent of Internet use intention variance. Liao and Fu (2014) conducted laboratory studies to investigate how credibility cues differently affects younger and older consumers of online health information. Findings indicated that credibility cues in user reviews or message contents could support credibility judgments of older adults. Sharit et al. (2015) investigated health information search via the Internet of adults with ages between 18 to 85 years old. Internet experience had no impact on search performance. In addition, older participants used longer search times and fewer amounts of search than younger participants. Chevalier, Dommes, and Marquié (2015) examined age-related differences in search performance and strategies using Google. Findings showed that older participants gained lower accurate and applied less efficient search strategies than younger counterparts did. Moreover, younger participants tried to improve their strategies more and more. Athukorala et al. (2016) explored indicators characterizing exploratory search behaviour. Three exploratory search tasks were comparison, knowledge acquisition, and planning. The indicators classifying exploratory search behaviour best were query length, maximum scroll depth, and task completion time. S. H. Wang (2017) studied the effects of technology attractiveness, medical credibility, and diversified medical information sources on people who had never used a web-based medical service for health information before. Perceived ease of use and perceived usefulness significantly increased users' behavioural intention. Bao, Hoque, and Wang (2017) tried to identify the antecedents of adult children's intention to use Internet health information for their aged parents. Findings indicated that attitude, subjective norm, perceived behavioral control, and risk were significant determinants of intention to use online health information whereas trust was not. Sirdeshmukh, Ahmad, Khan, and Ashill (2018) proposed a conceptual model regarding search engine performance. Functional performance significantly influenced search engine value, but aesthetic performance did not affect search engine value.

3 The Research Hypotheses

3.1 Determinants of Online Information Search Intention

The U&G theory were applied variously in the literature. For example, Information, convenience, entertainment, and social interaction factors were applied to the Internet study, while convenient entertainment, convenient info seeking, co-viewing, and social interaction factors were adopted in the study about YouTube (Liu et al., 2010). The U&G factors such as information were also explored as influences (motivations) of TV viewing and online user-shared video use (Bondad-Brown, Rice, & Pearce, 2012). Convenient information seeking was a convenient and quick way to find an update or in-depth information about the interest topics. Internet technologies such as blogs also offered vast dimension of information and provided links to aggregate news or experts (Kaye, 2010). Students mostly used the web for doing research or getting information (Metzger et al., 2003). Information seeking was one of factors received the highest mean scores as computer-user motives to use the Internet. It also significantly affected e-mail use and web browsing. Convenience was a remarkable factor which was the only significant factor driving the duration of the Internet use. It significantly predicted newsgroup or bulletin board use as well (Papacharissi & Rubin, 2000). Purposive value in terms of accomplishing informational or helpful purposes were believed to be a positive driver of students' intention to use online social networking systems (Ifinedo, 2016). Information seeking and convenience were two factors tended to associate with the Internet resources for political information (Kaye & Johnson, 2004). According to the literature research, easy to use was one of the most influential factors for website adoption (Liu et al., 2010). Web reliance was significantly impacted by the convenience of using the web (Johnson & Kaye, 2002). Effort and speed were the most important factors in choosing information sources.

Electronic materials were therefore preferred if they were faster or easier to access (Catalano, 2013). Ease of use was proposed to be positively related to search effectiveness, user satisfaction, and perceived benefit of online information search (Kulviwat, Guo, & Engchanil, 2004). Consumers tended to find products more easily and more productive when they perceived the website to be easy to use (Panjakajornsak et al., 2017). Fast and easy to search information was also the search engine value which positively associated with users' satisfaction with search engine (Sirdeshmukh et al., 2018). Therefore, the following hypotheses were suggested.

Hypothesis 1a: A full-time student's convenient information seeking positively affects his/ her intention to search for online information to fulfil his/ her task.
Hypothesis 1b: A full-time worker's convenient information seeking positively affects his/ her intention to search for online information to fulfil his/ her task.

Anti-traditional media sentiment was a reason people connecting to IT such as blogs because they wanted to independent from distasteful or biased traditional media (Kaye, 2010). Consumers were more likely to try a new medium when they were not satisfied with the current media (Jung, Chan-Olmsted, Park, & Kim, 2012). Flanagin and Metzger (2000) proposed that highly experienced users greater perceived the Internet as a credible information source, compared to conventional media such as TV, newspapers, or magazines than users with lower Internet experience. Johnson and Kaye (2002) believed that the credibility of traditional media would be positively driven by users' reliance on the Web and convenience of using the Web. Moreover, they proposed that reliance on the Web would be positively impacted by reliance on the traditional media, and reliance on traditional media such as newspaper, radio would be affected by the convenience of using the Web (Johnson & Kaye, 2002). The gratifications of printed media users and users' perceived need of printed media were positively related to e-book readers' awareness, interests, and their intention to use (Jung et al., 2012). The internet could satisfy users more with its broadest niche on users' gratifications than the traditional media (Dimmick, Chen, & Li, 2004). Therefore, the following hypotheses were proposed.

Hypothesis 2a: A full-time student's anti-traditional media sentiment positively affects his/ her intention to search for online information to fulfil his/ her task.

Hypothesis 2b: A full-time worker's anti-traditional media sentiment positively affects his/ her intention to search for online information to fulfil his/ her task.

The attractiveness of technology was also positively related to the behavioral intention in the context of web-based medical services (S. H. Wang, 2017). Aesthetic performance in the aspect of design attractiveness was a second major driver of search engine value. Perceived aesthetic performance was also proposed to positively affect the search engine value (Sirdeshmukh et al., 2018). Internet ambiance, adapted from the blog ambiance of Kaye (2010), were the enjoyment of users affiliating with a specific content. People preferred the good writing of online content and they found the content interesting. Media such as the Internet provided a wide range of content and gratification opportunities. Perceived content was one of the attributes of a medium, presenting gratification opportunities. A medium offering a greater array of content types better provided gratification opportunities to its audience (Dimmick et al., 2004). Perceived content quality had a positive impact on e-book adoption (Shin, 2011). Perceived value was proposed to be a direct determinant of behavioral intention (Panjakajornsak et al., 2017). Relevance (content) was proposed to be a driver of the Internet usage in terms of total using hours and activity levels (Nayak, Priest, & White, 2010). Information quality gratification was a main determinant of a media usage according to U&G theory. Information quality significantly predicted behavioral intention to engage in social commerce (Sharma & Crossler, 2014). Content gratification in terms of disconfirmation of self-documentation and disconfirmation of information sharing significantly increased Twitter users' level of satisfaction (Liu et al., 2010). Therefore, the following hypotheses were postulated.

Hypothesis 3a: A full-time student's Internet ambiance positively affects his/ her intention to search for online information to fulfil his/ her task.
Hypothesis 3b: A full-time worker's Internet ambiance positively affects his/ her intention to search for online information to fulfil his/ her task.

3.2 Online Information Search Intention and Credibility Judgement Intention

Students should be able to search and retrieve information from appropriate resources and evaluate obtained information, particularly information from the Internet (Shanahan, 2008). Credibility played a mediator role between technology attractiveness and patients' behavioural intention with regard to a web-based medical service (S. H. Wang, 2017). According to goal-sub goal relationships, plans were subject to hierarchical processes in which events happened in sequences: information search intention and intention to use the Internet to purchase, for instance. Intention to use the Internet to search product information also strongly lead to a positive purchase intention and mediated the relationships between purchase intention and other factors such as attitude toward online shopping, perceived behavioural control, and previous Internet shopping experience (Shim, Eastlick, Lotz, & Warrington, 2001). After people sought for information resources as the result of a predictive judgment, they would perform an evaluative judgment. For instance, they evaluated that whether the content was interesting, relevant, or trustworthy, how reliable or good Internet information appeared to be, or whether the website was official. This process would be repeated until the evaluative judgment met the expectation about the predictive judgment (Rieh & Hilligoss, 2008). Common criteria for credibility judgments were information itself (e.g. organization, content, breadth, depth, type), source (e.g. reputation), and presentation (e.g. design, layout, graphics, navigability, functionality, readability) (Rieh & Hilligoss, 2008). Therefore, the following hypotheses were developed.

Hypothesis 4a: A full-time student's intention to search for online information positively affects his/ her intention to judge online information to fulfil his/ her task.
Hypothesis 4b: A full-time worker's intention to search for online information positively affects his/ her intention to judge online information to fulfil his/ her task.

3.3 Determinants of Credibility Judgement Behavior

The Theory of Planned Behaviour (TPB) posited that intention to perform a behaviour caused a behaviour (Shim et al., 2001). Behavioural intention was the most important construct in predicting the decision to perform a certain behaviour (Al-Debei, Al-Lozi, & Papazafeiropoulou, 2013). It also was a significant motivator of continuance participation behaviour on Facebook (Al-Debei et al., 2013). Behavioural intention also had a significant impact on adult children's behaviour to adopt online health information for their aged parents (Bao et al., 2017). Motivation to search was proposed to be a positive influence of online information search (Kulviwat et al., 2004; Liao & Fu, 2014). The searching for information and the judgment of retrieved information were two core information processes (Chaxel, Russo, & Kerimi, 2013). Evaluating obtained information from the Internet was complex, including multiple criteria. The increase of multiple evaluation criteria for Internet information could raise the likelihood students using high quality information sources (Shanahan, 2008). Information, source, and presentation played the most vital role in credibility judgment that could be identified from participants' behavior and experience (Rieh & Hilligoss, 2008). Therefore, the following hypotheses were posited.

> *Hypothesis 5a: A full-time student's intention to search for online information positively affects his/ her credibility judgement behaviour.*
> *Hypothesis 5b: A full-time worker's intention to search for online information positively affects his/ her credibility judgement behaviour.*
> *Hypothesis 6a: A full-time student's intention to judge online information positively affects his/ her credibility judgement behaviour.*
> *Hypothesis 6b: A full-time worker's intention to judge online information positively affects his/ her credibility judgement behaviour.*

3.4 Differences between Full-Time Students and Full-Time Workers

When comparing between the student and employee groups, the impact (path coefficients) of perceived hedonic usefulness on intention to use IT was different across the two groups (Gu, Fan, Suh, & Lee, 2010). Compared to the non-student group, students perceived that all information channels were more credible than non-student samples (Metzger et al., 2003). NetGen respondents had the highest and Old Boomer respondents had the lowest means across all online users-shared video (OUSV) motivations. The overall OUSV motivations in the younger generations (NetGen and GenX) were generally higher than Old Boomers. Regarding TV viewing, information motivation of Silent/ GI generation was higher than information motivation of GenX (Bondad-Brown et al., 2012). There was a significant negative association between the age of adopters and non-adopters and broadband adoption. In addition, there was a significant correlation between the type of occupation (household occupation) of adopters and non-adopters and broadband adoption (Dwivedi & Lal, 2007).

Age was negatively related to awareness, interest, and intention to use e-book, while education was positively related to awareness, interest, and intention to use e-book (Jung et al., 2012). Age was significantly and negatively determined the use of websites for convenience, the use of bulletin boards or e-mailing list for entertainment/social needs and for guidance purposes. Education significantly and positively associated with the motivations to use Internet resources such as website, bulletin board, e-mailing list, and chat for political information (Kaye & Johnson, 2004). There were significant differences in age and education means regarding technophobia and technophilia except for technophilia about education. Younger people had a high probability of being the Internet users, compared to older people. Education also had a strong influence on the Internet usage (Donat, Brandtweiner, & Kerschbaum, 2009). Younger people viewed these media more credible than older people. Moreover, respondents who were less educated and had lower incomes believed online radio news more credible (Johnson & Kaye, 2002). Young people aged 18 to 34, computer owners, well-educated, and with English language skills had more possibility to access the Internet (Panjakajornsak et al., 2017).

Hypothesis 7: Antecedent factors affecting credibility judgment behaviour will result in several differences between full-time students and full-time workers.

4 Methodology

4.1 Questionnaire Development

Table 1. Sources of questionnaire items.

Construct	An Example Question	Sources
U&G Convenient Information Seeking	I use online sources because... to get information quickly (5-point Likert-type scale)	Adapted from Kaye (2010)

Construct	An Example Question	Sources
U&G Anti-traditional Media Sentiment	I use online sources because... to avoid conservative sources bias (5-point Likert-type scale)	Adapted from Kaye (2010)
U&G Internet Ambiance	I use online sources because... because of the good writing of Internet information (5-point Likert-type scale)	Adapted from Kaye (2010)
Intention to Search for Information	Please specify your level of intention when searching information from the Internet... Searching for new learning materials (5-point Likert-type scale)	Adapted from Lee and Tsai (2011) and Limberg and Sundin (2006)
Intention to Judge Online Information	Please specify your level of intention when verifying information from the Internet... Evaluate information factor (content quality) before use (5-point Likert-type scale)	Adapted from Rieh and Hilligoss (2008), Lee and Tsai (2011), Limberg and Sundin (2006) and (Flanagin & Metzger, 2000)
Credibility Judgement Behavior	Regarding information for studying/ working purposes, how many times have you checked the quality of information from 10 times lately? (ratio scale)	Adapted from Kaye and Johnson (2004), Metzger et al. (2003), (Nayak et al., 2010)

The online questionnaire was divided into four sections. The first section was designed to ask about the uses and gratifications of information from the Internet. The second section was designed to ask about searching for online information. The third section was designed to ask about the credibility judgment of the Internet information before use. The last section collected demographic data of respondents. The details and references of questionnaire development were described in Table 1.

4.2 Data Collection

This study is a sub-project of a project titled INFORMATION VERIFICATION. The online questionnaire was pre-tested and revised. The final questionnaire was sent to full-time students less than 35 years of age and full-time workers more than or equal 20 years of age. Two research assistants and their teams helped to collect the data using the Google form. Finally, four hundred and fifty three questionnaires were ready for further analysis. Of all data, 243 questionnaires were gathered from full-time students and 210 questionnaires were collected from full-time workers.

5 Data Analysis

5.1 Descriptive Statistics

Table 2. Sample demographics.

	Full-Time Students (n=243)	**Full-Time Workers (n=210)**
Gender		
Male	80 (32.9%)	59 (28.1%)
Female	163 (67.1%)	151 (71.9%)
Age (years old)		
< 15	10 (4.1%)	0 (0.0%)
15 – 19	86 (35.4%)	0 (0.0%)
20 – 24	142 (58.4%)	16 (7.6%)
25 – 29	5 (2.1%)	76 (36.2%)
30 – 34	0 (0.0%)	71 (33.8%)
35 – 39	0 (0.0%)	28 (13.3%)
>=40	0 (0.0%)	19 (9.0%)
Educational Level (Studying/ Graduated)		
Junior high school	17 (7.0%)	20 (9.5%)
Senior high school	17 (7.0%)	

	Full-Time Students (n=243)	**Full-Time Workers (n=210)**
High vocational certificate	6 (2.5%)	
Bachelor degree	193 (79.4%)	105 (50%)
Master degree	10 (4.1%)	85 (40.5%)
Doctoral degree		0 (0.0%)
Post-doctoral degree		0 (0.0%)
Internet Access Device		
Mobile phone	208 (85.6%)	193 (91.9%)
Tablet	66 (27.2%)	76 (36.2%)
Notebook/ Netbook	188 (77.4%)	147 (70.0%)
Desktop computer	109 (44.9%)	123 (58.6%)
Frequency of Judging Internet Information Credibility (from 10 times)		
Mean	5.05	5.93
SD	2.721	2.930

The demographics, presented in Table 2, showed that there were more females than males in both groups (full-time students and full-time workers). The majority of full-time students were in age between 20 and 24 years old, while the majority of full-time workers were at age between 30 and 34 years old. Full-time students were studying at the bachelor level. Full-time workers were graduated from the bachelor degree. The main devices that both full-time students and workers used to access the Internet was their mobile phones. From 10 times of acquiring information from the Internet, the average credible judgments of online information were slightly more frequent among full-time workers than full-time students.

5.2 Measurement Model

A Confirmatory Factor Analysis (CFA) was conducted to validate the convergent and discriminant validity of latent variables and corresponding items from literature. Convergent validity was evaluated by checking each item loadings for each corresponding factor was above the recommended value of 0.50 (Dubihlela & Dhurup, 2015; Dunn, Seaker, & Waller, 1994). For both university student sample and full-time worker sample, factor loadings were above 0.50 and were significant at the 0.001 level. The internal consistency of each factor was evaluated by Cronbach's alpha. As shown in Table 3 and Table 4, the results demonstrated acceptable internal consistency, based on the ideal threshold of 0.7 and an acceptable threshold of 0.5 (Tillmann & Silcock, 1997) or 0.6 (Churchill Jr, 1979; Rahimnia & Hassanzadeh, 2013). Composite reliability (CR) exceeded the suggested threshold of 0.7 (Dubihlela & Dhurup, 2015; Horng & Chen, 1998; Jum, 1978) and minimum threshold of 0.6 (Bagozzi & Yi, 1988; Fornell & Yi, 1992; Jahanshahi, Rezaei, Nawaser, Ranjbar, & Pitamber, 2012; Tsao & Chang, 2010) for factors in both samples.

As indicated in Table 3 and Table 4, the average variance extracted values (AVEs) were above the recommended cut-off value of 0.6 (Bagozzi & Yi, 1988; Tsao & Chang, 2010) and acceptable cut-off value of 0.4 (Adeleke, Bahaudin, & Kamaruddeen, 2015; Dubihlela & Dhurup, 2015; Li, Zhao, Tan, & Liu, 2008; Mohamed & Anisa, 2012), showing reliability for all items of each factor. Discriminant validity was assessed by comparing AVEs of two factors with the squared correlation estimates to evaluate whether constructs differ from each other. For all comparisons in both samples, AVEs were higher than the square of correlations as presented in Table 3 and Table 4, indicating good discriminant validity. In addition, common benchmark criteria were satisfied by the goodness-of-fit measures (Bentler, 2006; Bollen, 1987; Hooper, Coughlan, & Mullen, 2008; Kline, 2010; Lomax & Schumacker, 2004; Schermelleh-Engel, Moosbrugger, & Müller, 2003; Schreiber, Nora, Stage, Barlow, & King, 2006; Y. S. Wang, Wu, & Wang, 2009), showing the adequate fit of the research model, as described in Table 5.

Table 3. Results of the confirmatory factor analysis and inter-construct correlation matrix for full-time students

Construct	No. of items	CR	AVE	Cronbach's alpha	Mean	SD	UG_CIS	UG_AT	UG_IA	I_S	I_J
U&G Convenient Information Seeking	3	0.852	0.657	0.803	4.34	0.69	0.811				
U&G Anti-traditional Media Sentiment	3	0.866	0.684	0.801	2.98	0.93	0.112	0.827			
U&G Internet Ambiance	3	0.676	0.416	0.573	3.49	0.69	0.521	0.523	0.650		
Intention to Search for Information	3	0.787	0.553	0.770	3.73	0.64	0.548	0.259	0.647	0.744	
Intention to Judge Online Information	3	0.856	0.665	0.832	3.73	0.66	0.354	0.285	0.516	0.638	0.815

Table 4. Results of the confirmatory factor analysis and inter-construct correlation matrix for full-time workers

Construct	No. of items	CR	AVE	Cronbach's alpha	Mean	SD	UG_CIS	UG_AT	UG_IA	I_S	I_J
U&G Convenient Information Seeking	3	0.893	0.737	0.879	4.54	0.62	0.858				
U&G Anti-traditional Media Sentiment	3	0.905	0.762	0.867	3.10	1.01	-0.034	0.873			
U&G Internet Ambiance	3	0.779	0.541	0.685	3.73	0.70	0.449	0.470	0.736		
Intention to Search for Information	3	0.809	0.585	0.762	3.97	0.61	0.500	0.120	0.465	0.765	
Intention to Judge Online Information	3	0.871	0.693	0.848	3.84	0.70	0.349	0.216	0.335	0.659	0.832

5.2 Structural Equation Model Analysis

Table 5. Fit indices for measurement models and structural models

Goodness-of-fit measure	Recommend Value	Measurement Model of Full-Time Students	Measurement Model of Full-Time Workers	Structural Model of Full-Time Students	Structural Model of Full-Time Workers
$\chi 2$/df	<= .3	1.502	1.230	1.449	1.280
SRMR	<=.08	.0527	.0550	.0529	.0572
GFI	>=.9	.942	.946	.936	.935
AGFI	>=.9	.908	.917	.905	.905
NFI	>=.9	.920	.935	.909	.923
TLI	>.9	.960	.983	.960	.976
IFI	>.95	.972	.987	.970	.982
CFI	>.95	.971	.987	.969	.982
RMSEA *p-value* for test of close fit	<.06 .05<= *p* <=.10	.046 *p-value* = .651	.033 *p-value* = .906	.043 *p-value* = .755	.037 *p-value* = .880
HOTLER	>200	229	240	230	225

A structural model was applied to examine causal relationships among the theoretical constructs. The fit statistics for final models were good, as shown in Table 5. The overview of structural equation model results is shown in Figure 1.

For the full-time students, four of six paths were significant. The model accounted for 12.7% of the variance in the credibility judgment behaviour of students. Intention to search for online information and intention to judge online information significantly affected full-time students' credibility judgment behaviour with path coefficients of -0.236 ($p < 0.005$) and 0.462 ($p < 0.001$), respectively. Intention to search information online of students explained 42.6% of the variance in their intention to evaluate online information with a path coefficient of 0.652 ($p < 0.001$). One U&G factor that was Internet ambiance positively predicted students' intention to seek online information with the path coefficient of 0.690 ($p < 0.01$), and the variance was 0.545.

For the full-time workers, four of six links were significant. The model explained for 18.6% of the variance in the credibility judgment behaviour of students. Intention to judge online information significantly affected full-time workers' credibility judgment behaviour with a path coefficient of 0.433 ($p < 0.001$). Intention to search information online of workers accounted for 45.0% of the variance in their intention to evaluate online information with a path coefficient of 0.671 ($p < 0.001$). Two U&G factors: convenient information seeking and Internet ambiance, positively determined workers' intention to search information from the Internet with path coefficients of 0.382 ($p < 0.001$) and 0.275 ($p < 0.005$) respectively, accounting for 32.7% of the variance in the intention. Therefore, there were enough evidences to conclude the statements in hypotheses *H1b, H3a, H3b, H4a, H4b, H5a* (negative impact), *H6a*, and *H6b*.

For the student group, the significant paths were UG_IA- I_S, I_S- I_J, I_S- J_B, and I_J-J_B. On the contrary, for the worker group, the significant paths were UG_CIS-I_S, UG_IA- I_S, I_S- I_J, and I_J-J_B. The path coefficient for convenient information seeking and intention to search online information was not significant for the full-time students, whereas the path coefficient for intention to search for online information and credibility judgment behaviour was not significant for the full-time workers. Consequently, there was an empirical evidence to not reject the statement in Hypothesis *H7*.

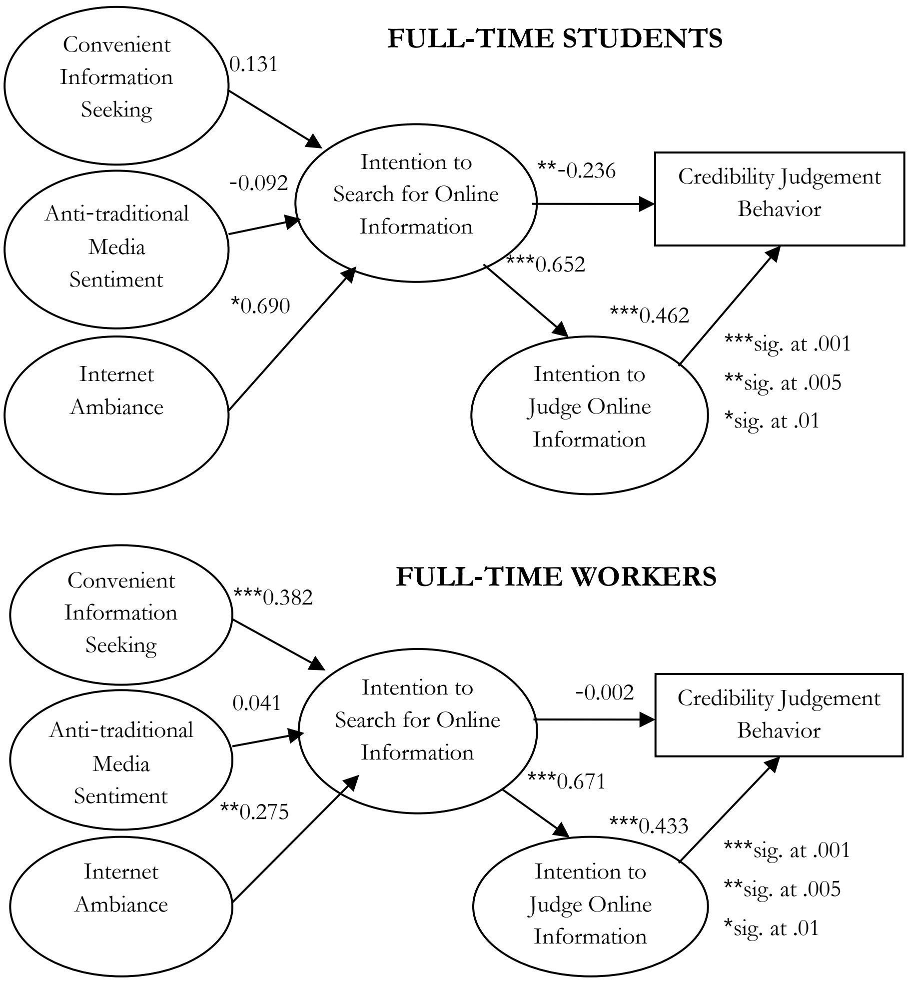

Figure 1. Standardized estimates for SEM of full-time students and full-time workers

5.2 Discussion of Findings

For full-time workers, their convenient information seeking and Internet ambiance motivations positively affect their intention to search for online information to fulfil their tasks. That intention positively drives their intention to judge the retrieved information. The intention to evaluate online information finally leads to their credible judgment behaviour. For full-time students, their Internet ambiance motivation positively influence their intention to search for online information to fulfil tasks. The intention to search later determines their intention to judge Internet information. Their intention to judge online information drives full-time students to evaluate the information quality. Antecedent factors of credibility judgment behaviour are different between full-time students and full-time workers. These findings conform to the literature research as explained in the section 3.

One hypothesis (*H5a*) is statistically meaningful, but in the negative way. This could be explained by the findings of Metzger et al. (2003) indicating that students perceived the credibility of all traditional media differently from non-students, but they did not differ in their ratings of Internet credibility specifically. Both students and non-students reported that they evaluate online information rarely or occasionally. Non-students emphasized that they verified online information more that students did. The students also used the Web for entertainment purpose rather than for research, news, or business information. High school students did not use the credibility as a factor in assessing information. They paid higher attention to the graphics and multimedia of a website than the quality of information (Agosto, 2002). Young people would compromise their credibility judgement when faced the dilemma to select between quickly access resources or to select more credible but more time-consuming resources. These cases frequently occurred when they believed that the consequences of using that information were not critical (Rieh & Hilligoss, 2008). In addition, not all college students were confident in their credibility judgment of information. Some students said they could not know the credibility of information or the believability of some information sources until they using it (Rieh & Hilligoss, 2008). Moreover, when using the acquired information for the reference purpose, respondents gave credibility ratings to the Internet as a source more than other media, i.e. magazines, radio, and television (Flanagin & Metzger, 2000). Thus, after the student intended to search information online, they may not immediately perform the credibility assessment because of their trust on the Internet credibility.

The rejection of the hypothesis *H1a* could be explained by the study of Bondad-Brown et al. (2012) pointing that information was not a significant driver of television viewing. The purposive value to accomplish something with specified informational purpose did not positively influence students' intention to use social networking systems (Ifinedo, 2016). Use motivations in term of convenience and information seeking did not correlate with the number of online activities (Kaye & Johnson, 2004). Ease of use did not significantly impact the Internet usage (Nayak et al., 2010). The perceived ease of use was also found to be stronger for older people than younger people (Pan & Jordan-Marsh, 2010). The rejection of hypotheses *H2a* and *H2b* could be explained by the study of Johnson and Kaye (2002) stating that reliance on traditional media did not predict reliance on the Web. Moreover, the credibility of other media (online newspapers, television news, radio news, and news magazines) was not predicted by reliance on the Web (Johnson & Kaye, 2002). Internet users did not significantly perceive the Internet to be a more trusted information source in relation to traditional media (Flanagin & Metzger, 2000). The rejection of the hypothesis H5b may be because intention to search did not directly determine credibility judgment behaviour, but indirectly affect the behaviour through intention to verify online information. The judging credibility of information was not always explicitly concerned every time a participant picking up an information source (Rieh & Hilligoss, 2008). In addition, there was a negative relationship between self-reported and real information evaluation behaviour (Flanagin & Metzger, 2007).

6 Implications for Theory and Practice

This study presents a noteworthy contribution to the literature to explore different aspects of the uses and gratifications theory as predictors of people's intention to search online information to complete their tasks. This study also investigates the direct and indirect influence of two wills: intention to search and intention to verify online information, on actual credibility judgment behavior. The strong point of the study lies in the extension of the established TPB framework with a novel view of the motivations and intention and the comparison between two groups: full-time students and full-time workers who may have different tasks to fulfill. The research model has a meaningful explanatory power, which could be extended to study individuals' in-formation seeking and verifying behavior in other contexts in the futures such as searching Internet information and using it for other purposes.

The findings of this study have practical implications for educators, managers, and policy makers who support the use of the Internet for searching information to improve productivity. Firstly, the quality of information is critical. It should be evaluated during online information search process. Secondly, the credibility judgment behavior of individuals is driven by their intention to evaluate information from the Internet. Credibility judgment intention could be aimed at assessing information itself, such as organization and content, its source, such as reputation and credibility of sources, or its presentation, such as design and layout. Educators, managers, and policy makers should guide their students, employees, and citizens about how to judge the online information quality. Thirdly, in terms of intention to search online information, students' intention to search for new learning materials, to read and understand the content carefully, and to organize and to synthesize founded materials or information from various sources negatively drives their credibility judgment behavior. This may happen because students plan to put some efforts in the information-seeking phase, so they possibly neglect to verify the quality of online information suitably. However, teachers or instructors should emphasize the importance of credibility evaluation to students. Intention to search online information directly affects intention to assess that information, and indirectly enhances the credibility judgment behavior. This result points that when students or employees conduct any information search for their tasks, they al-ways consider about evaluating the content, source, and presentation of Internet information. Therefore, educators, managers, and policy makers should increase knowledge and enhance the experiences of students and workers regarding searching for new Internet materials, skimming and scanning the retrieved information, and synthesizing information from different online channels. Lastly, to understand why students start an online search for task completion, they search from the Internet because of Internet ambiance. They like the good content/ writing of online content. They think that online content is interesting. They also want to access new content from new content providers or specific topics. Employees are driven to search online in-formation to fulfill their tasks due to the Internet ambiance as well. In addition, they access the Internet content because they want to get information quickly, to access information anywhere, anytime, and to reach a wide variety of information. Educators and managers should give some advices about objectives before search and clearly specify the seriousness of information credibility used to accomplish their school/ working tasks, to make students and workers properly trading off between speed and quality.

7 Conclusion and Future Research

This exploratory study introduces a research model of constructs that are possibly affect intention to seek for online information. The intention to search information to complete studying or working tasks together with the intention to assess the online information quality are later posited to influence actual credibility judgment. The research model is developed based on the Theory of Planned Behaviour and the Uses and Gratifications theory. This study fills the gap by utilizing nascent U&G factors as the determinants of individuals' decisions to evaluate information for task fulfillment critically. Structural Equation Modelling (SEM) is used to test the formulated model, applying data collected from surveys of full-time students and full-time employees. Findings indicate associations between U&G factors and TPB factors. Data analysis supports 9 out of the 13 proposed hypotheses. This paper presents two sample sets of the model and suggests some guidance for teachers/ instructors, administrators, and policy makers to nurture credibility judgment to their students and workers.

Although this study shows some interesting results, it has some limitations. Firstly, the majority groups were females and people with Bachelor degree backgrounds. Secondly, the purpose of information search and verification focused only on fulfilling school/ working tasks. Thirdly, some constructs met the acceptable criteria even though they were adapted from the literature research. Therefore, it could not claim that the findings can be generalized to other countries with different environments.

Future research should conduct the study with some more samples from other countries, different comparison groups such as undergraduate students versus graduate students, professionals versus trainees, various information seeking purposes such as for personal pleasure, and task types, to increase generalizability. More antecedents of information search and judgment should be investigated, drawing from other theories such as Behavioral decision theory. Relevant factors impacting credibility judgment behavior should be added such as knowledge for credibility verification. Socioeconomic factors relating to information-seeking process such as gender and occupation should be explored. Qualitative study should be conducted to enhance understanding about information-seeking process. Longitudinal study should be explored to expand conclusive information. More studies are needed to understand why some uses and gratifications constructs were not significant such as anti-traditional media sentiment. The measurement items for some constructs such as Internet ambiance should be further refined to meet the ideal threshold.

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The Potential Impact of Gamification Elements on the Acceptance of Technology in the Context of Education: A Literature Review

JAN VAN ELDEREN & ESTHER VAN DER STAPPEN

Abstract Innovative new digital technologies arise within the field of education every day. There seems to be a large potential impact in using gamification for improving acceptance and use of new technologies in education. This study aims to gain better and new insights on how to improve the acceptance of new educational technology by applying gamification elements. To this aim, we performed a systematic literature review of 1271 publications, yielding 56 relevant studies. We positioned these studies based on which gamification element(s) and which educational technology acceptance constructs were discussed. Our results show that few studies focus on individual gamification elements and that most studies focus on the same elements and constructs, i.e. Learning Expectancy, Social Influence and Hedonic Motivation are the most discussed constructs related to increasing the acceptance of educational technology when applying gamification, while Points, Badges, Leaderboards and Social Games & Teamwork are the most discussed gamification elements. The impact of gamifying educational technology is mixed – both negative and positive results are being reported – and thus we conclude that the knowledge of how to successfully gamify educational technology is still limited.

Keywords: • Gamification • Acceptance of Technology • Technology-Enhanced Learning • Adoption • Literature Review •

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1 Introduction

Innovative new digital technologies arise within the field of education every day. Many educational technologies have been developed over the last years: e-learning, Massive Open Online Courses (MOOCs), Computer Supported Collaborative Learning (CSCL) and many more (Kirkwood & Price, 2014). In literature, all are referred to as 'Technology-Enhanced Learning' (TEL). TEL has the potential to reproduce existing teaching methods and supplement or transform teaching and/or learning processes and outcomes (Kirkwood & Price, 2014).

Recent research on the acceptance of mobile e-banking (Baptista & Oliveira, 2017) showed that using gamification - 'the use of game elements in a non-gaming context' (Deterding, Sicart, Nacke, O'Hara, & Dixon, 2011) - has a big impact on the adoption of new mobile banking technology. Using game elements in a non-gaming context is already being applied in different industries, domains and subjects, such as health, retail, military, government and in education (Robson, Plangger, Kietzmann, McCarthy, & Pitt, 2015).

It is expected that gamification will more easily capture and sustain the interest of millennials (Baptista & Oliveira, 2017) - as they are 'raised on games' (Gamrat, Zimmerman, Dudek, & Peck, 2014). There seems to be a large potential impact in using gamification for improving acceptance and use of new technologies in education. This study aims to gain better and new insights on how to improve the acceptance of new educational technology by applying gamification elements. Currently, gamification has a low solution maturity (Liu, Santhanam, & Webster, 2017); we recognize the opportunity to contribute new knowledge to this field and to propose new connections. Our research intends to yield a deeper understanding on the impact of gamification in the adoption of technology (Baptista & Oliveira, 2017) by answering the following research question: 'What is the relationship – according to literature - between gamification elements and the core constructs that influence the acceptance of technology, in the context of education?'.

2 Theoretical Background

2.1 Technology-Enhanced Learning

Technology-Enhanced Learning (TEL) gives the advantage of easier access to information and creates flexibility in time and location of learning for the student, the lecturer and the organization. It is focused on being learner-centered to achieve positive learning results (Trepule, Tereseviciene, & Rutkiene, 2015). These advantages explain why innovations such as flipping the classroom or blended learning, backed by digital technologies have become popular lately (Y. Song & Kong, 2017). Various research (Al-Qahtani & Higgins, 2013; Garrison & Kanuka, 2004; Rovai, 2004; Yapici & Akbayin, 2012) shows that students' achievements and their attitudes toward learning in blended learning positively changed compared to face-to-face learning. The discrepancy between the intentions of TEL and its acceptance by learners is a widely recognized problem in educational settings and has been subject to various recent studies. The acceptance and adoption of TEL by students is influenced by the ease of use, usefulness, utility, enjoyment and software availability perceived by students (Acosta-Gonzaga & Walet, 2018; Bouchrika, Harrati, Mahfouf, & Gasmallah, 2018).

2.2 Acceptance of Technology

Problematic adoption of new educational technology is not without precedent (Flavin, 2017). To find reasons for (non)acceptance of new technology, multiple adoption theories have been introduced since the 70s. In 1980, Ajzen and Fishbein (Ajzen & Fishbein, 1980) published the 'Theory for Reasoned Action' (TRA), which was adapted by Davis (Davis, 1989) to the 'Technology Acceptance Model' (TAM). This model suggests that the adoption of an IT system is determined by the users' intention to use the systems, which is determined by the users' attitude towards this system (Davis, 1989; Surendran, 2012). The attitude is influenced by two perceptions: (1) the perceived ease of use, and (2) the perceived usefulness of the system. The most widely accepted theory today is the Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh, Morris, Davis, & Davis (Venkatesh, Morris, Davis, & Davis, 2003). Venkatesh, Thong and Xu (2012) consequently introduced a further refinement of the UTAUT model: the UTAUT2 model. While the first

UTAUT model only had four constructs, the new model has seven constructs (Venkatesh, Thong, & Xu, 2012): 1) Performance Expectancy; 2) Effort Expectancy, 3) Social Influence, 4) Facilitating conditions, 5) Hedonic Motivation, 6) Price, 7) Habit. In recent research on the acceptance of mobile e-banking (Baptista & Oliveira, 2017), it was found that using gamification has big impact on the acceptance of the new 'mobile banking' technology. In the next paragraph, we will elaborate on the concept of gamification.

2.3 Gamification

Gamification is defined in several different ways, and tends to differ per person, both in industry as within academia (Landers, Auer, Collmus, & Armstrong, 2018). However, the most accepted definition of gamification is "the use of game elements in a non-gaming context" (Deterding et al., 2011). This definition accurately describes both the means (game elements) and the context of application (non-gaming).

The world of games in real-life is immense: in 2015, 91.5 billion dollars was spent on playing digital games (Warman, 2015). Games are not only playful and fun, but have the opportunity to be instructive and meaningful for learning at the same time (Hummel et al., 2011). Central to the concept of gamification lies on the belief that, as gaming is more fun, adding game elements to a non-gaming system can make dull activities more attractive (Zichermann & Cunningham, 2011), and it triggers, if used in the right way, intrinsic motivation to use that system (Yildirim, 2017).

Gamification elements are the basic building blocks for gamified applications (Deterding et al., 2011; Liu et al., 2017; Werbach, 2014). The term 'elements' shows the difference of gamification and serious games (Deterding et al., 2011). In general, gamified solutions can be split up into three elements: rules, a system and fun (Mora, Riera, González, & Arnedo-Moreno, 2017). According to the MDA–framework proposed by Hunicke, LeBlanc and Zubek (2004), gamification can be divided into three design components:

1. ***Mechanics***, describing the particular components of the game, at the level of data representation and algorithms; They do not change from

one player to the next, but stay the same (Robson et al., 2015) and are the foundational aspects of the gamified experience.

2. ***Dynamics***, describing the run-time behavior of the mechanics on acting on player inputs and any other outputs over time; Dynamics are about 'how' the player follows the mechanics.
3. ***Aesthetics***, describing the desirable emotional responses evoked in the player when reacting with the game system (Hunicke et al., 2004).

Robson et al (Robson et al., 2015) conceptualized Aesthetics as Emotions. Gamification emotions are 'the mental affective states and reactions evoked among individual players when they participate in a gamified experience' (Robson et al., 2015). A preliminary, explorative literature review yielded no single accepted list of default gamification elements. Based on that review, we give a list of the gamification elements we encountered most often in gamification literature below, categorized based on the MDA-framework.

Table 1: Most encountered gamification elements in literature.

Mechanics	Dynamics	Aesthetics/Emotions
Points Badges Leaderboards Performance Graphs Virtual Gifts & Items	Increasing Task Difficulty Social Games & Teamwork	Avatars Meaningful stories

2.4 Linking gamification elements to UTAUT2-constructs

To explore the possible impact of gamification elements on UTAUT2 constructs, we created the table below with (an adaptation of) UTAUT2-constructs as columns and the above listed gamification elements as rows. Our adaptation of the list of UTAUT2-constructs is two-fold: 1) we changed Performance Expectancy into Learning Expectancy, since performance in TEL can be defined as learning and 2) we removed the construct Price, since users of TEL-solutions (pupils, learners, students) usually do not pay for this usage (licenses are paid for by the school or university). We will use Table 2 as an instrument to position studies we find in our systematic literature review later.

Table 2: Table to position studies that relate gamification elements to technology acceptance constructs.

		Learning Expectancy (LE)	Effort Expectancy (EE)	Social Influence (SI)	Facilitating Conditions (FC)	Hedonic Motivation HM)	Habit (HT)
Mechanics	Points						
	Badges						
	Leaderboards						
	Performance Graphs						
	Virtual Gifts & Items						
Dynamics	Social Games & Teamwork						
	Levels, Missions, Challenges & Quests						
Aesthetics	Avatars						
	Meaningful Stories						

3 Methodology

In this study, we aim to gain insights into which gamification elements have the potential to influence which aspects of the acceptance of technology. To achieve this goal, we performed a systematic literature review by following three steps as adapted from the approach by (Mortenson & Vidgen, 2016):

1. Define search criteria; To search though these databases we used a search query which was formulated based on our first explorative literature research: ("Gamification" OR "Game element*") AND ("Learning* OR "Learning Expectancy" OR "Effort*" OR "Social Influence" OR "Facilitating Conditions" OR "Hedonic Motivation" OR "Habit");
2. Searching in databases; We used a meta search engine which is connected to 63 of the biggest research databases worldwide. The following inclusion criteria are used during our search process:
    - Full-text, peer-reviewed publications;
    - Published in the last five years (between 2013 and 2018);
    - Written in the English language.
3. Selection; The resulting publications were selected based on relevancy for our research objective, with the specific focus on the acceptance of technology (instead of increasing learning performance in itself).

Whenever we found relevance sources in the full text, we followed the same process to check their relevance.

The included publications were then added to our database with name of the author(s), (sub)titles, and results (outcomes, game elements used), and used to fill Table 2.

4 Results

In this section the results of our literature review are presented. The total hits for our search terms (N = 1271), resulted in a total of 56 studies that meet the inclusion criteria, see Figure 1. After we selected the relevant studies, we positioned these studies according to the gamification elements and the technology acceptance constructs discussed in the respective studies. This gives us the complete overview and main result as presented in Table 3.

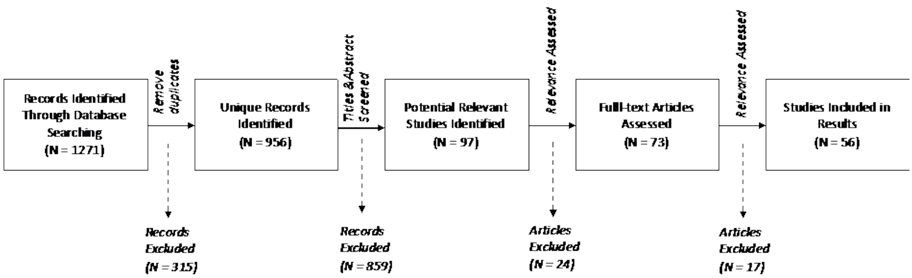

Figure 1: Search process results.

		Learning Expectancy (LE)	Effort Expectancy (EE)	Social Influence (SI)	Facilitating Conditions (FC)	Hedonic Motivation HM)	Habit (HT)
Mechanics	Points	(Attali & Arieli-Attali, 2015) (Hamari, 2013) (Robson, Plangger, Kietzmann, McCarthy, & Pitt, 2016) (Sailer, Hense, Mayr, & Mandl, 2017)		(Sjöblom, Törhönen, Hamari, & Macey, 2017)		(Aparicio, Vela, Sánchez, & Montes, 2012) (Doherty, Palmer, & Strater, 2017) (Mekler, Brühlmann, Tuch, & Opwis, 2017) (Pappas, 2015) (Przybylski, Rigby, & Ryan, 2010) (Robson et al., 2016)	(Chou, 2016) (Goehle, 2013) (Robson et al., 2016)
	Badges	(Gåsland, 2011) (Sailer et al., 2017) (van Roy & Zaman, 2018)		(Anderson, Huttenlocher, Kleinberg, & Leskovec, 2013) (Depura & Garg, 2012) (Hamari & Koivisto, 2013) (Kyewski & Krämer, 2018) (McDaniel, Lindgren, & Friskics, 2012)		(Aparicio et al., 2012) (Hamari, Hassan, & Dias, 2018) (Denny, 2013) (Hamari, 2017) (Hanus & Fox, 2015) (Mekler et al, 2017)	(Lucassen & Jansen, 2014) (Seaborn & Fels, 2015)
	Leaderboards	(Landers, Bauer, & Callan, 2017) (Sailer et al., 2017)		(Baabdullah, 2018) (Depura & Garg, 2012) (Jia, Liu, Yu, & Voida, 2017)		(Burguillo, 2010) (Landers, Collmus, & Williams, 2018) (Pappas, 2015) (Ruhi, 2015) (Song, Kim, Tenzek and Lee, 2013) (van Roy & Zaman, 2018)	(Landers and Landers, 2014) (McDaniel et al., 2012)
	Performance Graphs	(Cardador, Northcraft, & Whicker, 2017) (Ling et al., 2005) (Sailer et al., 2017)				(Doherty et al., 2017)	
	Virtual Gifts & Items	(Domínguez et al., 2013)				(Snyder & Hartig, 2013)	(Domínguez et al., 2013)
Dynamics	Social Games & Teamwork	(Diep, Cocquyt, Zhu, & Vanwing, 2016) (Hamari & Koivisto, 2015) (Hsu & Lu, 2004) (Toda, do Carmo, da Silva, Bittencourt, & Isotani, 2018)	(da Rocha Seixas, Gomes, & de Melo Filho, 2016)	(Baabdullah, 2018) (Hamari & Koivisto, 2015) (Molinillo, Muñoz-Leiva, & Pérez-García, 2018) (van Roy & Zaman, 2018).	(van Roy & Zaman, 2018)	(Hamari & Koivisto, 2015) (Hsu & Lu, 2004) (Lin, Wang, & Chou, 2012) (Mekler et al., 2017) (Shen, Cheung, & Lee, 2013) (Wang & Wang, 2008)	(Molinillo et al., 2018).
	Levels, Missions, Challenges & Quests	(Dong et.al, 2012) (Robson et al., 2016) (Toda et al., 2018)	(Landers et al., 2017)			(Aparicio et al., 2012) (Banfield & Wilkerson, 2014) (Dong et al., 2012) (Li, Grossman, & Fitzmaurice, 2012) (Seaborn & Fels, 2015) (van Roy & Zaman, 2018)	
Aesthetics	Avatars	(Annetta, 2010)		(Annetta, 2010)		(Annetta, 2010)	
	Meaningful Stories	(Groh, 2012) (Hitchens & Tulloch, 2018)	(Doherty et al., 2017) (Nicholson, 2015)	(Sailer et al., 2017)		(Clark & Rossiter, 2008) (Malamed, 2012) (Stott & Neustaedter, 2013)	

Table 3: Results of the systematic literature review.

A first glance at Table 3 makes us notice three aspects immediately:

1. Some of the cells are empty, i.e. we did not find any literature on the relation of 21 out of the 54 combinations of a gamification element and an UTAUT2-construct;
2. Some of the cells are very densely filled with references, i.e. most studies we found concentrate on the same combinations of a gamification element and an UTAUT2-construct;
3. Some of the selected studies appear in multiple cells, i.e. few studies focus on single gamification element and/or a single UTAUT2-construct.

We focus our review of the content of Table 3 on three notable aspects: Learning Expectancy, Social Aspects and Hedonic Motivation. For the sake of completeness, the entire table with results of the review is included as an appendix to this manuscript.

4.1 Learning Expectancy

For all gamification elements, we found studies that related that element to the construct Learning Expectancy. For the Mechanics elements such as Points, Badges and Performance Graphs and Virtual Gifts, many studies find that rewarding and showing progress increases the expectancy of the learner of the value of the TEL solution (Attali & Arieli-Attali, 2015; Cardador, Northcraft, & Whicker, 2017; Hamari, 2013; Landers, Bauer, & Callan, 2017; Ling et al., 2005; Robson, Plangger, Kietzmann, McCarthy, & Pitt, 2016; Sailer, Hense, Mayr, & Mandl, 2017). Points are typically used to give a reward for successful accomplishments of specified activities in the game, and serve to represent the progress of the player (Attali & Arieli-Attali, 2015). Badges indicate the achieved competence level and visibly show the level and goals (van Roy & Zaman, 2018). Clear achievements, like badges, improve safety and understanding of learning goals (Gåsland, 2011). By rewarding the player with an item, they will feel that they are performing well (Domínguez et al., 2013). Such Mechanics elements provide a continuous and direct feedback mechanism which links directly to perceived usefulness (Attali & Arieli-Attali, 2015; Cardador et al., 2017; Sailer et al., 2017) and visualizing competence development, increasing the feeling of value (Hamari, 2013) and the task meaningfulness (Sailer et al., 2017).

Furthermore, Dynamics and Aesthetics elements also have potential impact on Learning Expectancy. For example, interaction between students can achieve cross-learning and affect the performance expectancy of a game (Toda, do Carmo, da Silva, Bittencourt, & Isotani, 2018). Working in a team can positively influence the learner-learner interaction and improves knowledge sharing (Diep, Cocquyt, Zhu, & Vanwing, 2016), showing direct and explicit value. By giving players all a meaningful role, a sense of relevance can be triggered (Groh, 2012; Hitchens & Tulloch, 2018), boosting the expected feeling of value. And finally, avatar offers the players freedom of choice and autonomy and increases decision freedom and task meaningfulness (Annetta, 2010).

4.2 Social Aspects

We see a clear relation in Table 3 between the element Social Games and Teamwork and the construct Social Influence. Studies in this cell note that social gaming affects experiences of social relatedness (Molinillo, Muñoz-Leiva, & Pérez-García, 2018), e.g. students can 'play' in groups, and share their results and high-scores conveniently on (external) social networking platforms (Baabdullah, 2018; Hamari & Koivisto, 2015). Social gamification elements can even spark the 'fear of missing out' (van Roy & Zaman, 2018).

Mechanics elements also have a potential impact on social influence. For example, individuals are more likely to engage in behaviors that they perceive others are also engaged in (Sjöblom, Törhönen, Hamari, & Macey, 2017), which can further be triggered through badges and leaderboards. Badges symbolize membership in a group of those who own the same badge and it has a social influence on players and co-players, especially when these badges are rare or hard to obtain (Hamari & Koivisto, 2013). With a leaderboard, players are 'ranked' according to their relative success, measured against chosen success criteria. As it shows who of the players performs best, it triggers competitiveness. This competition can have a positive influence for the people at the top of the list, but can have negative effects for the players at the bottom of the list (Jia, Liu, Yu, & Voida, 2017). Landers (2017) states that positive effects are more likely if the 'competitors' have approximately the same level. Kyewski & Krämer (2018) showed that using badges that could only be viewed by the individual themselves was evaluated more positively than those that were openly shared with others. Aesthetics elements can also have impact on the Social Influence. A shared, meaningful goal, can foster experiences of social relatedness (Sailer et al., 2017) and in cooperative games, avatars can help to become a part of a community (Annetta, 2010).

4.3 Hedonic Motivation

Most selected studies that focus on Hedonic Motivation, operationalize this construct in terms of enjoyment, intrinsic motivation or engagement. Most studies relate this construct with the elements Points, Leaderboards and Social Games & Teamwork.

Interactivity and feedback have a positive impact on the perceived enjoyment (Hsu & Lu, 2004; Lin, Wang, & Chou, 2012; Wang & Wang, 2008). Pappas (2015) found in a survey that 89% of the students state that a point system would increase their engagement.

However, several studies propose conditions before gamification elements can have positive effects on Hedonic Motivation. For example, Aparicio et al (2012) found that positive effects only occur when Mechanics elements are presented in a non-controlling and voluntary setting. Points only increase intrinsic motivation when the reward is the outcome of an achievement (Doherty, Palmer, & Strater, 2017). Mekler, Brühlmann, Tuch, & Opwis (2017) found in a controlled experiment with points and badges - contrary to earlier studies - that points and badges did not affect intrinsic motivation significantly. Leaderboards also might have a negative impact: students in a team low in the rankings seems to suffer lower levels of self-believe and will likely move away from the solution (van Roy & Zaman, 2018).

Using social media or multi-player games creates a 'we-intention' (Shen, Cheung, & Lee, 2013) and social norms (Hsu & Lu, 2004). Meaningful stories, with narrative context, will give meaning to score more points and achievements (Malamed, 2012).

The element Levels, Missions, Challenges & Quests is closely related to the motivational aspect of mastery and indeed we see several studies stating that increasing the task difficulty does increase engagement and enjoyment (Banfield & Wilkerson, 2014; Li, Grossman, & Fitzmaurice, 2012; Seaborn & Fels, 2015).

However, again not all potential impact is positive. For example, (van Roy & Zaman, 2018) found challenges to only be effective for those students who we already motivated to do well from the very start.

5 Conclusion

We have conducted a systematic literature review on the potential impact of gamification elements on the acceptance of technology in the context of education. Supported with previous systematic reviews of current gamification research (Hamari, Koivisto, & Pakkanen, 2014; Mekler et al., 2017; Oliver, 2017; Pedreira, García, Brisaboa, & Piattini, 2015; Seaborn & Fels, 2015) and critical review studies related to gamifying education (Dichev & Dicheva, 2017; Stott & Neustaedter, 2013), we can conclude that:

1. few studies have investigated the effect on individual gamification elements, especially in encountered in a controlled experimental setting;
2. the success of its application is mixed and the knowledge of how gamify educational environments is still limited.

We see several opportunities for future research. It is still unclear how these gamification elements can be successfully implemented in existing TEL solutions in practical settings. Other listings or classifications of game elements could also be explored. Sometimes, several studies we reviewed contradict each other in terms of positive or negative impact on the acceptance. We still believe applying gamification in educational settings can have benefits, but we also acknowledge it is not an easy undertaking and requires both contextual and situational considerations. We hope our results can support both researchers and practitioners to make such considerations based on relevant literature. Finally, our model of positioning studies might help researchers in designing their studies and practicitioners in designing their interventions.

Appendix 1: Full Table with Results of the Systematic Literature Review

Learning Expectancy (LE)	Effort Expectancy (EE)	Social Influence (SI)	Facilitating Conditions (FC)	Hedonic Motivation (HM)	Habit (HT)	
Points provide direct feedback regarding task performance, which is one of the most frequently applied psychological interventions (Attali & Arieli-Attali, 2015). When gamers compare their points, badges and rewards, they are benchmarking themselves (Hamari, 2013) and therefore see their own competence development, increasing the feeling of value. Point and other rewards must be meaningful in the eyes of the players to enhance the expectancy of value (Robson et al., 2016). The need for competence can be addressed with points, badges, leaderboard and performance graphs (Sailer et al., 2017).		Individuals are more likely to engage in behaviors that they perceive others are also engaged in (Sjöblom et al., 2017), meaning other students' performance in points have a function as source of information.		Points, levels and leaderboards promote the competence need only provided they are presented in a non-controlling and voluntary setting (Aparicio et al., 2012). Points only increases intrinsic motivation when the rewards is the outcome of an achievement (Doherty et al., 2017). Mekler et al. (Mekler et al., 2017) found in a controlled experiment with points and badges, contrary to other researches, that points and badges did not affect intrinsic motivation significantly. Pappas (Pappas, 2015) found in a survey that 89% of the students state that a point system would increase their engagement. Goal metrics, like points and badges function as (positive and) informational feedback, and therefore improve intrinsic motivation, as they create opportunities for players to satisfy their need for competence (Przybylski, Rigby, & Ryan, 2010). Timing of (point) rewards is key. Reward behavior as quickly as possible after good performance. In addition by rewarding a series of simples behaviors, one can shape the desired complex	Rewarding points can be used to stimulate the participation of the users (Chou, 2016), resulting in being used to use the solution. Students were found to put in more effort to complete homework to obtain achievements (Goehle, 2013). In order to keep players playing, thereby contributing to the desired outcome, it is important to provide a sense of achievement and meaningful rewards for player behavior (Robson et al., 2016).	**Mechanics: Points**

Learning Expectancy (LE)	Effort Expectancy (EE)	Social Influence (SI)	Facilitating Conditions (FC)	Hedonic Motivation (HM)	Habit (HT)	
Clear achievements, like badges, improved safety and understanding of learning goals (Gåsland, 2011). The need for competence can be addressed with points, badges, leaderboard and performance graphs (Sailer et al., 2017). Results illustrated that students use badges and rankings to evaluate their own progress and evolution in the course, as they show the students their progression and competences explicitly (van Roy & Zaman, 2018).		Virtual badges have boosted user knowledge sharing via social media websites like Stackoverflow (Anderson, Huttenlocher, Kleinberg, & Leskovec, 2013). Using leaderboards, badges, e.g. improved the social bonding (Depura & Garg, 2012). It symbolizes membership in a group of those who own the same badge and it has an social influence on players- and co-players, especially when they are rare or hard to win (Hamari & Koivisto, 2013). Kyewski & Krämer (2018) showed that using badges that could only be viewed by the individual themselves was evaluated more positively then those that were openly shared with others. Students can be motivated to achieve badges that a friend already had achieved (McDaniel, Lindgren, & Friskics, 2012).		Points, levels and leaderboards promote the competence need only provided they are presented in a non-controlling and voluntary setting (Aparicio, Vela, Sánchez, & Montes, 2012). Results showed that users that could earn badges were significantly more likely to us the system in a more active way, contribute more and spend more time engaged with the system (Denny, 2013; Hamari, 2017). Denny (2013) found, in his study with undergraduate students in a gamified context with badges, that students had a moderate positively higher enjoyment and motivation derived from the solution. Individuals who focus on attaining specific outcomes rather than enjoying the process of attaining these outcomes could be expected to draw more motivation out of motivational features that emphasize to them the outcomes they want to attain and their value e.g. badges and medals (Hamari, Hassan, & Dias, 2018). The use of leaderboards and badges resulted in lower satisfaction, empowerment and motivation compared to the non-gamified class (Hanus & Fox, 2015). Mekler et al. (2017) found in a controlled experiment with points and badges, contrary to other researches, that points and badges did not affect intrinsic motivation	In research on gamification on consumer marketing, experts expressed that using badges could improve the loyalty, and therefore use of the solution/product (Lucassen & Jansen, 2014). Results showed that badges motivate the duration of engagement, without impacting response quality (Seaborn & Fels, 2015).	**Mechanics: Badges**

Learning Expectancy (LE)	Effort Expectancy (EE)	Social Influence (SI)	Facilitating Conditi	Hedonic Motivation (HM)	Habit (HT)	
A leaderboard showed a positive influence on performance levels, suggesting that participants implicitly set goals at or near the top of a leaderboard without prompting to do so (Landers et al., 2017). The need for competence can be addressed with points, badges, leaderboard and performance graphs (Sailer et al., 2017). Results illustrated that students use badges and rankings to evaluate their own progress and evolution in the course, as they show the students their progression and competences explicitly (van Roy & Zaman, 2018).		Players can play in groups and share their ranks and high scores, which will increase behavioral intention (BI) (Baabdullah, 2018). Using leaderboards, badges, e.g. improved the social bonding (Depura & Garg, 2012). The position a user has on the leaderboard has important effects on their perception of the leaderboard and the surrounding app. Still users recommend the system with leaderboard to friends, regardless of the ranking (Jia et al., 2017).		Leaderboards can increase the players' level of engagement and can have a contributive effect on participation (Burguillo, 2010). The presence of a leaderboard can increase task-motivation and performance, which is consistent with the well-known effect of goal setting (Landers, Collmus, & Williams, 2018). Pappas (2015) found, in a survey that 62% of students would be motivated to learn if leaderboards were involved and they had the opportunity to compete with others. Social elements are even more motivating when players are able to compare themselves to others in the same context as they then are able to make more accurate self-evaluations (Ruhi, 2015). Song, Kim, Tenzek and Lee (2013) found that players with a high-achievement motivation had a better performance in a competitive setting, while players with a low-achievement motivation had a more negative mood and where less intrinsically motivated.	A leaderboard motivated some students to seek out achievements and badges, which had a marginally positive influence on the overall use (McDaniel et al., 2012). Landers and Landers (2014) executed an experiment which showed the use of a leaderboard increased the amount of time students spent interacting with their group assignment.	**Mechanics: Leaderboards**
Access to performance information will give the gamer more 'direct feedback' (Cardador, Northcraft, & Whicker, 2017). Leaderboards, performance graphs and badges positively affect competence need satisfaction as well as the task meaningfulness (Sailer et al., 2017). The visible progress in performance and completion of goals lead to an increased satisfaction (Ling et al., 2005).				Simple, virtual, statistics were successfully implemented as an accomplishment technique, boosting motivation to use the solution (Doherty et al., 2017).		**Mechanics: Performance Graphs**

	Learning Expectancy (LE)	Effort Expectancy (EE)	Social Influence (SI)	Facilitating Conditions (FC)	Hedonic Motivation (HM)	Habit (HT)
Mechanics: Virtual Gifts & Items	By rewarding the player with an item, they will feel that they are performing well (Domínguez et al., 2013).				Rewards improved participation and engagement (Snyder & Hartig, 2013).	Players motivated by collectables will be tempted to continue working in order to get more items. When they are hidden and come by surprise, they may serve to promote exploration of the system features (Domínguez et al., 2013).
Dynamics: Social Games & Teamwork	Working in a team can positively influence the learner-learner interaction and improves knowledge sharing (Diep et al., 2016), showing direct and explicit value. "The more friends a user has in a service, the larger the effects are"(Hamari & Koivisto, 2015). Receiving recognition from (relevant) others can create reciprocal behavior, which can have a positive outcome to the (social) usefulness of the system (Hsu & Lu, 2004). Interaction between students can achieve cross-learning and affect the performance expectancy of a game (Toda et al., 2018).	Social/multi-player games can give players a sense of recognition for their effort (da Rocha Seixas, Gomes, & de Melo Filho, 2016).	Social gaming affects experiences of social relatedness, players can play in groups, and share their results and high-scores conveniently on e.g. social networking platforms (Baabdullah, 2018). Social influence, positive recognition and reciprocity will have a positive impact on how much people are willing to exercise as well as their attitudes and willingness to use the gamified service (Hamari & Koivisto, 2015). When strategies, tips and emotions (e.g. frustration and excitement) are shared, players develop strong social ties (Molinillo et al., 2018). "Data showed that group goals and activities became an incentive to use the solution and even sparked a 'fear of missing out'"(van Roy & Zaman, 2018).	A study in which students voluntary interacted with a gamified platform, showed that part of the students were not inclined to help their groupmates (van Roy & Zaman, 2018).	"Gamification elements that encompass a social element are generally experienced as more engaging than 'single player' elements" (Hamari & Koivisto, 2015). Using social media/multi-player games creates a 'we-intention' (Shen et al., 2013) and creates social norms (Hsu & Lu, 2004). Interactivity and feedback have a positive impact on the perceived enjoyment (Hsu & Lu, 2004; Lin et al., 2012; Wang & Wang, 2008). Players that are individually working on a single isolated task, generally experience little or no increase in motivation (Mekler et al., 2017).	Interaction with others has a positive impact on the convenience to play (Molinillo et al., 2018).

Learning Expectancy (LE)	Effort Expectancy (EE)	Social Influence (SI)	Facilitating Conditions (FC)	Hedonic Motivation (HM)	Habit (HT)	
Dong et.al (2012) found that a gamified puzzle helps the participants to learn how to use computer software, that the learning experience was evaluated to be effective, fun, unique and engaging. New levels, tasks or players are needed in order to continuously inspire. The difficulty must grow, while rules do not need to be changed (Robson et al., 2016). Cognitive challenges can be used to satisfy the players' internal needs of problem solving (Toda et al., 2018).	Goal setting is generally more effective for simple tasks, because it is easier for a person to see the connection between the effort and the goals achieved (Landers et al., 2017).			Points, levels and leaderboards promote the competence need only provided they are presented in a non-controlling and voluntary setting (Aparicio et al., 2012). A gamified puzzle increased students' intrinsic motivation to perform in a system engineering class (Banfield & Wilkerson, 2014). Dong et.al (2012) found that a gamified puzzle helps the participants to learn how to use computer software, that the learning experience was evaluated to be effective, fun, unique and engaging. Using levels/missions in a gamified course showed an increase in engagements, enjoyment and performance (Li et al., 2012; Seaborn & Fels, 2015). Van Roy and Zaman (2018) found a positive link to motivation in giving students challenges that felt like 'a free agenda', being able to decide when, how and how often they want to interact with the platform, although this also led to certain students not contributing at all. The challenges were only effective for those students who were already motivated to do well from the very start (van Roy & Zaman, 2018).		**Dynamics: Levels, Missions, Challenges & Quests**
An avatar offers the players freedom of choice (autonomy; decision freedom and task meaningfulness) (Annetta, 2010).		In cooperative games, avatars can help to become a part of a community (Annetta, 2010).		An avatar offers the players freedom of choice (autonomy; decision freedom and task meaningfulness) (Annetta, 2010).		**Aesthetics: Avatars**

Learning Expectancy (LE)	**Effort Expectancy (EE)**	**Social Influence (SI)**	**Facilitating Conditions (FC)**	**Hedonic Motivation (HM)**	**Habit (HT)**	
By giving players all a meaningful role, a sense of relevance can be triggered (Groh, 2012; Hitchens & Tulloch, 2018), boosting the expected feeling of value.	A story is the easiest element to implement, and has no direct impact on the effort of the player (Doherty et al., 2017). When the story is linked to real-world settings and in line with the players personal interests, it will inspire and motivate, and lowers the feeling of putting in effort (Nicholson, 2015).	A shared, meaningful goal, can foster experiences of social relatedness (Sailer et al., 2017).		Meaningful stories, with narrative context, will give meaning to score more points and achievements (Malamed, 2012). Providing a unifying story throughout the game can put the learning elements into a realistic context in which actions and tasks can be practiced, something that is considered extremely effective in increasing student engagement and motivation (Clark & Rossiter, 2008; Malamed, 2012; Stott & Neustaedter, 2013).		**Aesthetics: Meaningful Stories**

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Feel the Moosic: Emotion-based Music Selection and Recommendation

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Abstract Digital transformation has changed all aspects of life, including the music market and listening habits. The spread of mobile devices and music streaming services has enabled the possibility to access a huge selection of music regardless of time or place. However, this access leads to the customer's problem of choosing the right music for a certain situation or mood. The user is often overwhelmed while choosing music. Context information, especially the emotional state of the user, can help within this process. The possibilities of an emotional music selection are currently limited. The providers rely on predefined playlists for different situations or moods. However, the problem with these lists is, that they do not adapt to new user conditions. A simple, intuitive and automatic emotion-based music selection has so far been poorly investigated in IS practice and research. This paper describes the IS music research project "Moosic", which investigates and iteratively implements an intuitive emotion-based music recommendation application. In addition, an initial evaluation of the prototype will be discussed and an outlook on further development will be given.

Keywords: • Music • Emotion • Mood • Recommendation • Context • Digital transformation •

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1 Introduction

Smartphones, mobile broadband connectivity and music streaming services have massively changed the way people listen to music in everyday life. Music listeners now have the ability to access an almost unlimited number of songs and consume them anytime as well as anywhere. Listening to music accompanies us in all everyday situations (DeNora, 2011). Whether at parties or weddings, on the drive to work, in the gym or alone at home, music has become part of our social and physical environment (Pettijohn, Williams, & Carter, 2010). The time we spend listening to music every day increases from year to year. On average, people now listen to over four hours of music per day (Nielsen, 2017). Every second person uses music streaming services and around 80 percent of smartphone owners frequently use their devices to listen to music (Clement, 2018). Consequently, listening to music is the most important accompanying activity in our society (DeNora, 2011).

Music streaming has become the way music is consumed. From 2013 to 2018 the number of music streams listened to per year increased nine times and just from 2017 to 2018 it increased by 50 percent (IFPI, 2018; Nielsen, 2019). Streaming now accounts for 75 percent of music industry revenue (RIAA, 2018).

The mass of choices created by the digitalization and streaming of music, as well as the availability of music independent of time and place, can lead to user problems. Since music is emotional, it can strengthen and change the emotions of the listener. As a result, people enjoy listening to music that fits their mood and situation. It is not always trivial to find the right music for the listening situation and the user's mood. (Sloboda, 2011).

Users are often overwhelmed by the large number of digital music titles and the possibilities for selecting music based on mood are currently very limited. Music streaming services, such as Spotify or Apple Music, offer pre-defined playlists to structure music for their user base and to facilitate the selection. This can be done in different ways. The most common way to classify music has been the genre for a long time, although this distinction is usually not clear. Nowadays, playlists should be compiled according to the situation and mood. Accordingly, music platforms increasingly offer such playlists.

The problem with these playlists is, that they do not adapt to new user situations. If the situation changes, the user has to select a new playlist that fits to his needs. A change in the situation or mood leads to a new search and an associated high as well as time-consuming interaction with the service. However, if the service knows the situation or mood of the user, it can react accordingly and generate a new, adapted playlist. Thus, such a service would be called a smart, context-based music player.

Situations and activities often lead to certain user emotions or are associated with concrete moods. As a result, the categorization and selection of music according to mood or emotion is a modern possibility of context-based and user-centered music classification (Jamdar, Abraham, Khanna, & Dubey, 2015). The research field of emotional music recommendation in the IS discipline is relatively new, but on demand. The increasing sale of modern mobile devices such as smartphones and smartwatches is creating new opportunities for user interaction and the collection of user data. The research project Moosic deals with the development and investigation of an emotional music player which is easy and fast to use and enables an immediate emotional change in the music playback with one click.

In the context of this contribution the context-based – here especially emotion-based – music playback will be dealt with in more detail. It also shows how music can be classified on the basis of emotions and what possibilities the current prototype of Moosic offers to recommend music. Furthermore, a comparative user study to different user interfaces of Moosic will be introduced and discussed. Finally, the paper is summarized and an outlook on the future significance of context-based music recommendations in the digital world, as well as on the automatic capture of emotions as an extension of the prototype is given.

2 Theoretical Foundation

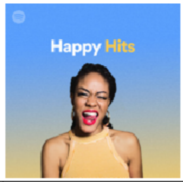
2.1 Music Recommendation

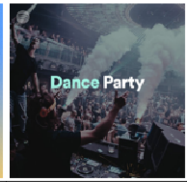
Music has an influence on our mood and can support or change it (Gaston, 1951). In order to bring the musical influence on our mood in line with our situation, music must first be categorized (Brinker, Dinther, & Skowronek, 2012).

As already mentioned, this can happen in different ways. The most commonly used way to classify music nowadays is by genre. The entire categorization of artists and albums, as well as the creation of chart rankings, is based on the classification by genres. Playlists such as "Hip-Hop", "Rock" or "Country", which are genre-based, are referred to as content-based playlists. However, these genres are often very broadly based and the boundaries between them are still blurred, making the problem of automatic classification of music a non-trivial one (Scaringella, Zoia, & Mlynek, 2006). Moreover, Daniel Ek – Founder and CEO of Spotify – said as early as 2015 that music search and classification is moving away from the genres. People are no longer looking for hip-hop or country, but for activities or a particular experience. Therefore, the playlists should be generated according to the situation and mood.

Playlists such as "Happy Hits" or "Sports Power" are composed accordingly and are referred to as context-based playlists. In addition to these two types of playlists, there are also those that cannot be clearly assigned. These playlists have both content-based and context-based characteristics. This is referred to as hybrid playlists. Examples would be playlists like "Dance Party" or "Chill Hits". The following Table 1 shows exemplary playlists from Spotify for the three different types with their key statistics. All playlists are from the Top 50 Spotify playlists.

Table 1: Examples for different playlist types





Playlist type	Content-based	Context-based	Hybrid
Playlist title	Rock Classics	Happy Hits	Dance Party
Follower	5,137,461	3,395,018	2,940,899
Avg. monthly listeners	689,253	964,063	110,936
Monthly listeners to followers ratio	13 %	28 %	4 %
Spotify ranking	12	31	45

(Data retrieved from Chartmetric.io on March 01, 2019)

Initial analyses have shown that the proportion of such context-based playlists is growing, even though content-based playlists are currently still more common. However, these available context-based playlists are already more popular. The analysis was based on the 973 playlists from the "Genres and Moods" section of the music streaming service Spotify. About 57 percent of the playlists examined are content-based and only about 37 percent context-based. Hybrid playlists account for about 7 percent. Nevertheless, if one considers the average number of followers, context-based and hybrid playlists are much more popular than content-based ones. The growth in followers from 2017 to 2018 is also more than 20 percent higher for these two playlists than for content-based playlists.
Accordingly, it can be deduced that there is already a rethinking about the composition of playlists in music streaming services, which is mainly influenced by the user base. The increasingly widespread digital personal assistants are also getting functions to get music for the current situation and mood. For example, Alexa (the virtual assistant of Amazon) now supports the selection of a playlist on request and takes current conditions and user preferences by interviewing the user into account (Welch, 2018).

2.2 Emotions and Music

In the course of the digital transformation, new possibilities arise to support the users on the hardware and software side. Modern mobile devices make it possible to precisely capture the context of a user. This is made possible by a multitude of sensors, which are installed in smartphones as well as smart watches and accompany the user inconspicuously in his everyday life. Thus, it is possible to move mobile applications even closer to the user needs in order to provide him with a concrete benefit in the situation. Due to technological progress, the cost and size reduction of devices and the further development of sensors in the context of digital transformation, situation-oriented applications are constantly being driven forward (Yurur et al., 2016). Current smartphones and smartwatches are able to determine the current emotion of the user. With the help of various sensors, like pulse, skin temperature or skin conductance, these mobile devices are able to draw conclusions about the emotional situation of the user. Due to the strong influence of emotions on the user, these will be examined in more detail below in relation to the music played. In the concrete case of the prototype Moosic, a service was created, which gives the user the opportunity to adjust the music playback to his current emotional state. This is done within the first prototype via user input (see also Chapter 3).

Emotions are the reaction of the human body to an occurring stimulus, such as an event of certain importance. The reasons for such an emotional reaction can be of different nature. For example, an emotional response can be triggered when a user is prevented from satisfying his needs or achieving his goals. Furthermore, the occurrence of an emotional response can be the result of an existing emotional situation or a previous emotional situation. In the perception of an event in the human environment, it also becomes apparent that emotions involve a degree of pleasure or displeasure (Brave & Nass, 2009; Cabanac, 2002). The emotional reaction to an event or a concrete situation can therefore be positive or negative. Emotions can also lower the threshold of the occurrence of other emotions. Emotions are a typically human trait which can influence many aspects of our lives. Thus, the perception, rational thinking and even the decision-making of a user are not free of emotions (Brave & Nass, 2009; Hussain & Bieber, 2009; Reeves & Nass, 1996). While emotions are triggered by a certain event and only exist in a relatively short time period, moods are caused indirectly and trend to exist over a longer term.

Thus, emotions last seconds and moods can remain for days. Moods are also able to influence judgement and decision-making, while at the same time they can lower the threshold for emotions (Brave & Nass, 2009). Although there is a difference between moods and emotions, in this paper, both terms are treated synonymously here. For instance, the Circumplex-Model-of-Affect by Russell (1980) offers a possibility to classify emotions and to represent them in a model (see Chapter 2.3).

Due to the strong influence of emotions on many different aspects of our lives, this prototype will use emotions as a basis for music selection and playback. The modern sensory possibilities of mobile devices offer the possibility to understand individual situations of a user and to provide suitable music for them. Since emotions are the result of a concrete situation, they can be used as a kind of situational variable to adapt the music playback to a special customer situation. Emotions and music are strongly connected. Music is capable of triggering emotions, amplifying, weakening or even changing them (Sloboda, 2011). Conversely, a concrete situation can influence the user's needs to listen to a specific type of music. Thus, situations cause emotions and emotions can act as a guide for the music selection. As already mentioned, common classifications of music often concentrate on genres and try to classify music into artificial and inseparable categories. A system-based and automatic (emotional) classification of music is already possible and appears to be more natural and humanly (Jamdar et al., 2015).

2.3 Emotion-based music recommendation

„The idea [of Context-Aware Music Recommender Systems (CAMRS)] is to recommend music depending on the user’s actual situation, emotional state, or any other contextual condition that might influence the user’s emotional response and therefore the evaluation of the recommended items.“ (Ricci, 2012, p. 865). CAMRS have been researched for some time, but the increasing mobile use of services is creating new challenges. Due to the great importance of emotions in and for music, emotional music recommendation has become particularly important as a sub-area of CAMRS. The research field of emotional music recommendation in the IS discipline is relatively new, but on demand. Only a few IS prototypes investigate emotional music recommendations (see e.g. (Ayata, Yaslan, & Kamasak, 2018; Janssen, Broek, & Westerink, 2012; Nathan, Arun, & Kannan, 2017)), but they do not sample a multidimensional emotion model that has already been verified. According to Russell's Circumplex-Model-of-Affect, emotions can be classified in a two-dimensional order. This model arranges the emotions in circular order according to arousal and valence. The dimension of arousal ranges from calming or soothing to exciting or agitating, whereas the dimension of valence ranges from highly negative to highly positive (see Figure 1, left side).

Therefore, the model is able to represent each emotional state in the form of a certain degree of these two dimensions (Kensinger, 2011; Russell, 1980). Basically, the emotions can be divided into the four quadrants Q1 - Angry, Q2 - Happy, Q3 - Sad and Q4 - Relaxed.

Based on Russell's circular emotion model, Thayer developed an alternative emotion model that arranges 11 emotional states using tiles (Thayer, 1991). Thayer's model is also based on the two dimensions arousal and valence (see Figure 1, right side). Both models were simplified as well as colour coded in the research project and for the prototype to simplify the user interface and accordingly the selection process by the user (see also Figure 3).

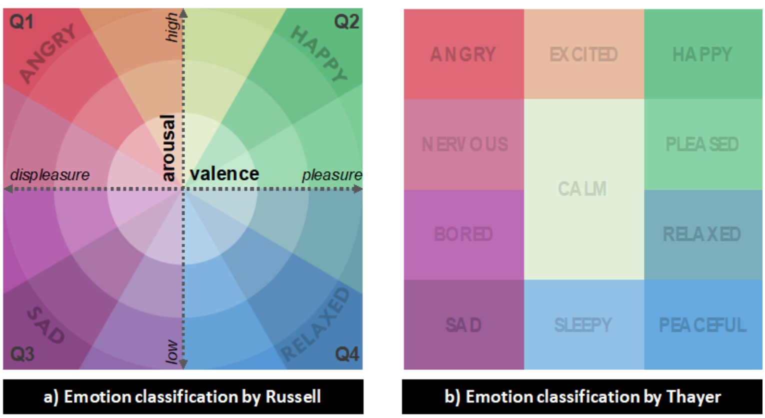
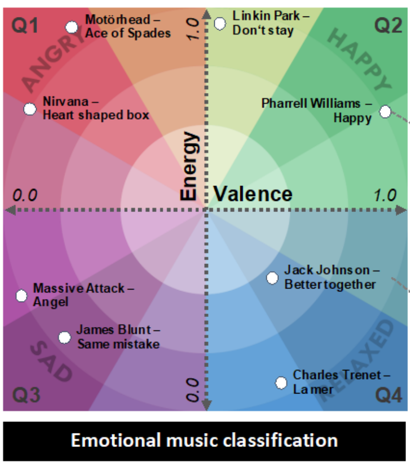


Figure 1: Human emotional classification model a) by Russell (1980) and b) Thayer (1991)

In the case of music, this two-dimensional scale can also be used to classify songs emotionally. Here energy corresponds to the human activation or arousal and valence to the human mood (Krause & North, 2014; Russell, 1980). Popular streaming services such as Spotify use these two music parameters to classify music (Jamdar et al., 2015). Energy in music is a perceptible measure of intensity and activity. Typically, energetic tracks feel fast, loud and intense. For example, Death Metal very often has high energy, while a ballad has low values on the scale. Valence, on the other hand, describes the musical positivity conveyed by a piece of music. Songs with high valence sound more positive (e.g. happy, cheerful, euphoric), while pieces with low valence sound more negative (e.g. sad, depressed, angry) (Kim, Lee, Kim, & Yoo, 2011). In order to better understand the emotional classification of music, Figure 2 shows the classification of different songs from various genres. Valence and energy are strong indicators for the acoustic mood and the overall emotional quality of a song (Krause & North, 2014).



Song	Pharrell Williams – Happy
Genre	Pop
Energy	0.822 (++)
Valence	0.962 (++)
Emotion	Happy

Song	Jack Johnson – Better together
Genre	Folk
Energy	0.346 (-)
Valence	0.659 (+)
Emotion	Relaxed

Comparison of two songs

Figure 2: Emotional classification of music by energy and valence parameters with exemplary songs for each quadrant

Spotify determines and stores these emotional parameters automatically by algorithms for each individual song in addition to other parameters such as danceability or speechiness. These so-called high-level parameters are generated by using low-level and mid-level features of the music. Low-level features are timbre and temporal features whereas mid-level features are rhythm, pitch, and harmony. Both have been used predominantly in music classification, due to the simple procedures to obtain them and their good performance. However, they are not closely related to the intrinsic properties of music as perceived by human listeners (Fu et al., 2011). Accordingly, nowadays the derived high-level features are primarily used to recommend music and to create playlists. These parameters are set on a scale from 0.0 to 1.0. Consequently, songs in the first quadrant have a high energy and a low valence value and songs in the fourth quadrant, for example, have a low energy and a high valence value.

The right side of Figure 2 shows the two songs "Better together" by Jack Johnson and "Happy" by Pharrell Williams with their genre classification and their values for energy and valence. Furthermore, it is indicated in which emotional quadrant they are classified.

The first song is characterized by a low energy and a high valence value. Accordingly it can be classified as relaxed. The second song has both, a very high energy and a high valence value and can be classified as happy. The presented parameters energy and valence as well as the two-dimensional emotion models were used in this project to develop a prototype, which selects and plays music based on an emotional mood input (see Chapter 3).

3 Moosic Prototype

The prototype "Moosic" was developed as part of the research project. The application uses Spotify and the available API to create a playlist based on the user-selected genres and the emotional input of the user (see Figure 3).

The music selection works via a circular avatar, which shows the Spotify profile picture of the user. Moving the avatar allows the user to select his emotional state. During the implementation of the emotional input area, attention was paid to a user interface that is as simple as possible and therefore color-coded. The models were implemented in a somehow simplified way to not overwhelm the user while selecting the emotional state. Both, an input area based on Russell's model (see Figure 3, right side) and one based on Thayer's model were implemented (see Figure 3, left side).

The advanced settings of the application can be used to switch between the two surfaces. In addition, the user can select several genres as well as the popularity of the songs to further adapt the music selection by the system to his personal preferences. The position of the avatar (user input) in the frontend is interpreted by the system in the backend as x- and y-axis values between 0.0 and 1.0. The position of the avatar on the x-axis represents the value for valence and on the y-axis the value for arousal. These values are provided with a certain tolerance range, which is +/- 0.1 by default, but can be changed in the settings. The tolerance range results in minimum and maximum values for valence and energy, which are combined into a request to the Spotify API for the selected genres. To this request, Spotify returns a playlist with 20 matching songs, which is played randomly (see Figure 4).

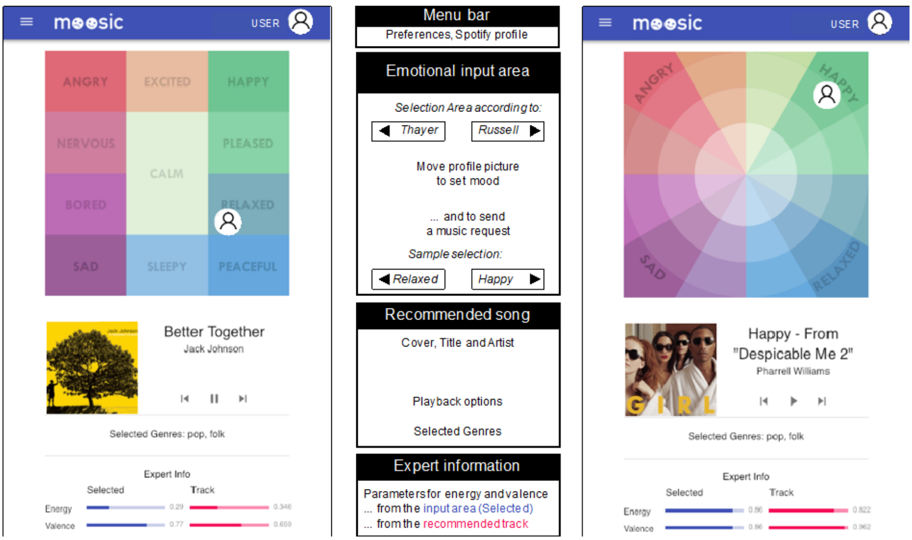


Figure 3: User interface of Moosic with input area according to Thayer (1991) left and Russell (1980) right using two example entries (Relaxed and Happy)

In addition to the emotional input area, the application provides information about the currently played song as well as the usual playback options. You can also activate an expert mode, which displays more information, like the search parameter input and the parameters for the actually played song. In addition, the expert mode allows the music selection to be further restricted.

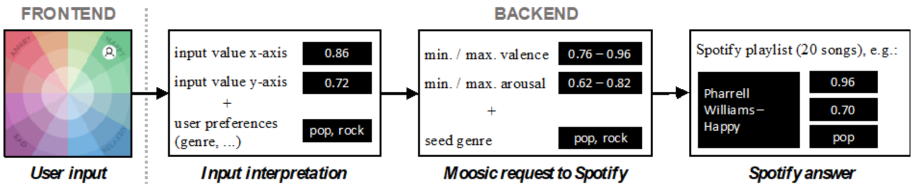


Figure 4: Input/output process and data processing of Moosic

4 Evaluation of Moosic

In a first experiment the prototype of Moosic was evaluated. The experiment was conducted in the form of a controlled laboratory experiment. Four participants carried out the experiment at the same time. In order to enable standardized test conditions that ensure comparability of the results, attention was paid to uniform instructions and equal the testing conditions. The probands were divided into two test groups, resulting in a Between-Subjects study design. Each participant received the same accompanying online questionnaire and was exposed to the same testing scenarios. Both, the general usability and the music playback of the prototype as well as the two different emotional input areas were tested. One test group got the prototype with the input area according to Russell's model (T1) and the other group according to Thayer's model (T2).

Totally 43 subjects (30 male / 13 female) took part in the experiment. The age of the subjects was between 20 and 34 years and the mean value is 24.4. About 86 percent of the participants use music streaming services (65% paid subscription, 21% free version). The composition of the test groups T1 (21 subjects) and T2 (22 subjects) was very similar based on sociodemographic data (see Table 2).

The majority of the total participants listened to music between 30 minutes and two hours a day (72 %). The most important channel is music streaming, as 65 percent have stated that they very often listen to music via this channel before YouTube (16 %) and classic radio (14 %). All other media and channels are negligible. With regard to music streaming, Spotify is clearly ahead with about 80 percent of the probands who use music streaming. About 92 percent of all test persons consider it as useful to receive music recommendations from the music provider. In their main activities, the respondents stated that they listen to music while on the move with mean value on a four-level frequency Likert scale of 3.35, followed by sports (2.95), housework and relaxation (2.56 each), work (2.28) and learning (2.12).

Table 2: Sociodemographics of the participants

Attribute	Overall	T1: Russell	T2: Thayer
Participants	43	21	22
Sex (male/female)	m: 30; f: 13	m: 14; f: 7	m: 16; f: 6
Age (by mean)	M: 24.4	M: 25.3	M: 23.7
Usage of music streaming services (yes/no)	y: 86%; n: 14%	y: 90,5%; n: 9,5 %	y: 81,8%; n: 18,2%

After the test had been carried out, the subjects were presented with standardized statements on the satisfaction with the prototype. These were statements about navigation, user interface, target fulfilment and mood input. These statements were evaluated on a four-level approval Likert scale. With the help of a mean value comparison significant similarities and differences can be determined (see Table 3).

Table 3: Results of the statements for the two different input surfaces T1 and T2 (on a four-level Likert scale by mean value comparison for each group)

Statement: The prototype …	T1: Russell	T2: Thayer
… is visually appealing.	2.86	2.91
… has an intuitive and understandable navigation.	3.00	3.18
… is user-friendly in its interface.	3.10	3.18
… is self-explanatory in its functionality.	3.05	3.09
… has responded to my individual needs.	2.57	2.82
… includes different expressions of the individual emotions.	2.76	3.23
… makes it easy to switch between different emotions.	3.62	3.45

… is applicable to all genres.	2.71	2.73
… can be used for different emotions.	3.14	3.27
… can be easily adapted to my emotion.	3.05	3.09
… represents an added value for music streaming services.	3.19	3.09
… has addressed my emotional receptivity to music.	2.62	2.55
… is valuable and recommendable.	2.90	2.91
Overall	**2.98**	**3.01**

The statement can be made that the test group of the Thayer surface (T2: 3.23) perceived the different expressions of the emotions better through the prototype than the participants who were provided with the Russell surface (T1: 2.76). This can possibly be explained by the fact that T2 verbalized significantly more emotions than T1. The surface has an effect on the perception of emotions by the participants. However, the fact that one prototype can better represent the currently perceived emotions than the other cannot be proven by the data collected. Nor is it possible to prove that one of the two prototype surfaces responds better to the individual wishes of the user.

Finally, it can be said that the participants stated a relatively high level of satisfaction with the prototype, which applies equally to both surfaces (T1: 2.98; T2: 3.01). Both test groups were willing to continue using the application for music selection and recommendation. However, with about 86 percent approval it was significantly higher for T1 than for T2 (64 %). A further qualitative study could possibly be used to gain further insights into the advantages of the two surfaces and to combine the advantages of both input surfaces into a new one.

5 Conclusions

Digital transformation is an all-encompassing phenomenon, which also influences the music market. Concrete manifestations of this transformation are the development and increasing use of streaming services such as Spotify, Apple Music, Amazon Music or YouTube (Music). These streaming service providers serve the user with a wide range of music titles, which makes the selection process of suitable titles more difficult. Music recommendations help to solve this problem. In addition, a change in user behavior can also be observed, as they increasingly consume their music in a mobile context thanks to increasingly powerful mobile devices (Clement, 2018). Typical mobile devices, such as smartphones, which contain a multitude of sensors, are able to observe and interpret the situation of a user (Yurur et al., 2016). For example, it is possible to measure the user's biofeedback and derive emotional states based on it. In this way, modern mobile devices in combination with smart and innovative services can deliver added value to the user. This makes it possible to adapt the selection of music to the current situation or to the current emotional state of the user. Music is able to influence our emotional state or the emotional state of the user influences the type of music he wants to listen to. Emotions are strongly linked to the listening behaviour of a user, which makes emotions a useful basis for music selection (Han, Rho, Jun, & Hwang, 2010).

Based on these findings and problems, a first prototype of an emotional music player was developed and evaluated. The presented prototype offers the user the possibility to enter his emotional state. Based on this input, a suitable playlist is generated. The user interface for entering the emotional state is based on two different two-dimensional models for classifying emotions according to Russell (1980) and Thayer (1991). Both models were implemented and integrated in a simplified and color-coded form.

Furthermore, an experiment with the prototypes was carried out, which already provided initial insights into its added value and its perception by the users. In addition to the test subjects' listening habits, connections between music and emotions, as well as the meaningfulness of emotions were queried as a data basis for a selection of music. An essential part of the experiment was the comparison of these two different surfaces. Here it was shown that the general satisfaction with the application is very high and the selection of music via the input of emotions is considered meaningful.

6 Future development and outlook

In the next steps of this research project the prototype will be extended by an automated emotion measurement, which can support or even replace the manual input of the user. The sensory possibilities described in chapter 2.2 will serve as a basis for the measurement. The measurement of various user characteristics with the help of smartphones and smartwatches is already possible today (Bachmann et al., 2015). The voice and facial expression can be used to draw conclusions about the emotional situation of the user (Essa & Pentland, 1995). However, these methods are less suitable in the mobile context of listening to music when the user does not interact directly with the system in the mean time. Furthermore, the measurement and evaluation of biofeedback offers a possibility to derive emotions. Promising sources of information can be heart rate, skin conductance or skin temperature (Picard & Klein, 2002).

In order to measure and use emotions for the music recommendation in a mobile context, unobtrusive and non-interfering possibilities of measurement are better suited. Smartphones and especially wearables, like smartwatches as well as activity trackers, which are equipped with various biometric sensors (Bachmann et al., 2015) should therefore be given priority. The smartphone based measurement of basic emotions, such as anger or joy, based on the change of the heart rate, was already proven (Lakens, 2013). A biofeedback-based and two-dimensional approach was described by Yamamoto et al. in 2009. This approach can be easily adapted for the applied emotion model(s) and the prototype. In this case heart rate corresponds to energy and skin temperature corresponds to valence (Yamamoto, Kawazoe, Nakazawa, Takashio, & Hideyuki, 2009). Therefore high heart-rate of the user can be interpreted as a high level of energy, whereas a high skin temperature would be classified into the positive area of the valence dimension. As smartphones and wearables become more and more powerful and even more sensors are implemented, biofeedback especially heart rate and skin temperature represent promising sources of user-based emotional information (Di Lascio, Gashi, & Santini, 2018).

Meanwhile, the self-input of emotion by the user is to be maintained and possibly extended by further elements. Because in addition to automatic measurement of the users' emotional state and music recommendation based on it, the user should still have the option to enter or specify his emotional state or preference manually. For this purpose, the use of emoticons and other adjectives is conceivable in order to offer the user a simpler way of expressing his emotional state (Meschtscherjakov, Weiss, & Scherndl, 2009). Further context of the user, such as the time of the day, weather or his location, can also help to better understand the user's situation and to ensure an even better music selection and recommendation depending on the situation. Furthermore, the consideration of different scenarios within the framework of a field experiment would be useful. Concrete use cases such as sports, shopping or learning are only a few examples in which an automatic emotion-based music recommendation could support the user.

In the experiment, the wish for an evaluation respectively feedback system was expressed several times. A feedback system would open up the possibility of a more customized music recommendation system which adapts even better to the preferences of a certain user by using his feedback data. Thus the system may learn that the user in a certain mood does not want to support this mood, but rather wants to initiate a change of his emotional state.

These functions and extensions will be implemented and tested iteratively in the next versions of the prototype as well as a slightly modified input surface.

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Trust, fear and social influence: on the use of social media in China's authoritarian governance regime

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Abstract This paper reports on the analysis of results of a survey among Chinese citizens about their intended use of social media to interact with government agencies and associated motivations. Citizens' use intentions were found to be correlated with citizens' trust in officials, social influence (peer pressure) and anxiety, but not with trust in government. These results provide building blocks for an explanatory theory of citizens' use of social media to interact with government, especially in an authoritarian regime like China's system of public governance. This explanatory theory is consistent with an institutional perspective on technology use, in which use intentions and behaviours are explained by norms, practices and taken-for-granted assumptions, rather than by rational cost-benefit considerations. The paper is concluded with recommendations for comparative research on antecedents of social media in government-citizen relations in various governance systems.

Keywords: • Social Media • Government - Citizen Interaction • Sina Weibo • China • Influence •

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1 Introduction

Today's social media channels offer governments improved ways to deliver public services to citizens. Inversely, social media provide citizens with new opportunities to provide feedback on policies, and/or initiate participatory initiatives (Bertot, Jaeger, & Grimes, 2012; Kassen, 2013; Mergel & Bretschneider, 2013). Perhaps to the surprise of many Western observers, one of the frontrunners in the use of social media is the People's Republic of China, a country with an authoritarian, unitary governance regime. Various government agencies, public service providers and regulatory agencies use hundreds of thousands accounts on platforms such as Sina Weibo, Tencent, People and Xinhua Net, serving a target population of hundreds of million users (Chan, Wu, Hao, Xi, & Jin, 2012; Ma, 2014; Schlæger & Jiang, 2014).

The academic literature on government social media use in China has, until date, focused on uses of social media from a government point of view. It has been observed that online participatory initiatives and new online political discourses have emerged (Schlæger & Jiang, 2014; G. Yang, 2009). On the other hand, Sullivan (2012) commented that social media are increasingly being 'occupied' by officials working for propaganda departments and security bureaus in order to curtail activities of opposition groups like environmental NGOs and anti-corruption movements. Furthermore, literature indicates that in China, social media are monitored by government in order to 'gauge the water', that is, to measure, shape and suppress public opinions (Cairns & Carlson, 2016; Guo & Jiang, 2015; Xu, 2015; G. Yang, 2009), especially during natural disasters (Deng, Liu, Deng, & Zhang, 2015; White & Fu, 2012) or diplomatic incidents (Cairns & Carlson, 2016; Jiang, 2016).

Academic literatures have resulted both in political commentary of government use of social media in China as propaganda spaces (including issues of censorship (Sullivan, 2012; King, Pan & Roberts, 2013), as well as in descriptive and explanatory accounts of diffusion of social media among government organizations and its organizagional and technological antecedents (Ma, 2014; N. Zhang, Zhao, Zhang, Meng, & Tan, 2017). Suprisingly little attention has been given to the citizen side of social media use in government-citizen relations, with Medaglia and Zhu's (2016) account of university students' deliberative practice being a notable exception.

This paper focuses on China's citizens' expectations, intentions and motives in dealing with government using Sina Weibo, arguably China's most well-known social media outlet. We address the question to what extent and why Chinese citizens intend to use Sina Weibo to communicate with government. The question is relevant since on the one hand, there is little empirical research on the actual practice of social media use in authoritarian government regimes such as China's governance system, and, on the other hand, China is especially interesting because its online community members have been described as relatively young, wild, and outspoken (Hassid, 2012; G. Yang, 2009), which furthermore fuels an interest in how Chinese citizens deal with new political opportunities in the context of an authoritarian political regime (for a study on the government's responsiveness, refer to Meng, Pan & Yang, 2017).

2 Context: China's political system and the emergence of social media

The People's Republic of China is structured into various administrative tiers: central level including autonomous regions (of which Tibet is one) and special autonomous regions (Hong Kong and Macau), provinces, prefectures, counties, districts, and towns and sub districts. Since the 1970s, more authority has been delegated to local governments.

Since about 2011, local government agencies have enthusiastically embraced the emerging social media technologies, albeit with a special focus on unilateral, top-down communication. Topics of communication that takes place on the newly emerged social media channels include quotes from top-level politicians, public service announcements, human interest stories, and morning- and afternoon general wisdom sayings (Schlæger & Jiang, 2014). Chinese citizens, on the other hand, are reported to be willing to voice their opinions on social media. Topics of discussions initiated by citizens include dissatisfaction with government performance, corruption, problems caused by socio-economic changes (Hassid, 2012; G. Yang, 2009) and environmental issues (Li, Homburg, de Jong, & Koppenjan, 2016; Li, Koppenjan, & Homburg, 2017). Sullivan notes that Chinese government's possibly biggest fear is the emergence of a coalition of laid-off workers, dispossessed homeowners, unemployed graduates, hungry farmers and ethnic and religious minorities that shares grievances online and may challenge the regime (Sullivan, 2014). Therefore, Chinese authorities tolerate online debates and feedback as long as they are specific, localized and do not contain threats of collective action (Cai, 2010; Meng, Pan & Yang, 2017). Authorities, on the other hand, seem to impose regulations on Internet providers to monitor online communication and to prevent protests from gaining traction (Qin, Strömberg & Wu, 2017). Chinese government's attempts to allow citizens to vent their anger as long as systemic problems are not explicitly addressed are referred to in the literature as 'consultative Leninism' (Tsang, 2009) and 'networked authoritarianism' (MacKinnon, 2011; Tsai, 2016).

3 Design of a survey of adoption and diffusion of social media in China

3.1 Research strategy

Academic literatures have reported quite extensively on in-depth case studies of social media use during citizens protests in China (Deng et al., 2015; White & Fu, 2012) and local governments' experiences with social media (Ma, 2014; Schlæger & Jiang, 2014). Until date, more large-n, quantitative studies of use of social media (particularly Sina Weibo) by Chinese citizens, has been lacking.

In the study this paper reports upon, we conducted a survey among Chinese citizens living in the province of Hunan, People's Republic of China, with which citizens' use of Sina Weibo was described, as well as with which candidate explanatory variables of social media could be constructed and assessed. It must be stressed that until date no adoption and diffusion theories exist that take into account particularities and sensitivities of the Chinese context, and therefore, the research objective of this study is to contribute to an explanatory theory of social media use in an authoritarian governance system context, rather than to test an existing theory. From the analysis of the results of the survey, constructs and relations between constructs are suggested as to be able to produce rather than strictly test an explanatory account of Chinese citizens' use of Sina Weibo to interact with government.

3.2 Theoretical foundation of the questionnaire and measurement of constructs

Frequently used starting points for studies of individuals' uses of technology are adoption and diffusion models such as the Technology Acceptance Model (TAM), the Technology, Organization and Environment model (TOE) and the Unified Model of Acceptance and Utilization of Technology (UTAUT and UTAUT2). In existing tests of these kinds of theories and their derivates in the context of electronic public service delivery in the United States (Carter & Bélanger, 2005; Carter & Schaupp, 2009; Carter, Christian Shaupp, Hobbs, & Campbell, 2011), the Netherlands (Horst et al., 2007), India (Rana, Dwivedi, Williams, & Weerakkody, 2016), China (Mensah, 2017) and Hong Kong (Venkatesh et al., 2016), over time, more emphasis has been put on institutional factors including citizens' *perception of risk, privacy concerns and anxiety* (Min et al., 2008; Q. Wang, Yang, & Liu, 2012; Lai & Shi, 2015; Carter et al., 2011; Rana, Dwivedi, & Williams, 2013), *trust in government* (Chong, Ooi, Lin, & Bao, 2012) and *peer pressure* (Venkatesh et al., 2016) as predictors.

In the current study, we conceptualized *anxiety* and *risk* as an individual's negative affective reaction due to envisaged unappreciated social media activity (X. Li, 2013) or incompetence in dealing with the system (Rana et al., 2013; Rana et al., 2016). For the questionnaire we included slightly adapted Likert items borrowed Venkatesh et al., (2011) to measure anxiety and risk.

The concept of *trust* is generally associated with perceptions of safety, and more precisely defined as actor A's expectations that while B has the capacity to harm A, B refrain from doing so. By accepting the vulnerability, A possesses trust; by refraining from exploiting vulnerability, B is trustworthy (Frederiksen, 2014; Pavlou & Gefen, 2005). In a Chinese cultural context, trust can be thought of as being composed of two distinct concepts. The first one is trust in institutions (*institutional trust*), that is, the belief that an individual citizen has in administrative, legal and societal institutions such as the Chinese Communist Party, government apparatus, councils, courts, associations, media and complaints bureaus (Q. Yang & Tang, 2010). In the questionniare we included adaptations of Likert items taken from Yang & Tang, 2010. The second one is related to intricate and pervasive relational networks called guanxi (Yen, Barnes, & Wang, 2011). Guanxi consists of feelings of empathy and solidarity (*ganqing*), reliability and sincerity (*renqing*) and reliance and sincerity (*xinren*) and it can be developed in relations between citizens and very specific government officials to protect citizens against administrative hurdles or unforeseen risks. This notion is referred to as *interpersonal trust*. Interpersonal trust was operationalized using items taken from Poppo, Zhou, & Li (2016) and Reich-Graefe (2014).

Peer pressure refers to a form of social influence beyond one's own personal considerations, to an individual's conformation to the expectation of other people. In this study, social influence was measured using items that were adapted from Venkatesh's (2016) operationalization.

The dependent variable in this study was *intention to use Sina Weibo to interact with government*. We chose for intention to use rather than actual use since asking for intention is, in a Chinese context, considered to be less sensitive than asking for actual behaviors, and because in the literature it is reported that intentions are adequate predictors of actual behaviors (de Lange & Homburg, 2017).

3.3 Questionnaire design and data gathering procedures

Following the definitions and operationalization of theoretical constructs reported in section 3.2, we compiled a 71-item questionnaire in English. We thoroughly discussed possible sensitivities in the questionnaire, and subsequently had the questionnaire translated into Mandarin. We then piloted the questionnaire using a panel of Chinese students, on the basis of which several formulations of items were changed. Then, we asked another interpreter to translate the adapted Mandarin questionnaire back to English so that misinterpretations could be checked, discussed and corrected whenever necessary.

Once the questionnaire was developed, we asked various China-based companies specializing in marketing and opinion polling to gather data among citizens living in Hunan, located in the South-Central part of the Chinese mainland. Perceived sensitivity of the subject matter turned out to be prohibitive for many companies to carry out the survey. Eventually, data were gathered by a Shanghai-based survey company using an online survey tool. Responses from 1572 citizens could be recorded. Data were scanned and screened for kurtosis and unengaged responses based on standard deviations of Likert items and time it took for respondents to complete the survey. Data from five respondents were dropped because of distrustful characteristics (age). Ten unexpected missing values were replaced by the median of nearby data points, following general data screening guidelines (Gaskin, 2017).

4 Descriptives, analyses and model construction

4.1 Demographics

Respondents were 914 men (58%) and 658 women aged 15 to 67 (men: M = 36.9, SD = 8.4; women: M = 34.6, SD = 7.0). the majority of the respondents (86%) reported to be living in an urban area. Professional activities included going to school (3%), working in the public sector (30%), working in the private sector (60%), keeping house (3%), and something else (2%). The highest level of completed education was junior high school and below (2%), senior high school (8%), college (37%), university (49%) and postgraduate (3%). Monthly salary ranged from less than RMB 2000 (3%), 2001-5000 RMB (23%), 5001-8000 RMB (39%), 8001-12000 RMB (27%) and above 12000 RMB (6%).

4.2 Scale construction and reliability of variables

As we slightly adapted existing items by means of which the various constructs were to be measured, and items were translated back and forth, possibly resulting in less than optimal coherence of items, we carried out an exploratory factor analysis in order to identify the underlying structure of the measured variables in the questionnaire. First of all, the factorability of all Likert items in the questionnaire was examined. A cross table analysis of all items showed that many items correlated at least .3 with at least one other item, suggesting factorability. The Kaiser-Meyer-Olkin measure of sampling adequacy was .968 and thus well above the commonly recommended value of .6, and Bartlett's test of sphericity was significant (χ^2 (1176) = 31145.577, p < .0001). The diagonals of the anti-image correlation matrix were above .5 with the exception of the items on anxiety. Finally, the communalities were all above .3, further confirming that each item shared at least some common variance with other items. Given the above considerations, factor analysis was deemed to be suitable with all items. Factor analysis was carried out using maximum likelihood extraction method since the variables were generally normally distributed. Since our dataset was relatively large (more than 1500 observations), we decided to opt for ProMax rotation. Eventually, a five-factor solution explaining 44.9% of the variance could be identified (see table 1).

Table 1: results of factor analysis (maximum likelihood extraction, ProMax rotation)

	Behavioral intention	Social influence	Anxiety and risk	Interpersonal trust	Institutional trust
Q17	.667				
Q18	.684				
Q19	.633				
Q28		.463			
Q29		.485			
Q30		.401			
Q31		.476			
Q38			.806		
Q39			.878		
Q40			.880		
Q41			.796		
Q42				.452	
Q43				.589	
Q44				.625	
Q45				.698	
Q46				.586	
Q47				.590	
Q48				.615	
Q49				.679	
Q50				.509	
Q51				.557	
Q52				.649	
Q53				.365	
Q54					.376
Q55					.430
Q56					.445
Q57					.596

	Behavioral intention	Social influence	Anxiety and risk	Interpersonal trust	Institutional trust
Q58					.625
Q59					.569
Q60					.553
Q61					.741
Q62					.744
Q63					.609
Q64					.713
Q65					.746

Table 2: reliability, descriptives and bivariate correlations of variables

	Cronbach's alpha	Mean (SD)	Behavioral intention	Social Influence	Anxiety	Interpersonal trust	Institutional trust
Gender (1=female)		0.42	-,046	-0,03	-0,02	.022	-.138
Age		35.9 (7.9)	-0,43	-0,40	-0,29	-0,07	.018
Area (1=Urban)		0.87	-0,10	-0,10	-0,03	-0,12	-0,13
Education (1=University & postgraduate)		0.52	-0,08	-0,03	0,04	-0,05	-0,09
Job (1=Civil servant)		0.30	-0,04	-0,02	-0,09	-0,05	-0,03
Behavioral intention	.708	1.68 (.55)	1				
Social Influence	.762	1.96 (.63)	.500	1			
Anxiety and risk	.895	3.50 (1.09)	-.358	-.170	1		

Interpersonal trust	.854	1.95 (.50)	.535	.628	-.253	1	
Institutional trust	.891	1.88 (.51)	.414	.575	-.104	.685	1

Subsequently, internal consistency of the identified factors was measured using Cronbach's alpha (reported in table 2). All measures for consistency were acceptable; no improvements could be made by dropping items from the scales. Subsequently, composite scores were created for each of the factors based on the mean of the items factor loadings greater than .3. Table 2 furthermore lists means and correlations between various variables.

4.3 Model construction

In order to construct a basic multivariate explanatory model with one dependent variable (behavioral intention) and four independent variables we conducted a multiple linear regression analysis.

Before the actual regression was implemented, we checked the following model assumptions for multiple regression analysis following guidelines set out by Field (2009). Multicollinearity was checked by inspecting the correlations of the independent variables in Table 5 and by inspecting the VIF values of each independent variables. As none of the correlations are above .7, and all VIFs were below 4, this assumption is met (Belsley, 1991). Homoscedasticity was checked using a scatterplot of standardized residuals and predicted values; no anomalities were found. Independent errors were checked using the Durbin-Watson statistic and the value of 1.910 revealed no problems associated with this assumption. The assumption of normally distributed errors was tested via inspection of unstandardized residuals. Whereas the Q-Q plot revealed a relatively normal distribution, the Shapiro-Wilk test for normality (SW = .972, df = 1572, p<0,01) suggested normality was not met.

The impacts of the variables social influence, anxiety, interpersonal trust and institutional trust on behavioral intention to use social media to communicate with governments (controlling for age and gender, and for area, education and job type) are assessed using multiple linear regression analysis. A significant regression equation was found for gender and sex (F (2, 1569) = 3.645, p < 0,05), gender, sex, area, education and job type (F (5, 1566) = 6.805, p < 0,001) as well as for gender, sex, social influence, anxiety, interpersonal trust and institutional trust (F (9, 1562) = 112.507, p < 0,001). Coefficients and significance levels of the various independents are reported in Table 3.

Table 3: regression results on Behavioral Intention (* p<0,05; ** p<0,01; ***p<0,001)

	Model 1	Model 2	Model 3
	Beta (significance)	Beta (significance)	Beta (significance)
Age	-0,050*	-0,066*	-0,055*
Gender	-0,053*	-0,057*	-0,062**
Area		-0,088**	-0,035
Education		-0,069**	-0,036
Job Type		-0,025	-0,037
Social Influence			.247***
Anxiety and risk			-.247***
Interpersonal trust			.279***
Institutional trust			.045
	ΔR^2= .003 (adj)	ΔR^2= .018 (adj)	ΔR^2= .390 (adj)

5 Conclusion and discussion

The results presented in the previous section provide core components of a theory that explains why Chinese citizens, living in an authoritarian governance regime, intend to interact with government using Sina Weibo. Regression results indicate that intention to use may be explained by (1) interpersonal trust, (2) social influence and (3) negatively, by anxiety and (perceived) risk. Altogether, these variables champion an institutional explanation of social media use in a state regime with limited freedoms and heightened levels of societal surveillance, emphasizing the pressures of values in interpersonal, social environment (trust in government officials, and anticipated expectations of nearest and dearest), and of norms (conformance to expected behaviors, whereas deviance may be sanctioned).

The explanation that may emerge from these statements is that citizens in China's authoritarian regime are pressured by expectations from their respective social environments to use social media to interact with government, whereas fears of sanctions holds them back. There are, however, a number of limitations and rival explanations that must be considered.

The first one is related to the association between social media use intentions and trust. In existing UTAUT and UTAUT2 frameworks, it is hypothesized that trust impacts use intentions and ultimately may impact use behavior. However, it may be argued that recurrent use of social media may inversely impact trust, either institutional trust or trust in individual officials. Cross-sectional studies like the one this paper reports on, however, are incapable of demonstrating the direction of causation. Therefore, other methods, such as longitudinal studies of individual citizen's experiences and motivations, could be employed to contribute to explanatory theories related to this issue.

The second one is related to the finding that anxiety and risk are negatively related to citizens' social media use intentions. It must be noted that in China, a social credit system (SCS) is under development that ranks and rates citizens based on their offline (smoking where smoking is not allowed, breaking traffic rules) and online (posting fake news) behaviors. Under a more fully developed SCS, scheduled for 2020, specific social media behaviors may face much more tangible repercussions (rewards and sanctions) than in the current situation. In the current study it was not possible to incorporate citizens' anticipations on SCS, but future research on social media uses in China should arguably take implications of SCS into account.

The third one is arguably an even more challenging one. In the current study, the focus was on theory construction of social media use in a specific unitary authoritarian governance regime, which led to specific inferences about antecedents of citizens' use of social media in contacts with governments. At this moment, however, we cannot attribute these inferences to the overarching authoritarian regime. It does, however, point to new avenues for comparative research: as various state structures (think of authoritarian unitary regimes like China, compared to Western state structures such as liberal welfare state regimes, corporatist regimes, and socialdemocratic regimes) with each structure having specific levels of centralization, checks and balances and transparency, to name just a few attributes of state structures. Comparative, large-n research on social media use in citizen-government relationships could throw light on possible interactions between citizens' preferences and motives for using social media to interact with government, and attributes of overarching state structures. In such a way, a much more informative theory of antecedents and impacts of social media in government-citizen relationships could be constructed.

The fourth one is that the current study is based on survey data, and the use of survey data that are gathered for academic purposes is rather sensitive in a Chinese context. Privacy concerns in an authoritarian governance regime are different than those in Western liberal democracies, and possible respondents' biases (or discretion) may exist and may have affected the analyses. Given limited experience with studies that are based on survey data on political communication in China, it is very hard at this moment to assess whether and if so to what degree biases may have affected the outcomes of the analyses.

As a final note, this study – even when considered in the light of the limitations mentioned above – does suggest a number of new research directions and perspectives on future research. The first one, arguably, is to furthermore explore how citizens' anxieties, trusts and societal pressures shape interactions between government and citizens in countries generally, and in authoritarian governance regimes in particular. At local governance levels in China, participative and grassroots initiatives are taking shape and these initiatives are tolerated and sometimes even encouraged as long as they do not pose a threat to those in power. The interactions and their ramifications are at this moment in time far from clear and this observation warrants further qualitative and quantitative study of how new technologies are adopted and used, both in government-initiated, as well as in more bottom-up inspired initiatives. A second one is that also in the Western world, there is an ongoing debate about the political role of social media platforms. Further investigations could shed light on the roles of platforms such as Facebook and Twitter in the Western world, and Sina Weibo and WeChat in the Chinese context, in shaping and possibly framing political discourse.

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Fit for Purpose Enterprise Architecture

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Abstract Today's enterprises are confronted with an ever-changing environment demanding continuous (digital) transformation. Currently enterprise architects tend to guide these changes with so called 'one size fits all' architectural approaches. However, tuning such approaches to a variety of change situations is difficult. There is a call for a more flexible instrument among practitioners that is designed to be tailored to the context of a specific situation. Such fit for purpose enterprise architecture approaches have the potential to play a key role in the current times of digital transformation. In this paper we present the first steps towards a situational enterprise architecture approach that is based on differentiating between subsystems within organizations, by defining which characteristics of subsystems are relevant to determining the correct enterprise architecture approach.

Keywords: • Systems • Differentiation • Characteristics • Digital Transformation • Enterprise Architecture •

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1 Introduction

Today the environment of organizations seems to change faster than ever before. New (digital) technologies, related cyber security issues, new dynamic start-ups and a changing political landscape that impacts world trade and legislation, all mean that enterprises need to adapt and change with a high frequency. This requires a high level of flexibility of an organization. According to DaSilva (2004) many enterprises turn towards business models as an answer to how to deal with innovative technology and other forms of potentially new and profitable business concepts. Many fledgling enterprises rushed to the market with identical business models lacking strategies to differentiate themselves in which customers and markets to serve, what products and services to offer, and what kinds of value to create (Margretta, 2002). Unsurprisingly, this led to poor results. A winning enterprise is defined by its ability to differentiate and satisfy customers while performing at competitive cost levels (Edwards, 1997).

In the context of IT and information systems the developments as described above cause a major challenge for enterprise architects as they are confronted with an enterprise that must undergo change in different areas, with different purposes, transformation speeds and complexity (Gampfer, Pucihar, Ravesteijn, Seitz & Bons, 2018). A challenge that is magnified by current enterprise architecture (EA) approaches. EA is based on the essential elements of a socio-technical organization, their relationships to each other and to their changing environment as well as the principles of the organization's design and evolution (Lapalme, 2016). Over the past three decades enterprise architects and stakeholders of change processes have used various '*one size fits all*' EA approaches. Such approaches are typically characterized by their 'Swiss army knife' principle, good for everything but not excelling in anything. It seems that the old enterprise architecture models cannot keep up with today's rate of technology change (Rowe, 2016). Buckl, Schweda and Matthes (2010) even suggest that such approaches are theoretical and impossible to implement. Furthermore, Korhonen and Halén (2017) suggest there is a need for more adaptive conceptualizations of enterprise architecture that address the requirements of new (digital) environments.

Applying the concept of differentiation within enterprises and their business models creates new opportunities for the development of fit for purpose enterprise architecture approaches. Differentiation within an enterprise implies identifying subsystems with a specific scope, purpose and unique characteristics, dealing with specific situations. The question we need to investigate is how to determine a proper enterprise architecture approach in relation to these subsystems given specific situations of change. We propose that the characteristics of subsystems contribute to this determination process. Based on this the following research question is formulated:

In which way can characteristics of subsystems contribute to determining a situational enterprise architecture approach?

This research paper is structured as follows, in the next section the theoretical background that serves as foundation for this research is described. An explanation of the research approach is presented in section 3, succeeded by the research findings in section 4. A discussion of the findings is given in section 5 and finally, in section 6, conclusions are drawn and implications, limitations and suggestions for further research are described.

2 Theoretical Background

DaSilva and Trkman (2014) argue, based on their resource view and transaction cost economics perspective in regard to business models, that business models represent a "specific combination of resources which through transactions generate value for both customers and the organization" (DaSilva & Trkman, 2014, p. 4). We adopt this view and see a clear resemblance with Systems thinking within enterprises (which is the focus of our study). In this research we consider an enterprise as a complex, socio-technical system that comprises interdependent resources of people, information and technology that must interact with each other and their environment in support of a common mission (Dietz, 2006; Giachetti, 2010) which are "comprised of processes, products, organizations, and information" (Nightingale, 2002, p. 2). Chan (2015) mentions that systems are created by humans and can refer to a group of people, a firm or organization, or more abstract concepts like political, religious, or social beliefs.

To fully understand the structure of an enterprise, its attributes of agility, resilience and governance, we need to regard the enterprise as a system and approach enterprise architecture systemically. The application of Systems thinking in enterprise architecture brings an opportunity to differentiate and leave the commonly used 'one-size fits all' enterprise architecture approaches. "Differentiation of an enterprise, see figure 1, involves the creation of new types of corporate units, revealing divisions of labour, organized to pursue diverse goals within and between institutional domains" (Abrutyn, 2016, p. 22). Luhmann (1977), refers to differentiation as the reflexive form of system building. Differentiation within the enterprise leads to two or more subsystems. (Sub)systems are not restricted to borders of an enterprise and inner 'classic' hierarchical top down structure such as for example departments. They can contain one or more business functions and capabilities. Differentiation within the enterprise by identifying subsystems leads to a whole new dimension of connections with the external environment and between (sub)systems.

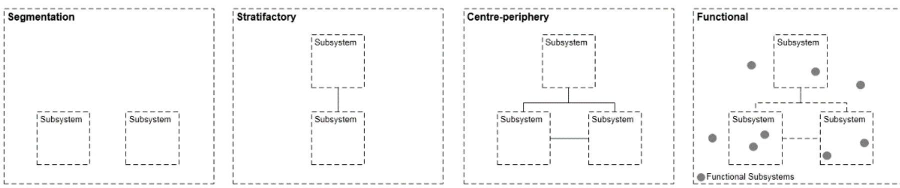

Figure 1: Differentiation Examples of an Enterprise, Luhmann (1977)

The process of differentiation is a means of increasing the complexity of a system. The advantage of differentiation is that it allows for more variation within a system to respond to variation in the environment. Increased variation facilitated by differentiation not only allows for better responses to the environment, but also allows for faster evolution. Ashby's (1991) famous law of requisite variety has come to be understood as a simple premise. If a system is to be able to deal successfully with the diversity of challenges that its environment produces, then it needs to have a range of responses which is (at least) as distinct as the problems created by the environment.

Differentiation within a system contributes to gaining circumstantial control of the systems' response to the environment and today's digital transformation challenges. Each (sub)system has its own characteristics and context and needs a situational approach suitable to the system's characteristics. Situational method engineering offers possibilities for the creation of a situational enterprise architecture approach.

A method is a way, technique or process for doing something. The approach developed in this study has its foundation in Brinkkemper's (1996) method engineering, which is the discipline to design, construct and adapt methods, techniques and tools for the development of Information Systems. The agility of method engineering allows for increased variation and response to todays digital transformation environment, and differentiation within an enterprise. Harmsen (1997) developed a process called Situational Method Engineering, see figure 2. This process focusses on characterization of situations as a means for developing a custom made / situational approach for the transformation given any situation of change.

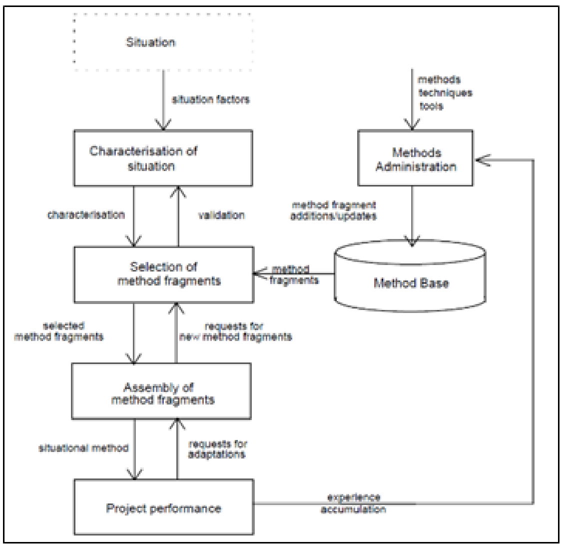

Figure 2: The process of Situational Method Engineering (Harmsen, 1997)

A situational approach is the result of an assembly of Enteprise Architecture Fragments

(EAMF). Fragments may be categorized into product oriented fragments like an architecture deliverable e.g. a specific model, principles, start architecture etc. Fragments may also be categorized as process oriented fragments like specific architecture activity e.g. a qualitycheck. Fragments require their own research.

This research is focussed on identifying and describing relevant (determining) characterstics of (sub)systems and the characterization of the situation of change. Our proposition statement is that characteristics of (sub)systems contribute to the design of an enterprise architecture approach, allowing enterprise architects to compose a selection of Enterprise Architecture Method Fragments (EAMF).

3 The Research Method

The goal of this research is to determine which system characteristics contribute to the assembly of EAMF, in specific a situational enterprise architecture approach. We conducted a systematic literature study of 72 academic papers (see table 1) followed by a Delphi Study to determine the system characteristics that determine the suitability of an enterprise architecture approach. The literature research was carried out by considering papers, discussing a diverse range of system types, to create a foundation for answering our research question. We retrieved a set of 171 non-unique system characteristics, their description and in some cases their definition. Using a characteristic composition process. This process consisted of four stages: 1) defining the academic paper search criteria (system topics), 2) executing the academic paper search and selection process, 3) defining and executing the characteristics search criteria in the papers and 4) defining, composing and selecting an appropriate characteristic set for our research.

Table 1: The Academic Published Papers – Non-Unique Characteristics

Academic Paper System Topic	Unique Sources	Non-unique characteristics	Period of publication			
			< 1990	1990 < 2000	2000 < 2010	> 2010
Adaptive	1	1	-(-)	-(-)	-(-)	1(1)
Innovation	1	1	-(-)	-(-)	1(1)	-(-)
Sectoral	1	1	-(-)	-(-)	1(1)	-(-)
Social	6	14	2(10)	3(-)	1(4)	-(-)
Socio-Ecological	1	3	-(-)	-(-)	1(3)	-(-)
Socio-Technical	19	67	2(8)	2(8)	8(25)	7(26)
System of Systems	19	44	1(1)	1(2)	14(31)	3(10)
Systems	24	40	2(7)	7(6)	12(22)	3(5)

Note. The numbers in brackets represent the amount of Non-unique characteristics

The Delphi Study is "an iterative process to collect and distil the anonymous judgments of experts using a series of data collection and analysis techniques interspersed with feedback." (Skulmoski, Hartman & Krahn, 2007, p.1) The applied Delphi study allowed us to create structured anonymous interaction, concerning system characteristics, among a homogenous group of enterprise architects as shown in table 2.

Table 2: The Delphi Expert Panel Participants

Industry	Panel members	Architecture Experience (years)	10 – 15 years	15 + years
Government	1	15	-	1
Education	5	73	4	1
Commercial Industry	9	127	6	3

The full Delphi study consisted of three rounds in which experts answered questions about if, why and in which way characteristics (derived from literature) contribute to an architecture approach. Each round the experts were enabled to revise and give justification for their answers. The Delphi question strategy per round is outlined in table 3.

Table 3: Delphi Study Question Strategy

Delphi Round	Purpose
1	To introduce (sub)system characteristics and their definition to the expert panel members with the intention to assess if and in which way (sub)system characteristics are determining for the choice of Enterprise Architecture Method Fragments. This is done to gain consensus about determining characteristics.
2	Gain further consensus on characteristics which reached no consensus during the first round.
3	Gain expert panel insight in situational factors that would influence the choice in Enterprise Architecture Method Fragments.

A set of definitions of the key concepts used in the Delphi study was composed as a reference point for the participating expert panel members during the Delphi rounds, see table 4.

Table 4: Applied Definitions Delphi Study

Definition	Description
Characteristic	a distinguishing trait, quality, or property of something that belongs to something and makes them recognizable
Determining Characteristic	Causing something to occur or be done in a particular way; serving to decide something; to control or influence something directly, or to decide what will happen; to come to a decision.
(Sub)system*	A (sub)system is a set of interdependent resources of people, information, and/or technology that must interact with each other and their environment in support of a common purpose. The common purpose is what binds the components of the (sub)system.
System Context	System context is the situation in which the system exists, identified by the internal environment (e.g. stakeholders, aspect of business processes), external environment (e.g. trends), articulated business strategy and identified requirements.
Enterprise Architecture Method Fragments*	An architecture method fragment is a part of 'working under architecture' which can be considered as a building block that, together with other building blocks, shapes 'working under architecture'. A building block can refer to a type of activity, a deliverable, an aid, a form of organisation, etc.

Note. (*) Definitions were derived from a focus group on Multi Dynamic Architecture as part of another project.

4 Findings

The literature review revealed that different studies define and describe characteristics in their own way. There is no universally agreed upon normalized academic list of characteristics. Our systematic literature review and the applied characteristic composition processes resulted in 50 system characteristics which we presented to the experts in our Delphi study, see Table 5.

Table 5: The Delphi Study Characteristics

Adaptability	Emergence	Multiskill	Socio-technical
Agility	Evolution	Non-ergodic	system- safety
Ambiguity	Flexibility	Non-monotonic	Stakeholder congruence
Autonomy	Future visions	Power and agency	Structure
Behaviour	Hierarchy	Quality of the-	System control
Belonging	History	interfaces	Task allocation
Boundary role-	Holistic problem-	Resilience	Technological
location	space	Resource sharing	innovation- system
Complexity	Human value	Reuse	Transformability
Congruence support	design	Role dynamics	Transformation-
Connectivity	Information flow	Self-adaptability	capability
Contextuality	Interaction	Socio-technical	Unanticipated variety
Coupling	Interdependence	integration	Variability
Diversity	Iteration	Socio-technical-	Variance control
	Modularity	interaction places	Variety

Over the three Delphi rounds academic rigour was maintained with a response rate larger than 70%, with 14 out of 15 experts participating each round. Round 1 & 2 of the Delphi Study delivered consensus on 29 characteristics of which 27 characteristics were found to be determining for an enterprise architecture approach (presented in table 6). The definitions of these characteristics are provided in the appendix.

Table 6: Positive Consensus Characteristics

Adaptability	Contextuality	Interdependence •	Stakeholder
Agility	Coupling •	Iteration	congruence
Ambiguity	Flexibility	Power and agency	Structure •
Behaviour	Future Visions	Resilience	Task allocation
Belonging	History	Reuse	Unanticipated
Complexity	Information flow	Role dynamics	variability
•	•-	Socio-technical	Security •*
Connectivity	Interaction	integration	Information
			Intensity*

Note. (*) characteristics are characteristics suggested by the expert panel
• Context independent characteristics
- Case relevant consensus characteristic (Context & Context + Change scenario case)

Furthermore, in round 3 of the Delphi Study, the expert panel identified six characteristics as being system context independent. This result indicated that the expert panel members have consensus that these characterstics are relevant given any situation of change and are to be used at all times.

Subsequently, during round 3, the expert panel members were presented with two specific cases (descriptions of different contexts) and asked to select the ten characteristics most relevant to determining the right EA approach. The expert panel members achieved consensus on only one characteristic: information flow. A large variation of characteristics was chosen by the expert panel members for each of the given cases. Reasons for the variation and therefore lack of consensus may be caused by the quality of information presented in the case, field of expertise and experience of expert panel members, and personal interpretation of the characteristics having in mind specific Enterprise Architecture Method Fragment.

As a final result Delphi round 3 delivered insight and consensus about situational variables which, besides characteristics, also determine the choice of enterprise architecture approach. The expert panel members found that the system context, change scenario and the maturity of the enterprise architecture function all influence the enterprise architecture approach, see figure 3.

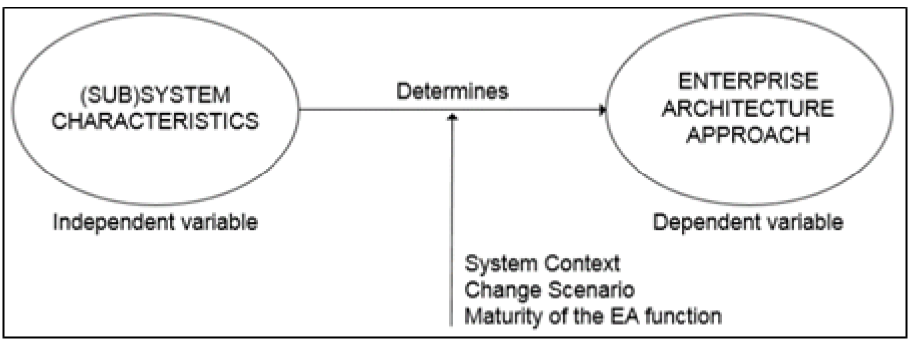

Figure 3: Situational Influential Variables

5 Situational Enterprise Architecture Approach

Based on the outcome of the Delphi study it is possible to develop a Situational Enterprise Architecture Approach using Harmsen's Situational Method Process (figure 4). A repository (Subsystem Characteristic Base) is constructed consisting of the characteristics on which the expert panel reached a positive consensus.

The change situation's system context, the given change scenario and the maturity of the Enterprise Architecture Function influence the characterization of the situation. A unique array of characteristics, chosen by the Enterprise Architect, is used to define each situation that requires architecture. The situations relate to the current situation (As Is), the pursued future situation (To Be or future state) and/or the system of change itself, e.g. project, programme etc. The application of the subsystem characteristic base, by selecting either situation independent and/or situation dependent characteristics enables Enterprise Architects to create a specific view of the situation necessary for architects to select Enterprise Architecture Method Fragments, fit for the specific purpose of change.

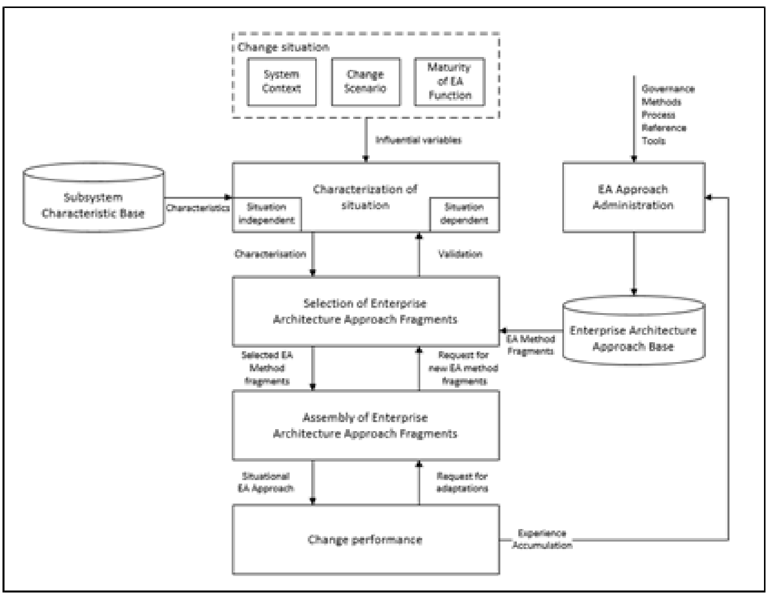

Figure 4: Situational Enteprise Architecture Approach

Fragments can relate to key elements of an Enterprise Architecture approach e.g. Governance, Methods, Process, Reference and/or Tooling fragments. The combined fragments result in a situational approach, which we refer to as fit for purpose Enterprise Architecture. Continuous performance monitoring of the Enterprise Architecture Assembly may lead to adjustments of the assembly of architecture approach fragments to secure a fit for purpose Enterprise Architecture.

6 Conclusion

In this paper we propose an way to design a Situational Enterprise Architecture Approach that enables enterprise architects to differentiate within enterprises. This creates a new way for architects as an alternative to the 'one size fits' all approach of current enterprise architecture frameworks.

A Situational Enterprise Architecture Approach could allow for increased responsiveness, further digitalization of the guidance process concerning change, improved decision making and communication. This approach can be used in changing situations and thereby contributes to the further development of the discipline of enterprise architecture.

The system characteristics identified and described in this research are a first step towards building a characteristics base for a Situational Enterprise Architecture Approach. It is the combination of several characteristics which creates synergy and enables the enterprise architecture approach design. The expectation is the more characteristics applied, the clearer the situation becomes and the stronger the effect and accuracy in selecting Enterprise Architecture Method Fragments. The contribution of this research is, that enterprise architects are provided with a rich repository of characteristics that allow for a new way of creating standardised views of situations of change that can help in the choice of Enterprise Architecture Method fragements and identify best practices suitable to specific situations of change.

The study has some limitations. The characteristics were defined at a high conceptual level. This was largely achieved by sourcing from peer reviewed academic papers. Though all expert panel members were asked to use the general definitions provided at the start of each Delphi round, we cannot rule out that expert panel members made their own interpretation based on their own experience.

The results of the Delphi study, the subsystem characteristics, are indicators that characteristics are determining the choice of Enterprise Architecture Method Fragments. Without formalized, or standardized values, characteristics are not made SMART (Specific, Measurable, Achievable, Realistic and Time bound). By making them SMART, the characteristics found in this research may contribute to further standardisation of enterprise architecture approaches and add to the creation a common language among enterprise architects and the stakeholders concerned with change. Besides these important aspects, it seems that (sub)system characteristics have the potential for the use of pattern recognition and may therefore be an interesting building block for artificial intelligence and machine learning.

One shortcoming of the study is the lack of rigorous empirical validation of the usage of characteristics and the proposed design approach. The current research has taken a first step towards improving the theoretical knowledge about (sub)system characteristics, however we recommend demonstration and evaluation of the Situational Enterprise Architecture Approach by testing it in practice.

As a venue for further research we propose a full research into the exact relation between the characteristics of subsystems and the characteristics of Enterprise Architecture Method Fragments. Another important question to be addressed is: 'What are possible values of the characteristics?'. Standardization and normalization of characteristics values seems necessary to further institutionalize the proposed Situation Enterprise Architecture Method and making characteristics 'SMART'.

Finally, in our opinion, it is important to create a standard list of characteristics of subsystems and influential variables related to the enterprise architecture definition.

Finding answers to the questions above would help to further define and explain in which way all characteristics can contribute to the proposed Situational Enterprise Architecture Approach.

Appendix 1: Full Table with Results of the Systematic Literature Review

Characteristic	Definition
Adaptability	Adaptability is the system's ability to respond to exerting pressure for change with sufficient adaptive capacity such as a coordinated response and resources (e.g. finance, legitimacy or competence) based on new appraisal criteria to manage resilience.
Agility	Agility is the systems capability of handling long term and short-term changes which demands development of the existing system and utilising the existing system.
Ambiguity	Ambiguity is the difficulty of clearly demarking problem boundaries, as well as their interpretation within or beyond the system.
Behaviour	Behaviour is the observable activity of the system between stable and unstable caused by the behaviour of their elements.
Belonging	Belonging is the acceptance of the system to form relationships with other autonomous systems, to be persuaded to make a valued contribution to the goal of the larger entity, to change, to render service and to collaborate.
Complexity	Complexity stands for the complex interaction between the systems elements (e.g. humans and or technology) that result in unpredictable behaviours.
Connectivity	Connectivity is the system's capacity in determining the connectivity they wish to form with elements or subsystems as needed to benefit the system.
Contextuality	Contextuality stand for the circumstances, conditions, factors, patterns that give meaning and purpose to the system.
Coupling	Coupling is the type of coupling (tight or loose coupling) of components in a system, depending on the complexity of the system, which determines the system's ability to recover from discrete failures before they lead to an accident or disaster.
Flexibility	Flexibility is the ability of the system to respond to the external environment, or actions to manipulate it, such as public awareness campaigns.
Future Visions	Future visions are collectively held and communicable schemata of the system that represents future objectives and express the means by which these objectives will be released.
History	History stands for past events considered together which influences attitudes of the systems behaviour in the present.
Information flow	
Interaction	

Interdependence	Information flow stands for the design of the systems information delivery to either the point of action and problem solving or to provide information based on hierarchical channels.
Iteration	Interaction stands for dynamic and non-linear interactions between systems, actors, and rule regimes and offers in general two or more options for decision making.
Power and agency	Interdependence is the dependence of component and (sub)systems on each other for their functioning which makes them difficult to change.
Resilience	Iteration is a mechanism for proceeding from the interpretation of the customers' requirements to an optimized product within and across all levels of integration and all phases of a system life cycle.
Reuse	Power and agency are the authority to affect change and the ability to intervene and alter the balance of exerting pressures or adaptive system capacity.
Role dynamics	Resilience is the capacity of a system to absorb changes, disturbances and reorganize so as to still retain essentially the same function, structure, identity, and feedbacks - in other words, stay in the same basin of attraction.
Socio-technical integration	Reuse stands for a repetition or similarity in design within or among (sub)systems.
Stakeholder congruence	Role dynamics stands for clearly separated roles versus boundary dissolvement between the roles, where new roles emerge, and roles are highly dynamic.
Structure	Socio-technical integration is the combining of social and technical systems as such that synergy can be achieved.
Task allocation	Stakeholder congruence is the (in)difference in expectations, assumptions, or knowledge about some key aspect of the system and the context it is operating in by frames of various stakeholder groups affecting the systems alignment.
Unanticipated variability	Structure is the configuration of and relations between elements of the system with the distinction between mechanic and organic structures depending on the rate of change.
	Task allocation is the assignment of work between humans and machines in a system and among systems with respect to the criticality of the performance of the system.
Security	Unanticipated variability is a manifestation of emergence phenomenon that arises from the richness of the interactions between the system elements as well from the fact that system

Information Intensity	elements receive information from indirect or inferential information sources, independently of any central control or design.
	Security stand for the requirements for availability, Integrity, confidentiality, verifiability and irrefutability of information and processes in an enterprise
	The extent in which information exchange is an important aspect of the system

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Guided Machine Learning for Business Users

ADRIAN BOURCEVET, GUNTHER PILLER, MATTHIAS SCHOLZ & JAN WIESEMANN

Abstract Advanced and predictive analytics are playing an increasingly important role in all industries. However, the productive use of new analytic methods and applications seems to stagnate. One reason for this is a lack of people with the necessary data science skills, especially for small and medium sized businesses. This paper proposes design principles that are important for enhancing the usage and adoption of applications for advanced and predictive analytics. The identified principles are implemented in a prototype application for predictive maintenance which can be used by employees without knowledge of data mining and machine learning.

Keywords: • Data Mining • Machine Learning • Predictive Maintenance • Technology Adoption • Business Users •

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1 Introduction

Advanced and predictive analytics will play a most crucial role in all industries. This is the strong belief of many companies. For example, in a study of BARC (Derwisch, Iffert, 2017) about 94% of 210 participants consider advanced and predictive analytics to be important in the future. The number of companies using it already is stagnating at 5% for frequent use and 31% for occasional use. In particular small and medium size enterprises (SME) are often laggards when it comes to the use of advanced analytical tools and methods. One reason for a slow adoption is the shortage of people with data science skills (Derwisch, Iffert, 2017; Piatetsky, 2018). This is especially true for SME.

One way to encourage the use of advanced and predictive analytics is to provide tools and methods that do not require deeper mathematical or statistical understanding or data preparation skills. There are several software vendors offering solutions in this direction (see e.g. (Alteryx, 2019; RapidMinier, 2019; SAP Predictive Analytics, 2019)). However, these either still use advanced data science vocabulary and processes or are fully automated. In the latter case, users typically remain alone with the challenges of interpreting the results and have no chance to improve their analyses further.

This paper addresses these shortcomings by investigating design principles that are important for enhancing the usage and adoption of advanced and predictive analytics for users without data science experience. The identified principles are implemented in an exemplary fashion in a prototype application for predictive maintenance which can be used by employees from, e.g., SME without knowledge of data mining and machine learning. As its key elements the prototype application puts the analysis process into the business context of the end user, automates major analysis tasks and provides guidance for the interpretation of results and potential improvements.

In the next section we briefly sketch the design science approach on which this work is based. We then summarize relevant literature regarding knowledge discovery, automation in machine learning and technology acceptance which are used as theoretical foundations. The design principles are explained next. Their implementation is then illustrated with an application prototype for a predictive maintenance use case from the polymer film production industry. Finally, we conclude with future directions.

2 Methodology

Design science research is driven by business needs to ensure relevance and uses theoretical knowledge for rigor (Hevner et al., 2004). The research process is structured into the following steps (Gregor and Hevner, 2013; Kuechler and Vaishanavi, 2012): Based on the problem formulation, we begin by discussing kernel theories that guide the identification and implementation of design principles that promote the adoption of predictive analytics tools for non-experts. Together with the findings of practitioners, this knowledge is used to propose generalizable design principles. These form the basis for the implementation of the application prototype for predictive maintenance. Finally, an initial evaluation of the prototype is carried out.

3 Theoretical Background

Business users, e.g., in the area of production are familiar with their business context, such as production processes and product quality issues. However, they usually do not have any significant knowledge of data science methods and techniques. For them, the use of currently available tools for data mining and machine learning is a major challenge. In order to guide our research and reduce these hurdles, we use concepts of technology acceptance, knowledge discovery and metalearning.

The most frequently used model for IT adoption is the technology acceptance model TAM (Davis, Bagozzi, Warshaw, 1989). It contains perceived usefulness and perceived ease of use as the key drivers for the attitude and intention to use a new technology. In the extended model TAM2 external variables were introduced to provide a more detailed explanation for users who find a particular system usable. The major ones are (Venkatesh and Davis, 2000): *Subjective Norm* that is understood as the perceived social pressure for the use of a technology; *Image*, the degree of influence of the use of a technology on the status of the employee; *Job Relevance*, whether the functions of a system assist a person in the performance of her tasks; *Output Quality*, a qualitative measure of how well a system performs given tasks; *Result Demonstrability*, the extent an increase in work performance is directly attributable to the new technology. In addition, TAM2 also uses two moderating variables, *Voluntariness* and *Experience*, influencing the effect of Subjective Norm. There are further extensions of TAM, in particular TAM3, where external variables for perceived ease of use were modelled (Venkatesh and Bala, 2008). In this work TAM2 is used as a basis for the identification of suitable design principles. It contains all the important variables and has limited complexity, which is advantageous for our case.

Several models are available to structure data mining and machine learning analyses (see e.g. (Mariscal, Marban Fernandez, 2010)). One especially widespread approach is the Cross-Industry Standard Process for data mining, CRISP-DM (Wirth and Hipp, 2000). It is a widely adopted industry-oriented process for knowledge discovery and serves as a de-facto standard (Kdnuggets, 2014). The CRISP-DM process structures data analyses into the six phases *Business Understanding*, *Data Understanding*, *Data Preparation*, *Modelling, Evaluation* and *Deployment* (Wirth and Hipp, 2000). The typical tasks in those phases can be used as a guide for the implementation of design principles.

A central element of making predictive analytics applicable to business users without data science knowledge is automation. To achieve this, it is important to identify analytical components, in particular data preparation and modelling algorithms, that fit to the addressed analysis tasks and the properties of the available data. The concepts of metalearning can be used for this purpose (see e.g. (Brazdil et al., 2009; Lembke, Budka, Gabrys, 2015)). Here metadata – so-called metafeatures – for analysis tasks, data and algorisms help to select and combine suitable analysis components that cover all essential CRISP-DM phases.

4 Design Principles

In a design science approach, kernel theories can be used to guide the design of IT-based solutions (Gregor and Jones, 2007). Central to the project described here is that the design of the projected software application is suitable for business users without data science experience. To ensure the acceptance of the planned solution, the technology acceptance model TAM2 is used as guidance for the identification of design principles. These have been developed in workshops with industry experts and consultants having project experience in the area of business analytics. The relation of TAM2 variables to the design principles is described below and summarized in Table 1. Hereby we first discuss the principles related to variables for *Perceived Usefulness and then the ones for Perceived Ease of Use.*

Table 1: Design principles and relations to variables from TAM2

Design Principles	Job Relevanc	Output Quality	Result Demon-	Image	Perceived Ease of
Comprehensive business context (DP1)	X				
Quick and easy availability of results (DP2)		X	X		
Guided extensibility of analyses (DP3)		X		X	X
Discovery of (hidden) insights (DP4)		X			
Result presentation for business users (DP5)			X	X	
System control by business users (DP6)					X

Job Relevance is a key variable of TAM2 driving *Perceived Usefulness*. It is defined as an individual's perception regarding the degree to which a software solution is applicable to her job (Venkatesh and Davis, 2000). To ensure that a business user realizes the possibilities and value a predictive analytic tool provides for her tasks, a comprehensive presentation of the business context of available data and analysis options (DP1) is most important. An example of this is the presentation of business processes, including all data and measurements with target values, actuals and deviations.

The variable *Output Quality* describes how well tasks are performed by a system. For an advanced analytics system for business users, this means in particular that first analysis results should be quickly available without being hampered by a lack of experience (DP2). If initial results do not correspond to the expected level of detail, the users must also be guided on how to improve analyses (DP3). Finally, all potentially relevant relations between data – also hidden ones such as clusters or patterns – must be identified when analysing specific business issues (DP4).

Innovative systems are more accepted if people can attribute improvements in the accomplishment of their work tasks to the use of the system. In TAM2 this is described by the variable *Result Demonstrability*. Our first design principle DP1 – providing comprehensive business context to data and analysis options – is certainly important here. In addition, interim and final results of analyses must be easy to understand from a business point of view. They must "speak" to the business audience (DP5).

The degree to which the use of an innovation is perceived to enhance one's status in one's social system is described by the variable *Image* in TAM2. Nowadays, when data science and predictive analytics are being hyped quite a lot, it is prestigious to perform and understand such kind of analyses. Design principles DP3 and DP5 support this aspect.

In TAM2 the variable *Perceived Ease of Use* is a direct determinant of *Perceived Usefulness* and is also directly linked to *Intention to Use*. The less effortful a system is to use, the more using it can increase job performance (Venkatesh and Davis, 2000). Since the intended users of our system do not have data science experience, control of the system by employees from business departments is a most important design principle (DP6). A further principle relevant here is DP3.

5 Design and Implementation for Predictive Maintenance

For the design and implementation of the application prototype for predictive maintenance, the functional requirements were structured according to the CRISP-DM phases and the design principles from Section 4 were applied. Their realization is illustrated in this chapter for an application scenario from the polymer film production industry (see e.g. (Kohlert, M. and König A. (2015)).

Providing comprehensive business information around the production process is the key to meeting the first design principle that requires comprehensive business context (DP1). For the first phase Business Understanding of CRISP-DM, this means, e.g., displaying production steps, machine data, process parameters and sensor measurements. An example for this is illustrated in Figure 1. One can see different steps of the production process, such as extrusion or cooling and the corresponding machines with information about their output and built-in sensors. In addition, access to all sensor measurements during the process under consideration is provided. Amongst other things, the corresponding time series are displayed and compared with target values and tolerances.

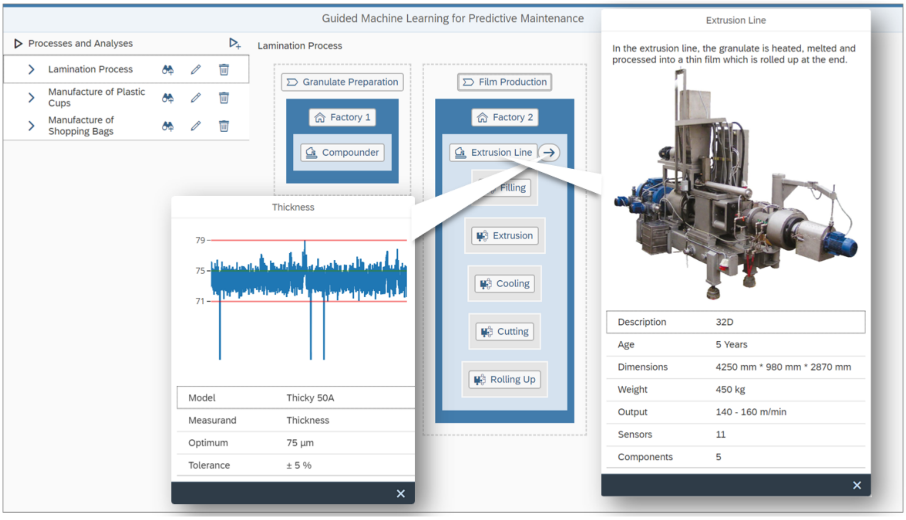

Figure 1: Context information about production process, machines and data

A major component related to the second design principle – quick and easy availability of results (DP2) – is the provisioning of process templates for different analysis methods. These typically span over several CRISP-DM phases. They are mandatory for automatic analyses, especially in the phases of data preparation, modelling and evaluation. Figure 2 illustrates a decision tree classification template used in the prototype.

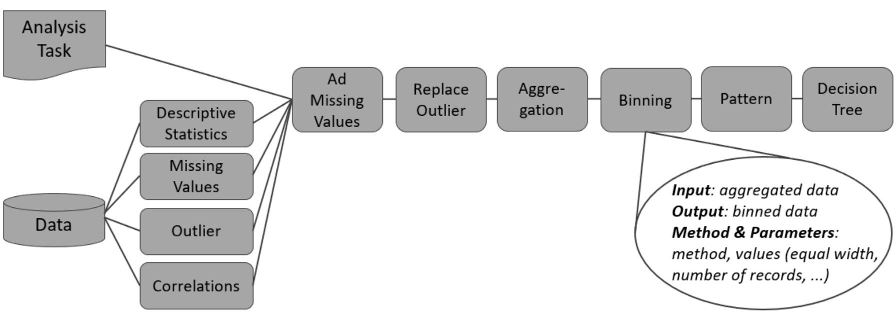

Figure 2: Process template for classification

The starting point is the business question to be analysed and the available data. The data are examined with the help of several components that determine the properties required for further processing. These are, for example, statistical parameters such as mean values and standard deviations, missing values and outliers, as well as correlations. The data are then pre-processed by reconstructing missing values and replacing outliers. As a next step data are aggregated, e.g. to average sensor values per minute. Then discretization follows. Here values that are considered similar are assigned to one class. Since frequent patterns of sensor values can also be important features for classifications, these are determined next. Finally, a decision tree algorithm is performed.

Each of the analysis components is characterized by specified input values, output values, a method and corresponding parameters. Discretization by binning, for example, starts with the previously aggregated data and delivers discretized data. A typical method for this splits the data into equal intervals with specified size. Input and output of the building blocks in the process templates are coordinated with each other and enable an end-to-end analysis of a given task. The methods and parameters are initially specified so that automatic execution is possible. Their selection can be systematized by metafeatures, describing analysis task, corresponding data and analysis components (see e.g. (Brazdil et al., 2009)).

Guided extensibility of analyses (DP3) ensures that users are not left alone with results that do not meet their expectations. Corresponding assistance is typically placed in the CRISP-DM phase on model evaluation. The proposed extensions will typically focus on variations in data preparation and modelling.

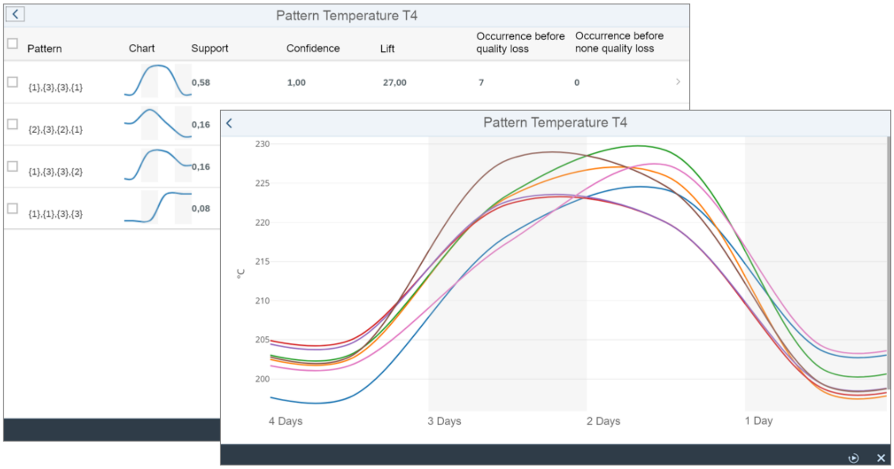

Figure 3: Frequent sequential patterns for sensor data on temperature and corresponding measurement details

A typical example for the phase on data preparation are suggestions to review the methods used for data discretisation by binning (see e.g. (Han, Kamber Pei, 2011)). Initial analyses are determined by parameters in best practice templates that include several alternatives. The results can sensibly depend on the binning method, e.g. equal-width or equal-frequency, bin-size or smoothing method, e.g. by means or median. If this is the case for automatic calculations, the system should recommend that the user checks the binning from a business point of view and changes it if necessary.

Another example for the CRISP-DM phase on modelling relates to feature selection. Features for, e.g., decision tree algorithms may include patterns of various sensor measurements. If the results of pre-defined analysis templates vary significantly with the number of included patterns, users shall be asked to revisit the identified patterns and evaluate their use for model building from a business perspective.

The discovery of insights in data that are sometimes hidden (DP4) is most relevant in the CRISP-DM phase on data understanding. Here data are automatically examined using various statistical methods, such as correlation analysis, and data mining methods, like clustering and pattern mining. Goal is, to provide business users with potentially surprising insights, even if those are not directly related to the analysis task specified in the beginning. The results found can be evaluated from a business point of view and used later during model building.

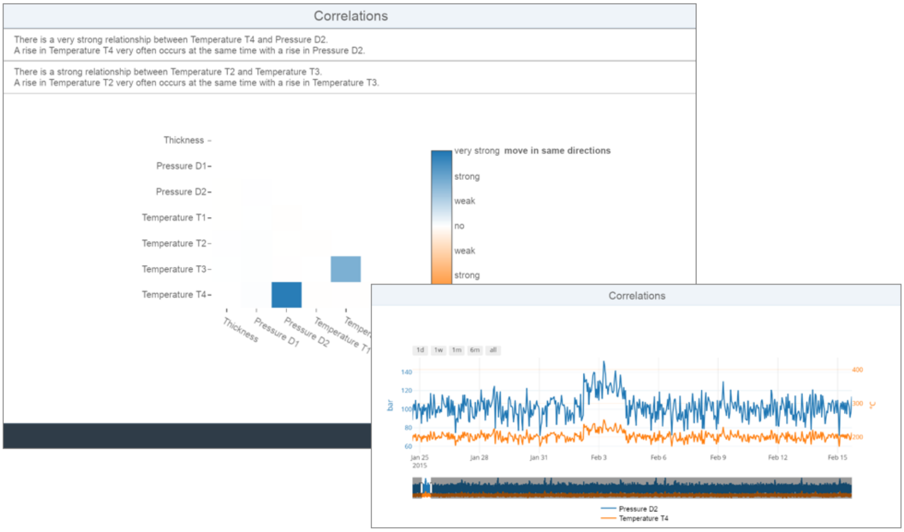

Figure 4: Visualization of correlations

Figure 3 demonstrates an example from the predictive maintenance prototype. The detection of frequent sequential patterns of sensor values was implemented using the SPADE algorithm of the R package arulesSequences (Buchta et al., 2018). Shown are results for frequent sequential patterns of sensor data for temperature prior to quality issues. The application lists the patterns and corresponding key figures for their relevance. It also allows detailed inspection onto the course of the measured values in the respective patterns.

It is crucial that users without data scientific knowledge can understand, evaluate and interpret intermediate and final results. Therefore, result presentation for business users (DP5) is a design principle which is relevant for all CRISP-DM phases where analyses are performed. For example, during the phase on data understanding it is important to explain the level and meaning of identified correlations between different parameters. Methods and results in data preparation for dealing with missing values and outliers must also be explained in a way that is easy to understand. The same applies, of course, to the presentation of the results from the modelling and evaluation phases.

As an example, Figure 4 displays the user interface of our prototype showing the results of a dependency analysis of different variables based on Pearson correlation coefficients. The direction and level of identified correlations are visualized through colour coding and natural language. In addition, the user can view and track the data history for the different correlations in detail.

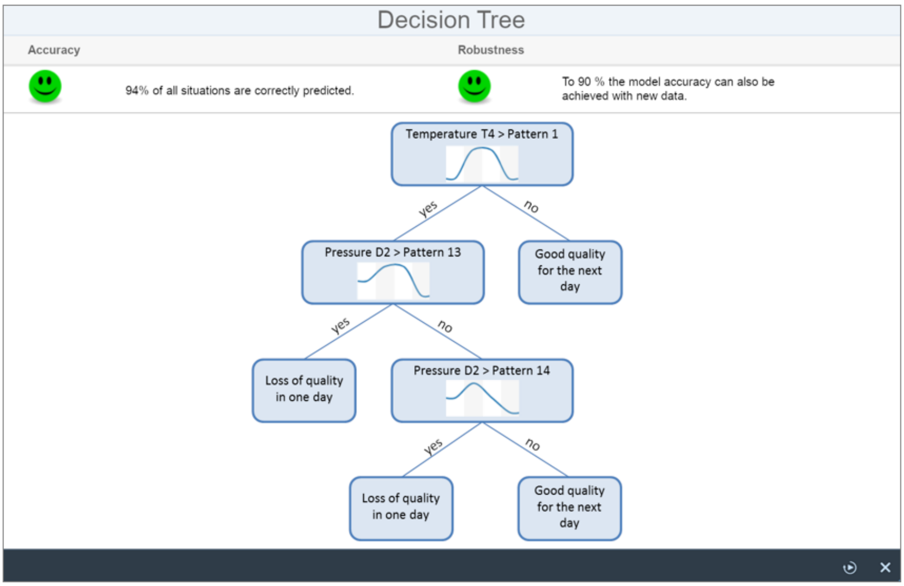

Figure 5: Display of a predictive model based on a decision tree

Figure 5 shows an example for a simplified predictive model. In our prototype the classification of quality risks is predicted here with the help of a decision tree model based on the CART algorithm. The corresponding template for automatic analyses allows as features sensor data, machine parameter as well as frequent patterns. The visualization of the resulting model displays the tree and its nodes, including the involved sequential patterns. The calculated reliability and robustness of the model is illustrated through corresponding key figures and icons (see e.g. (Han, Kamber Pei, 2011)).

The last design principle, system control by business users (DP6), is most important for the target audience of our predictive maintenance applications which is assumed to have no data science experience. It also guides the implementation of the aforementioned principles. Specialist terminology in connection with data mining and machine learning must be avoided. Automation (DP2), guidance (DP3) insights (DP4) and results (DP5) must always be embedded in the business context (DP1) of an analysis task. Decisions to be taken during an analysis by a user must be phrased in terms of possible consequences with respect to business questions. Any system help must provide information to the business user regarding model-building choices. This information – which must always be formulated in business terms – can be provided as outcome feedback, showing the consequences of choices, or feedforward (Schymik et al., 2017).

6 Status and Outlook

Following the design principles from Section 4 and their implementation, as illustrated in Section 5, a working prototype for predictive maintenance has been developed. It has been built upon two different technology stacks. Stack 1 uses PostgreSQL as database (PostgreSQL, 2019), node.js for application logic and R for advanced analytics (node.js, 2019; R, 2019), OpenUI5 for user interfaces and plotly for diagrams (OpenUI5, 2019; plotly, 2019). Stack 2 uses dominantly SAP technology with the SAP HANA database, SAP PAL for advanced analytics, SAP XSA for application logic (SAP HANA, 2019), and again OpenUI5 and plotly for user interfaces. Both stacks can be deployed on-premise or in cloud environments.

Functional tests were performed with analysis templates for regression and classification. Additionally, a descriptive evaluation of the prototype has been conducted. Hereby the usage of the application against typical analysis scenarios from polymer film production has been evaluated. In particular all steps of the scenario were matched against the design principles from Section 4.

As a next step experimental tests with different companies are planned. For this purpose, the analysis scenarios of the prototype have to be adapted to specific use cases of the participating companies. For small and medium businesses, the prototype implementation of stack 1, running on the Cloud Foundry platform is used (Cloud Foundry, 2019). Stack 2 is used for companies having SAP technology already in place.

Future research focusing on metalearning concepts could probably further improve the use of predictive analytics for people without data science knowledge. Currently the application captures metafeatures about analysis tasks, datasets and analytic components. The combination of metafeatures with the quality of answers for specific analysis tasks are stored in a knowledge base. A systematic use of this information for future analyses along the ideas of metalearning is an interesting option to investigate further (see e.g. (Brazdil et al., 2009; Lembke, Budka, Gabrys, 2015)).

Acknowledgments

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Technological and Human Aspects of a Successful Business Intelligence Project

JULIJA LAPUH BELE, TOMAŽ DULAR & ROK PIRNAT

Abstract This article is written as an attempt to help companies that have decided to introduce business intelligence (BI) methods or have already introduced them with unsatisfactory results. We will discuss the measures that should be implemented before a BI project is launched. The most crucial part of the process is diagnostics, which provides an assessment of the status of technology, operations and human resources' knowledge and skills in the company. In order to carry out efficient and precise diagnostics, we designed a questionnaire that helps us to understand the operational and technological aspects related to a project as well as the qualifications of available human resources. In the article, we enumerate all factors that must be assessed in individual BI projects, and those that must be changed in the organization in order to successfully implement such projects.

Keywords: • Business Intelligence • BI • Data visualization • Digitalization • Human Aspects •

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1 Introduction

The most successful companies constantly strive to achieve greater operational efficiency and to optimize their business processes. For this reason, both commercial enterprises and government entities are introducing methods of Business Intelligence (BI).

Managers who do not make use of BI methods tend to rely on data collected from Enterprise Resource Planning (ERP) systems and simple intuition. Good intuition is always welcome in business, but it is similar to talent in sports. It is no longer sufficient as a way of winning in a strong competitive field. Research has shown that companies that adopt BI methods early and make decisions based on the results generated by these methods do better than their market competitors in terms of profitability, quick decision-making, and implementation of operational decisions (Pearson and Wegener, 2013).

According to our experience, the management of many companies would like to increase operational efficiencies using BI methods, but fear that they are not sufficiently prepared and sense that the implementation of such projects might fail. Managers often wonder if the company is "mature enough" for the launch of such projects and what they should do in order to insure that such projects will be successful. These questions go directly to the point as international research shows that many BI projects fail. In addition to the predictable reasons for unsuccessful projects, many other factors lead to failure: ambiguously or unsuitably defined business goals, technological factors such as poor data, inadequate preparation for the transition, and insufficiently trained human resources (Sherman, 2015).

Necessary preparations are therefore the first important step on the path toward the successful implementation of BI projects. The task of project leaders and consultants is to run diagnostics and prepare the company and its human resources for the introduction of the project in order to facilitate the achievement of company goals.

This article is written as an attempt to help companies that have decided to introduce BI methods or have already introduced them with unsatisfactory results. It emerged on the basis of known facts, our experience and ongoing development of good practices introducing BI to several successful companies with whom we have collaborated.

At the beginning of the article, we describe the theoretical framework. In the empirical section, we present evaluations of the preparedness of organizations for the introduction of BI. We also present key areas that need to be researched before concrete projects are launched.

We designed a questionnaire that we use to systematically perform diagnostics and generate a list of necessary steps to take in the preparatory phase of the BI project. We combine information gathered from the questionnaire with our own expertise to help clients avoid the obstacles and correct the problems that often lead to project failure.

2 Theoretical Framework

In recent years, there has been much talk about digitalization.

The term digitalization not only means the transition from analogue to digital operations, which has been a continual process since the invention of the computer, but has acquired a deeper and more contemporary significance. Namely: digitalization is the use of digital technologies to change the business model and to provide new revenue streams and value-producing opportunities (Gartner, 2018).

Today BI offers the key methods and tools for digitalization. However, there is not yet a unified definition for BI, although certain concepts appear in most definitions, such as efficiency, optimization, and better or quicker management decision-making.

David Loshin (2003) defined BI as the processes, technologies, and tools that are necessary for the conversion of data into information, information into knowledge, and knowledge into plans, which leads to more efficient operations.

The following definition of BI is offered by the Gartner Report: BI is an umbrella term that includes the applications, infrastructure and tools, and best practices that enable access to and analysis of information to improve and optimize decisions and performance (Gartner, 2018).

BI is important for the improvement of decision-making on the basis of past results. However, statistical data and the analysis derived from them are not sufficient to forecast the future. The process should be enhanced by using data mining methods, which are essential for not only forecasting the future but also anticipating certain events that might occur.

In practice, we use predominantly statistical methods to conduct research into the data of a company and to generate visually transparent reports that offer management tools for a better overview of operational processes, better and quicker decision-making, and the optimization of operational processes.

Business and the achievement of business goals are clearly at the centre of the interest in BI.

Businesspeople see BI project results through their tool interfaces and dashboards (Sherman, 2015). Therefore, the following perspectives of a BI project must be considered in order to achieve the set of objectives: business, technology and human resources.

2.1 Business Perspective

Planning, setting goals and introducing changes are important tasks of management.

In order to monitor the implementation of plans and to provide clear visual presentations of the current state, it is essential that goals are measurable.

BI project results are reports that suggest necessary changes even when their introduction may be difficult. Many theoreticians and practitioners question why, despite numerous available methods, introducing changes is so often problematic and inefficient.

Organizations change slowly and with difficulty. Most often changes are introduced with the authority of top management, while lower-level employees show little enthusiasm for them. The basic condition for the successful introduction of changes is that participants understand why the changes are necessary. BI and its reports help to clarify and justify recommended changes.

Among the most frequent reasons that the companies with which we collaborate decide for BI projects is to create conditions in which a wider circle of employees will understand the state of the company, and the gap between the current state and defined goals, and will work enthusiastically to achieve the defined goals. In essence, BI is a way for top management to empower lower-level management and employees to work toward concrete results. It makes it easier to introduce changes and to monitor whether changes have a positive influence on business results. We observe that in organizations that have high-quality BI, more attention is directed toward looking for changes, inventions, and innovations in the area of products and business processes on all levels (Lapuh Bele et al, 2018).

In companies we usually use business-management software, which is typically a set of integrated applications that facilitates the collection, storage, management, and interpretation of data from several business activities, such as accounting, manufacturing, purchasing, sales, etc. This kind of application suite is called an ERP (Enterprise Resource Planning) system.

In recent times, managers have begun to expect better information from their technology than ERP systems generally offer. Namely, they expect efficient control over large amounts of data, continual oversight on the achievement of key performance indicators (KPIs), the detection of properties that are not easily observable, regular access to information (24/7/365) through various devices, including mobile devices, and clear reporting that provides key information and relevant visual data (Sherman, 2015).

On the basis of our research of a number of companies, we attempted to identify the most frequent goals for implementing BI projects. They generally have to do with the improvement or optimization of important operational processes, including the following:

- sales profitability,
- productivity,
- elimination of a bottle neck in operations that causes delays,
- reduction or elimination of damaged goods,
- reduction or elimination of errors,
- adjustments to activities that do not meet rules or standards,
- reduction or elimination of activities that do generate revenues,
- identification of returns/complaints and the reasons for them,
- introduction of intelligent planning of operational processes and cashflow,
- introduction of efficient inventory management (Lapuh Bele et al, 2018).

2.2 Technological Perspective

Technology is an important factor in digitalization and in all BI projects. Technology in this sense refers to data and the analytical methods and tools that help us glean valuable information to aid decision-making.

The three core technological building blocks of a BI project are: providing quality data, analysing data and presenting information.

One of the key deliverables in BI is providing consistent, comprehensive, clean, conformed and current information for business people to enable analysis and decision-making. Therefore, we need data that meets the 5Cs requirements:

- clean – without missing parts or incorrect entry;
- consistent – there should be no arguments about whose version of the data is the correct one;
- conformed – the business needs to analyze the data across common, shareable dimensions if business people across the enterprise are to use the same information for their decision-making,
- current – because up-to-the-day data is sometimes not current enough;
- comprehensive – all of the needed data is available (Sherman, 2015).

Company data are mostly saved in databases. For the use of BI, data should be suitably prepared, designed, and stored within data warehouses.

Firstly, we explain terms data warehouse and data warehousing.

Data warehouse (DW) is a central repository of integrated data from one or more different sources. The latest data from the company's transactional databases, summarized data, and data from older time periods are stored in the data warehouse. Current and historical data are stored in, to enable creating analytical reports.

Bill Inmon (1992), known as the father of data warehousing, described data warehousing as the subject-oriented, integrated, time-variant, and continual collection of data to support management decisions. Data stored in data warehouses are usually read only.

In BI implementations, data warehousing is not necessary. It is recommended. In many projects that introduce BI, the importance of the data warehouse for quality analysis is overlooked or neglected, and this is later recognized as the principle cause of the project's failure (Loshin, 2012).

Of course, it is not enough to merely copy data from databases to a data warehouse. Firstly, data integration and data cleansing must be performed.

Often the same data are duplicated in several databases, which present a problem if they are not consistent. Therefore, the first step in data preparation is data integration, and the second step is data cleansing.

Well-prepared data is as important to a BI project as a good foundation is to a building. It is estimated that data preparation may represent 80% of the time spent on a BI project (Mueller & Massaron, 2016). We are often confronted with the problem of missing data that must be replaced with data from other sources or using statistical methods. Sometimes it is necessary to begin collecting certain kinds of data.

Sherman (2015) compares data integration to an iceberg. BI gets all the attention, just like the part of the iceberg that is visible. But the vast majority of the iceberg is below the waterline, just as the vast majority of the work in a BI project is designing and developing data integration processes. As much as three quarters of time is devoted to data integration when new data sources are added to data architecture.

Readying data for storage in a data warehouse is a demanding task, to be performed by IT experts with special training in this field. Such experts are called data architects.
After providing quality data, we perform analysing data and data visualization.

There are two approaches in analysing and presenting data: corporate BI and self-service BI.

Corporate BI is a traditional approach suitable for large projects. A BI project starts with managers' requests for new reports. Managers submit a list of business requirements in order to obtain the information they need for business decisions. Data scientists and IT professionals control access to data and deliver reports using BI tools and methods.

Dashboards and various charts are extremely meaningful for BI reports. Data visualization has a huge role in presenting a BI project's results to managers.

Data visualization is a general term that describes any effort to help people understand the significance of data by placing it in a visual context. The main goal of data visualization is to communicate information clearly and efficiently to users. To convey ideas effectively, both aesthetic form and functionality must go hand in hand, providing insights into a rather sparse and complex dataset by communicating its key-aspects in a more intuitive way (Friedman, 2008).

2.3 Human Perspective

Human resources are of the utmost important in implementing any BI project. Sometimes we are concentrating too hard on products or technological aspects of a BI project. In today's society, people often assume technology is going to magically solve their problems. However, a solution's critical success factors lie within the three Ps: people, politics and policies. Politics and policies also depend on people. Successful BI projects focus on business needs, not IT needs. The business people expect to get the right information to do their jobs in the right way. One of the biggest reasons BI projects are considered failures is because they do not meet expectations (Sherman, 2015).

The human factor in BI projects means IT experts, managers, and other users of BI solutions. All of these must work together on the BI project as partners. Managers as well, not just IT experts from the project group, must understand the professional and technological requirements and challenges that must be solved before launching the project.

The human resources allocated to implementing, and later maintaining and using the results of a BI project, must be properly trained.

3 Business Intelligence Readiness Diagnostics

According to our experience, we must discover if the company is sufficiently prepared, and what it is necessary to do at the beginning of the project in order to maximise the possibility that all activities in the project will be well directed and managed.

On the basis of the existing theoretical framework and our experience from numerous projects for successful Slovenian companies, we created a questionnaire that helps us to assess the preparedness of companies for the introduction of a BI project. The diagnostics phase involves intense conversations with all relevant participants. In addition to doing diagnostics on the state, it is also important to prepare the entire ecosystem of the company for new methods of decision-making on the basis of information delivered using BI methods.

During the diagnostics phase we dedicate special attention to the following three area:

- Operations: goal-directed management, operational goals and client's expectations, change management

- Technology: data about key processes, planning data, data sources (ERP system and other business software)
- Human resources: management, business analysts, data architects and IT experts

Successfully implemented BI projects require understandable and measurable indicators of operational success (KPIs), goal-directed leadership, high-quality data, and that management and other employees are trained in the principles of the BI project, and in providing data and analytic services.
The purpose of the diagnostics phase is to generate a detailed understanding of the client: its activities, organization, business, its needs, challenges, strategic goals, its human resources training, level of information and communication technology, the state of its data infrastructure, and previous experience in BI. The omission or superficial implementation of the diagnostics phase can lead to a discrepancy between client expectations and results, which can cause even well implemented later phases and resolutions to not achieve client goals.

The questionnaire helps the project consultant to understand the general state of the company. It is also important to interview key participants with the goal of acquiring answers to essential questions and discover as much relevant information as possible that will provide the foundation for high-quality project preparation. Because the time of both the project consultant and the client is valuable, the interviews should be well prepared. The goal of the good consultant is to find out the client's needs and expectations in order to achieve the greatest business success.

The result of the diagnostics phase is a report that contains general context, identifies gaps or missing BI elements in the environment, defines KPIs, a data warehousing plan, and access metrics. Once we perform the diagnostics phase, we determine which of the client's goals cannot be realized without certain changes.
Using the questionnaire, we are focused on operations, technology and human resources.

3.1 Operations

The operational area is the starting point for the analysis of the company's needs as well as its current state. All processes must be directed toward the final goal, the final goal being suitable management support for quicker and better decision-making for the introduction of measures that will lead to ongoing improvement in all operational processes.

It is important to ascertain if the business has specific, clear, realistic operational goals that are also defined in terms of when they should be achieved. The goals must also be defined in such a way that their achievement can be measured. First, we assess whether KPIs have been defined and written in a suitable way. We also try to assess whether, to the contrary, the company has goals that have not been defined in a suitable way, and, if this is the case, we rearticulate them and also identify measurable KPIs.

Another key element for the successful implementation of a BI project is that specific employees or departments are responsible for each KPI. We need to know who is responsible for the achievement of individual operational goals, and responsible parties must have sufficient authority to achieve success (typically the authority of personnel in lower management).

It is extremely important at the very beginning of the project to define and understand the client's expectations. It frequently happens that certain goals need to be developed and expanded in the preparatory phase. Sometimes it is necessary to collect more data, or at least to start the process of collecting that data. Together with the client, we also define additional KPIs if necessary, which will help us to both achieve and measure the expectations and goals of the company.

It also happens in certain cases that there are too many indicators and we have to decide which are the most essential and will be included in the project. Certain clients may decide to start with specific and narrow goals, for example with the optimization of production and sales, and will later expand BI to cover other areas.

Although it may appear that determining the expectations and goals of a company is simple, it often happens that clients fail to express themselves in a clear manner, or the project consultant fails to understand. This relates to the level of knowledge of human resources and the ability of the project consultant to conduct interviews in a way that reveals and clarifies the client's expectations and goals in cases where they are not clearly expressed.

During the diagnostics phase of the project, we take a particular interest in the culture of the company and how employees in position of authority introduce changes. A well-managed BI project will inevitably demand changes in operational processes. For this reason, it is very important that the management team is aware of the significance of and reason for proposed changes, and that they are ready and able to carry them out.

3.2 Technology

In terms of technology, we are mostly interested in data. We have identified three specific areas: ERP systems data, planning data, and data about key processes.

In most BI projects, the first step is to calculate the most important KPIs. The data for the calculation of most indicators can usually be found in the ERP system, which is why it is one of the main data sources.

We often encounter the problem that key operational processes have not been digitalized. In order to introduce BI in production processes, for example, there needs to be a structured method for collecting data about production quantities, number of quality pieces produced, number of non-quality pieces produced, etc. Only with this data can indicators, such as Overall Equipment Effectiveness (OEE) and scrape rate, be correctly calculated.

During the diagnostics phase, we must evaluate whether the existing data collections provide all data necessary for analysis. We must also evaluate the technical accessibility of the data collections, and the obstacles or limits related to transferring data to the data warehouse.

We often encounter data collections that permit unsupervised correction of past data, or contain only partial data reflecting conditions at a given moment (for example, inventory levels), which cannot be cross checked with transaction documents. The preparation of data from such sources requires additional verification, and results derived from them are often of questionable value.

It is important to verify if the data source are also IOT devices, how data is stored, and if their quality is suitable as input to analysis.

We also evaluate data collections and their normalization levels. It is important to ask whether the organization implementing the project has a data warehouse or not, and if it does, whether the warehouse contains all the data necessary for the successful implementation of the project.

Planning data is usually generated with Excel, the ERP system, and other applications. In order to calculate KPIs, we need data with comparable values. In order to calculate KPIs on the company level, it is sometimes acceptable that plans are divided into separate timeframes have just two dimensions (time and quantity or amount), but for the best decision-making it is necessary to go into greater depth. In this way, we can recognize deviations within indicators. In order to visualize these deviations in depth, in the case of sales, we must have complete plans that include data on buyers, articles, and month. With certain companies, it is necessary to have more detailed plans, in others less, but all must be clearly defined in the diagnostics phase.

We have discovered that in the first year of implementation of a BI project, companies tend to give little attention to the defined plans. This is often because the plans are poorly prepared. Seasonal components have not been considered, and comparisons with forecasts and actual results are relatively rare. Most participants prefer to use data from previous years in comparative studies.

Most companies that decide to implement a BI project have extensive and efficient ERP systems. However, we have experienced difficulties in project implementation with even the most successful companies. Certain clients have their ERP systems adapted to specific needs, and this specificity prevents the upgrade of the system. If we conclude on the basis of initial results that the implementation of a BI project requires changes to the ERP systems and that these systems cannot be upgraded, this can become an obstacle to changing operational processes. For this reason, finding resolutions for such situations should take place before problems occur.

Because BI projects require changes in organization and processes, and this includes data processing, it is essential that the ERP system is able to accommodate these demands. In our experiences, most BI projects end up requiring the collecting of additional data. The condition for the collection of high-quality additional data is that the company's ERP system is both flexible and up-to-date.
Many companies have information solutions that support key operational processes separated from ERP systems. These systems usually contain a large amount of transactional data that do not include any financial valuation, and this can limit their use in analytics.

We have to research applications that support key business operations and the data these operations use and provide.

3.3 Human Resources

Questions related to human resources are usually associated with availability, knowledge (or skill base), and experience. The level of knowledge and experience must be assessed in the following employees: managers, analysts, data architects and custodians of data collections.

Although it may seem that management's knowledge in the field of BI is irrelevant, this is not the case. If managers understand the significance of structured data collection, are able to distinguish between data for transactional work and data for analysis, understand the importance of the data warehouse and know how to use analytical tools to the extent that they can clearly express demands, the planning and implementation of the project will proceed much more quickly and efficiently than in cases where management employees do not possess this knowledge and skill base. In cases where management do not possess these skills and do not receive appropriate training, and only receive it once the BI project is already underway, there are often delays in the project, additional demands for changes, as well as conceptually incomplete or even illogical demands.

Most companies employ analysts that perform business analysis but do not necessarily master BI tools. Also here, many levels of knowledge must be assessed. The first and most basic question is whether analysts master the concept of merging many data sources and conducting analysis with pivot tables. The next skills we verify among analysts are direct networking with data sources, modelling data, and the mastery of state-of-the-art analytical languages (such as DAX and MDX). At the highest level, we evaluate skills in the field of data mining, advanced statistical methods for forecasting, profiling, extracting hidden properties of data, and the explication of pattern-consequence structures from the past.

Because useable data are especially important, we need to find out if the organization has employees that can perform the structured preparation of data for analysis. It is essential that the company has employees with knowledge of a range of programming languages for data extraction through various interfaces, and are versed in system skills related to server infrastructure. The results of this discovery process should provide information as to what extent it will be necessary to rely on consultants and external data architects in the phase of data preparation.

It is also important to evaluate the skill and knowledge of personnel in charge of data collections. Some data collections are extremely complex. If the data warehouse is to contain only correct and useable data, it is necessary to establish certain rules and recognize details in the data entry process. The search for data and the effort to understand its content can result in excessive use of time during project implementation.

3.4 The Analysis of Results

Company participants fill out the questionnaire and are interviewed.

The questionnaires are then analysed. In cases where there is a lack of clarity or discrepancies in the answers, additional interviews are conducted. On the basis of the diagnostic analysis, we evaluate the preparedness of the company for the BI project, which we present in graphic form (see Figure 1). In this process, we consider the insights of both external and internal participants, that is of the consultant and client respectively.

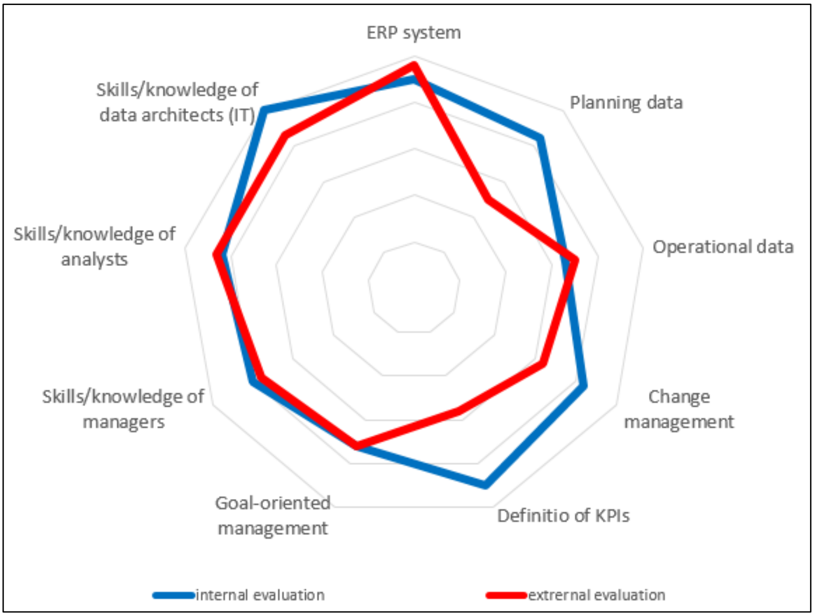

Figure 1: Example of evaluation of the company's preparedness for the development of its business ecosystem and the implementation of a higher level of BI

Once diagnostics have been carried out, it is necessary to present the results to management along with conclusions about necessary changes in areas of the company where there are indications that business goals would not be achievable.

The content of the project, its timeline, and the product set are determined on the basis of this assessment.
Both the client and the consultant must agree on the company's current state, what segments of their business require special attention, and what specific changes or activities need to be introduced. The diagnostics phase is essential in order to avoid the traps and delays that hinder many such projects.

4 Conclusions

In successful companies, managers are generally aware that, in order to maximize business efficiency, it is necessary to adopt BI technology and make use of all of the company's available information. Some companies have made the initial decision to implement a BI project; others have already begun implementation and have encountered difficulties and challenges. In either case, skills, knowledge, and experience of good practices are extremely important for the company to successfully implement the project. It should not be necessary to repeat the mistakes that others have already made and learned from.

We have written this article with the intention of encouraging and helping interested companies to thoroughly prepare for BI projects so that all participants will be satisfied with the results. If companies are to implement a successful BI project, it is necessary to undergo appropriate preparations either in the case of a wide-ranging project or a more specific project. We call this phase diagnostics and its purpose is to first evaluate the current state of preparedness of the company and second to introduce necessary changes prior to project implementation.

We have concluded that successful project implementation requires a sufficiently developed business ecosystem that includes three main areas: operations, technology, and human resources. We present problems from practice and pose questions that help us to assess how well-prepared an organization is for the implementation of BI, and what elements are necessary to upgrade or improve before the project is launched in order for successful implementation and fulfilment of the goals of the company.

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Antecedents of Market Orientation in The Banking Sector During Its Digital Transformation

HANNELE HAAPIO, HEIKKI KARJALUOTO & JOEL MERO

Abstract Firms are under increasing pressure to remain relevant for their customers and need to rethink how to remain market-oriented in the digital age. This is evident in the banking sector where the traditional banks are gradually being challenged by digital native competitors and growing customer demands. Consequently, this study examines what it takes to be market oriented in the banking sector at the age of increasing digitalization. Specifically, we focus on developing the theory on the antecedents of MO and examine how banks can regain market orientation under changing market conditions. Although Market Orientation (MO) has been a widely studied concept that has been applied in numerous different contexts, the role of digitalization as the transformer of MO is not well understood. The main findings of this study indicate market orientation at the digital age is manifested as the firm's ability to offer seamless and valuable customer experience across all service channels. Realizing this ideal necessitates a low organizational structure, managerial understanding of data and technology usage, interdepartmental management of external partnerships, as well as a managerial mindset that is genuinely concerned about customer needs.

Keywords: • Market Orientation • Digital Transformation • Retail Banking • Touchpoints • Banking sector •

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1 Introduction

Digitalization and the emergence of new technologies are rapidly changing the business landscape (Kumar, 2018; Overby, Bharadwaj, & Sambamurthy, 2006). In the banking sector, digitalization is transforming the market dynamics at three main fronts. First, digitalization has empowered customers to demand a frictionless experience across various service and communication channels whenever they want (Cao & Li, 2015; Lemon & Verhoef, 2016; Verhoef, Kannan, & Inman, 2015). Second, digitalization has led to new regulatory initiatives, such as the Revised Payment Service Directive (PSD2) and the General Data Protection Regulation (GDPR) that are challenging traditional banks' business and operating models. Third, digitalization has made competition global, and new digital competitors (fintechs) are entering the markets with new digital solutions (Rigby, Sutherland, & Noble, 2018).

The dominant business models in the banking sector seem to streamline banks' operations and extend their business rather than try to meet customers' needs (Camarero, 2007; Nätti & Lähteenmäki, 2016). However, the new market dynamics require banks to shift their focus from developing internal banking processes to creating valuable interactions with customers (Holmlund, Strandvik, & Lähteenmäki, 2017). In a similar vein, Kolar (2006) suggests that banks should move from a traditional "inward focus" to more market-oriented ways of doing business.

Against this backdrop, we propose that succeeding in the new market reality requires banks to restore focus on market orientation (MO). Although MO has been a widely studied concept that has been applied in numerous different contexts since the seminal paper written by Kohli and Jaworski (1990), the role of digitalization as the transformer of MO is not well understood. The objective of the study is to examine, what it takes to be market oriented in the banking sector during the digital transformation. In particular, we follow the model by Kohli and Jaworski (1990) and examine the antecedents of MO.

This study proceeds as follows. In the next section, we present the theoretical underpinnings and antecedents of MO. After that, we explain and justify the data collection and analysis methods. Finally, we present the study findings and discuss the contributions, limitations, and future research avenues.

2 Antecedents of market orientation

With more than 1000 articles published since 1990, the theory of MO might be one of the most cited concepts in the field of marketing (Jaworski & Kohli, 2017). Kohli and Jaworski (1990) propose that the key elements of MO are intelligence generation, intelligence dissemination and responsiveness, whereas Narver and Slater (1990) propose that MO consists of customer orientation, competitor orientation, and inter-functional coordination. Hartline, Maxham, and McKee's (2000, p. 35) definition suggests that MO manifests itself as a firm's commitment to "put customers' interest first, but not to exclude the interests of stakeholders with the outcome to develop a long-term profitable company". Although different approaches seem to be consistent with that of Kohli and Jaworski (1990), their approach to MO is still the broadest. That is consistent with Kolar (2006) who compared a number of definitions of MO and found that they do not represent substantial improvements to the conceptualizations by Kohli and Jaworski (1990) and Narver and Slater (1990). Thus, this study uses the antecedents of MO adopted from Kohli and Jaworski's (1990) theory.

Kohli and Jaworski (1990) propose three categories of antecedents (senior management factors, interdepartmental dynamics and organizational systems) that affect the implementation of MO (Table 1). The category of senior management factors includes the communication-action gap of top management, suggesting that the actual behavior of senior managers does not always match their words. That is consistent with Harris and Piercy (1999), who argue that the level of MO in an organization is dependent on the abilities and commitment of senior management. Other senior management factors are the risk aversion of senior management, upward mobility and the education of top management, marketing managers' ability to win the trust of non-marketing managers and the senior management's attitude toward change (Kohli & Jaworski, 1990).

The second category of antecedents is the interdepartmental dynamics. Interdepartmental conflict may appear inherently because of different desires of various departments. That is in line with Holmlund et al. (2017) who argue that it is natural for managers to optimize the function for which they are responsible. According to Kohli and Jaworski (1990), interdepartmental conflict inhibits communication across departments, and thus, limits the dissemination of market intelligence and hinders the generation of a holistic understanding of customers' needs. A low level of concern for the ideas of other departments will result in ineffective processes. However, a positive effect can be achieved by interdepartmental connectedness (i.e., formal and informal contact among employees across departments), which will ensure the dissemination of market intelligence.

Third group of antecedents is organizational systems. Per Kohli and Jaworski (1990), barriers, such as formalization and departmentalization, inhibit an organization's MO. Formalization is the degree to which rules define the roles, communication, authority relations, and procedures of the organization. Departmentalization is a barrier to communication whereas centralization defines authority and participation in decision making. Long-term market-based reward system is another organizational system. Webster, (1988) claim that how managers are evaluated and rewarded is one key dimension for developing a market-oriented and customer-driven organization. Additionally, one barrier is the acceptance of political behavior. Harris and Piercy (1999) argue that political and formalized behavior of senior management is linked to low levels of MO. That idea is consistent with Kohli and Jaworski (1990), who argue that political behavior represents individuals' attempts to promote self-interests and threaten others' interests.

Table 1: Kohli and Jaworski (1990) Antecedents of MO

Senior management factors	Communication-action gap of top management
	Risk aversion of top management
	Upward mobility and education of top management
	Marketing managers' ability to win trust of non-marketing managers
	Top managements' attitude toward change
Interdepartmental dynamics	Interdepartmental conflict
	Concern for ideas of other departments
	Interdepartmental connectedness
Organizational systems	Formalization
	Departmentalization
	Centralization
	Market-based reward system
	Acceptance of political behavior

3 Methodology

Qualitative approach was used as the research strategy of this study. According to Maxwell (1996), qualitative research has the capacity to examine the particular context within which participants act and how the context influences their actions. A qualitative inquiry was considered the most suitable approach because our purpose was to generate in-depth understanding of the phenomenon rather than to provide evidence for causal claims.

Non-directive interviews served as the primary data collection method. These involved unplanned and planned questions and allowed for in-depth exploration of the issues (Gray, 2004). The target group for the interviews was bank managers in three leading Nordic retail banks. Following Eisenhardt and Graebner's (2007) recommendations, we collected data from interviewees who view the phenomena from diverse perspectives, are from different hierarchical levels, and are from different functional areas. We interviewed executives and middle managers, from development units and from units with direct customer interactions. Six interviewees were selected via purposeful sampling (Patton, 2002) meaning that those banking professionals who had experience of undergoing a digital transformation in their organizations were selected as interviewees (Table 1). The interviews took place between mid-April and mid-May 2018.

Table 2: Interviewed bank managers

Level and role/responsibility	Name	Length of interview
Executive/development unit	Ann	53 min
Executive/leader of units with direct customer interactions	Mary	56 min
Middle management/development units	John	49 min
Middle management/ leader of units with direct customer interactions	Timothy	55 min
Middle management/ leader of units with direct customer interactions	Claire	61 min
Middle management/ leader of units with direct customer interactions	Stuart	58 min

The interviews were conducted partly face-to-face (four interviews) and partly over the phone (two interviews). The average length of the interviews was 55 minutes, and all the interviews were audio recorded with the permission of the interviewees. The interviews focused on the challenges that digitalization causes for banks. We did not ask about either MO or customer experience management directly, although we wanted to understand whether those are top priorities during digital transformation. During the interviews, the elements of MO entered the discussion.

All study data were documented and appropriately stored in a study database. For the analysis, we followed a three-step process, which included data condensation, data display, and drawing conclusions (Miles, Huberman, & Saldaña, 2013). For data condensation, we used descriptive coding to create relevant categories, such as customer focus, organizational behavior, regulatory changes, managerial behavior, customer behavior, technology, perceived risks, etc. During the data display phase, the data were organized by using the guiding framework, and they were grouped according to the context. Finally, the findings were reviewed and compared with the theoretical model, which led us to propose the changes that are presented in this paper.

4 Findings

Findings for senior management factors are shown in figure 1, where the proposed new factors are marked with an asterisk (*). All interviewees discussed the senior management communication-action gap, which according to Kohli & Jaworski, (1990) occurs, when the actual behavior of senior managers does not match their words. Specifically, it became evident that the senior management talks a lot about customer orientation but the actual decisions are sometimes contradictory. This result mirrors the findings of Fellesson (2011), who state that, although companies may believe that they are customer oriented, their actions do not correspond to this belief. In fact, managers' mental models direct what is considered important, what is monitored, and what is done in an organization (Holmlund et al., 2017). It seems that, there is a limited focus on customers as a starting point among retail banking executives; the focus is on developing business and renewing internal banking issues (Holmlund et al., 2017). For example executive level manager (Ann) and middle level manager (Stuart) stated:

> *"We say that we listen to customers and react on their needs. However, to be honest, that is not what we do, we still rely on traditional customer satisfaction measurements. Those are too slow and don't really tell anything anymore" (Ann)*

> *"Managers say that the customer is the most important, but how important it really is? Do we have one-time deals, or do we have persistent customer work? Managers should understand customers and that does not come from only staring at figures." (Stuart)*

The banking industry is rapidly evolving, and this requires that the management's attitude toward change is positive. Five interviewees explicitly mentioned the senior management's attitude toward change as an important antecedent of MO during digital transformation. In line with Nätti and Lähteenmäki (2016) who find that the long period of regulation has made banking managers more risk averse, multiple interviewees of this study considered that the risk aversion is a dominant characteristic among the banking executives. Overall, our data suggested that the senior management in the banking industry is more risk oriented than market oriented. One interviewee described the lack of customer orientation as follows:

> *"The whole sector has only taken a few steps from the time when customers came with their 'hat in hand' to the bank. That, we have not yet understood; we are too arrogant" (Ann).*

All interviewees discussed the managerial need to understand data and technology, which naturally plays a core role in digitalization. Interestingly, all interviewees considered mobile as the prioritized customer interaction channel because it is an entrance to all services. One interviewee summarized,

> *"We don't talk about mobile only but mobile first. We say that mobile is a remote control panel for banking business" (Mary).*

While the study data implied that the digital transformation in banking emphasizes mobile channels, the consequences do not seem to be clear. Bátiz-Lazo and Wood (2003) find that there is a risk in the prevailing bank management style. They argue that senior management's lack of understanding of new opportunities and consequences might hold back development or lead to the pursuit of inappropriate growth opportunities. As one interviewed puts it:

> *"We put a lot of focus on mobile channels, but I'm not sure how well we really understand the consequences" (Timothy).*

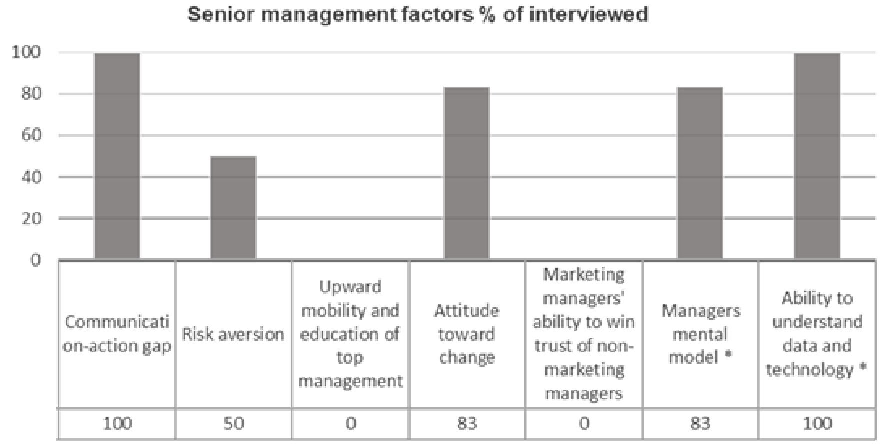

Figure 1: Findings of MO antecedents of senior management factors

Figure 2 illustrates our findings for the second category, the interdepartmental dynamics. The proposed new factors are marked with asterisk (*). This study confirms what (Pantano & Viassone, 2014; Rust & Day, 2006; Verhoef et al., 2015) claim about the need to integrate channels to gain a seamless customer experience. Customers require a consistent, uniform, and integrated experience in all of the channels they use (McLean & Wilson, 2016). In addition customers want to use the channels they prefer, whenever they want to (Cao & Li, 2015; Lemon & Verhoef, 2016; Verhoef et al., 2015). Simultaneously, the natural borders between different channels are disappearing, and the channels are blurring with each other (Verhoef et al., 2015). Further Piotrowicz and Cuthbertson (2014) find that when different channels are managed separately the silo mentality occurs. The cooperation between different channels and departments as well as how organizations still seem to have silos was discussed by all interviewed. These silos inhibit banks from MO and from delivering seamless customer experiences in all channels. One interviewed noted the following:

> *"We should get out of pipes. The thinking of only channels leads to silos. Channels are managed separately, and we are good at some and poor at some. We are not connected with the experience of our end customer" (Ann).*

Additionally, due to regulatory changes, banks need to manage possible silos and ensure connectedness also with external partners. All interviewed brought up one fundamental regulatory change that affects the financial sector's digital transformation, the recent update of the PSD2 in January 2018, which compelled banks in the European Union to open their APIs to third parties. The financial sector uses the term "open banking" in reference to the use of open data and open source technology. Under the open banking framework, third parties would be able to create new financial products by utilizing banks' data. These changes require traditional banks to form partnerships, which, at their best, will add to the connectedness of an organization and, at their worst, will further increase the silos. Without these partnerships, there is a risk that banks will become merely account and deposit holders for customers that also provide customer data to third parties. To be successful in this new environment, it is crucial to avoid silos inside an organization while exploiting partnership companies.

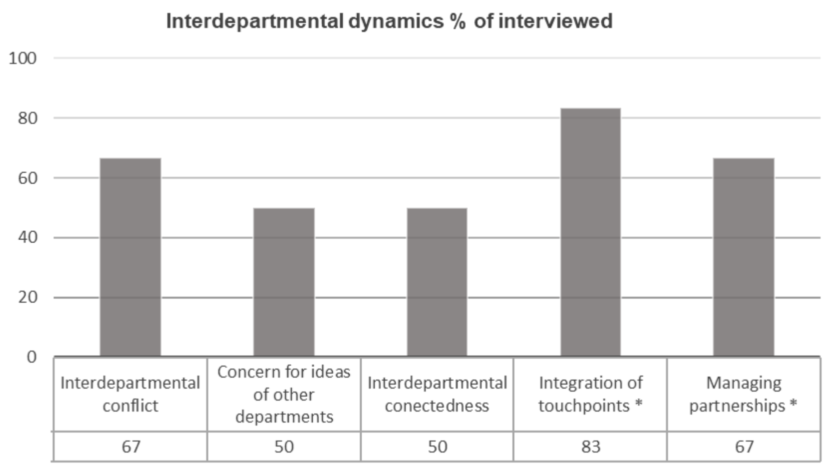

Figure 2: Findings of MO antecedents of interdepartmental dynamics

Findings for organizational systems are shown in figure 3, where the proposed new factors are marked with asterisk (*). Organizational systems, as they are described by Kohli and Jaworski (1990), are relevant in the digital transformation of the banking industry. Banks are large and complex organizations in which a decentralized organization structure with fewer formal procedures seems to be more efficient, which is confirmed by this study. That is also in line with Olson et al. (1995) who find, that organization with few formal procedures empowers managers and employees in close decision making. In line with that, 67% of interviewed find the centralization to inhibit MO as one interviewed stated,

> *"Organizations should be very low and very near customers. Solutions should be made near customers" (John).*

This study affirms that especially in complex organizations, that are facing substantial changes, all employees in an organization must understand what is expected from them to be market-oriented. Recent research by Dikert, Paasivaara, and Lassenius (2016) claim that marketing doctrine can help ensure that all employees understand the "rules" of MO and are aligned. The likelihood that employees do not rely on personal ideologies or mental models is bigger when companies provide marketing doctrine as guidance for decision making (Challagalla, Murtha, & Jaworski, 2014). One middle manager emphasized:

> *"First of all, you need to have a clear strategic vision. You need to get 100% commitment on these principles…More solution orientation and responsibility is needed for all" (Timothy).*

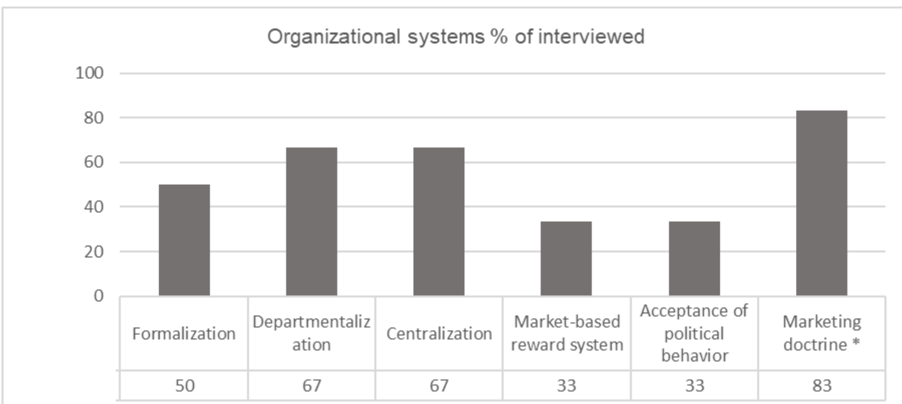

Figure 3: Findings of MO antecedents of organizational systems

This study confirms that many of the antecedents presented by Kohli and Jaworski, (1990) are relevant in MO during a digital transformation. Based on the empirical material, we did not find any support for the senior management upward mobility and education neither for the marketing managers' ability to win trust of non-marketing managers. Although they could be considered valued antecedents of MO, they are excluded from this model. Additionally we propose five new factors to be added on the antecedents: in senior management factors; managers mental model and the ability to understand data and technology, in interdepartmental dynamics; the integration of all touchpoints and managing partnerships and for organizational systems we propose to add the marketing doctrine. The proposed model for antecedents of MO during digital transformation is shown in table 3. The percentage define the share of interviewed that has reflected on the factor and the proposed new factors are marked with asterisk (*).

Table 3: proposed model for antecedents of MO during digital transformation

Antecedent		%
Senior management factors	Communication-action gap	100
	Risk aversion	50
	Attitude toward change	83
	Managers mental model *	83
	Ability to understand data and technology *	100
Interdepartmental dynamics	Interdepartmental conflict	67
	Concern for ideas of other departments	50
	Interdepartmental conectedness	50
	Integration of touchpoints *	83
	Managing partnerships *	67
Organizational systems	Formalization	50
	Departmentalization	67
	Centralization	67
	Market-based reward system	33
	Acceptance of political behavior	33
	Marketing doctrine *	83

5 Discussion

This study makes a number of theoretical contributions. From a theoretical perspective, we wanted to broaden our understanding of MO antecedents. By examining whether digital transformation affects the model we found that, although the antecedents defined by Kohli and Jaworski (1990), are valid, they need to be viewed via the lens of the digital era.

First, this study identifies that most of the senior management factors are still relevant in the context of banking during its digital transformation. In particular, our study data highlighted that managers' mental models and the understanding of data and technology usage form the senior management factors that affect MO. The key to the market-oriented mental model was found to be the managers' focus on customers. Against this view, the previous studies have shown that the banking managers' focus is on business development and streamlining banks' operations (Camarero, 2007; Holmlund et al., 2017; Nätti & Lähteenmäki, 2016). This contradiction is alarming from the MO perspective. We conclude that banking managers need to adopt a genuinely customer-focused mindset if the bank is to become truly market-oriented. Notably, the understanding of data usage and technology is crucial during digital transformation to avoid Bátiz- Lazo and Wood (2003) finding that the lack of understanding of new opportunities might hold back development.

Second, this study contributes to the literature by arguing that digitalization requires the management of many touchpoints in an integrated manner to prevent organizations from building silos (McLean and Wilson, 2016; Pantano and Viassone, 2014; Rust and Day, 2006; Verhoef et al., 2015). An additional finding was that the changes that are faced by the banking industry are forcing banks to consider forming external partnerships that enable quick reactions to regulatory changes. Companies' messages need to be consistent across all touchpoints. Additionally, organizational structures and routines (e.g., divisional silos) and a power struggles can block the MO. Therefore, it is not only internal silos that banks should address; they should also understand external partnerships and how to work with them.

Our findings offer several contributions to practice. For example, senior management has a crucial role in how market-oriented an organization will be. This calls for managers to understand both the antecedents and the changes that are required to acquire a competitive edge during the digital transformation. This study provides practical information for senior managers to achieve the necessary changes.

Additionally, this study enhances managers' understanding of major changes that are brought by digital disruption in light of MO, including some ideas of how both the PSD2 and Gaffect MO, the importance of understanding technological opportunities, including the use of data, and managers' mental models.

5.1 Limitations and future research

In closing, we recognize that this work has several limitations. One limitation is the Nordic perspective of this study. All interviewees were from banks that have headquarters in Nordic countries (Scandinavia and Finland). Because digital transformation is not dependent on any region, in future studies, the antecedents of MO during digital transformation should include traditional banks that are located outside Nordic countries.

From the managerial perspective, it might be useful to develop measures of MO to better understand the impact of each antecedent on MO. This study does not answer the question of whether some antecedents have more impact on MO than others; that would assist managers in finding the right focus. Further, this study focuses on the antecedents of MO, while the consequences are only briefly mentioned. Future research could explore how the changes in the model are linked to the consequences of MO theory.

On a more general level, we believe that additional research on organizational culture and employees' roles during digital transformation would enhance our knowledge of the antecedents of MO. Furthermore, research on how marketing in financial sector should be organized during a digital disruption to gain the maximum level of MO could produce important knowledge.

This study follows the structure of Kohli and Jaworski's (1990) theory of MO. Future research could compare the organizational culture and setup of, for example, fintech companies or startups to big banks. It would be interesting to understand how Kohli and Jaworski's (1990) theory would apply in smaller and later established companies. Furthermore, more research is needed to investigate the changes that the financial sector is facing during its digital disruption (e.g., the PSD2).

Another interesting possibility for future research is the balance among data, technology, and soft items. Is the balance at the right level, and does that affect the consequences of MO? This question is especially pertinent now, when customers require a seamless omnichannel experience.

Overall, while these limitations do not jeopardize the integrity of the results, they do limit the conclusions that can be drawn.

6 Conclusion

To summarize, this research highlights the importance of considering MO in the banking sector at the age of increasing digitalization. Building on the theory of MO (Kohli and Jaworski, 1990), this paper proposes new elements to the original MO framework by identifying five novel antecedents: managers' mental model, ability to understand data and technology, integration of touchpoints, managing partnerships and marketing doctrine.

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Transformation of Medical Diagnostics with Machine Learning by Considering the Example of Atrial Fibrillation Identification

SIMONE SCHNEIDER, THORSTEN GAU, ANNIKA GROSSE, HOLGER HENNIG & CARMEN WINTER

Abstract The paper addresses the problem of detecting one of the most common cardiac arrhythmias atrial fibrillation with artificial intelligence. The arrhythmia increases the risk of suffering from a stroke massively. Because of this, it is essential to detect atrial fibrillation early. As the arrhythmia occurs in short sequences, it is only possible to detect the disease in long-term measurements for example with electrocardiography. All common current detection techniques are calculating the R-R intervals with variations of the root mean square of successive differences. Because this approach is inflexible and expensive, a major hospital in Germany suggests the implementation of an artificial intelligence solution for atrial fibrillation detection. The aim of the paper is to study the feasibility of atrial fibrillation detection with artificial intelligence in the clinical setting of the hospital.

Keywords: • Atrial fibrilliation • Artificial intelligence • LSTM • Hospital • Machine learning • Clinicial setting • Prototype • Tensorflow • Keras • Python • IBM Cloud • Angular • TypeScript •

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1 Introduction

The paper addresses the problem of detecting one of the most common cardiac arrhythmias atrial fibrillation with artificial intelligence. The arrhythmia increases the risk of suffering from a stroke massively. Because of this, it is essential to detect atrial fibrillation early. As the arrhythmia occurs in short sequences, it is only possible to detect the disease in long-term measurements for example with electrocardiography. All common current detection techniques (Franke-Gricksch, 2017; Gentile et al., 2017; Lee et al., 2012; McManus et al., 2013; Ricci, Morichelli, & Santini, 2009; Scully et al., 2011; Varma, Stambler & Chun, 2005) are calculating the R-R intervals of an electrocardiogram with variations of the root mean square of successive differences. The R-R interval describes the distance between two R peeks in a normal sinus rhythm (see figure 1).

This paper first discusses the methodological principles and secondly presents the conceptual foundations for the smart city conceptual model. Conclusion section summarizes and finalizes the paper.

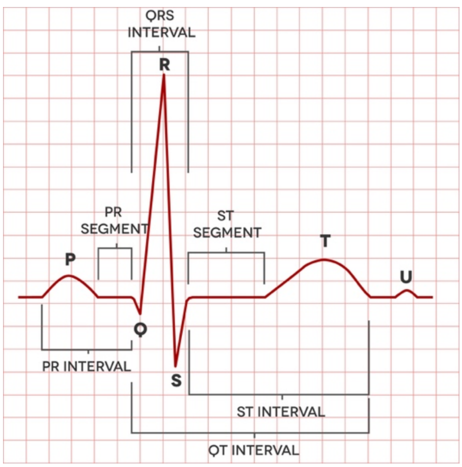

Figure 1: Normal Sinus Rythm ECG with R-R Interval Ilustration (US National Library of Medicine, 2013)

Compared to a normal sinus rhythm the distance between two R-R is unsteady (see figure 2). Also, the P wave in front of the R peek is completely missing (Birbaumer & Schmidt, 2006; Foster, 2007; Price, 2012).

Because this approach is inflexible and expensive, a major hospital in northern Germany suggests the implementation of an artificial intelligence solution for atrial fibrillation (AF) detection. The aim of the paper is to study the feasibility/possibility of atrial fibrillation detection with artificial intelligence in the clinical setting of the hospital. Therefore, the paper discusses the implementation of a prototype as well as a concept for an integration of the artificial intelligence solution in the hospital. The content of the paper is acquired during a bachelor thesis identically named. The following paragraphs are excerpts of the bachelor thesis slightly shortened or adjusted. At the end of every paragraph there is a reference to the corresponding chapter of the thesis.

Figure 2: Atrial Fibrillation ECG compared to Normal Sinus Rhythm ECG (Lifeline, 2015)

1.1 Requirements for the solution

The aim of the artificial intelligence atrial fibrillation detection is a full integration into the current processes in the hospital with no paper-based actions remaining. The process will start with the patient being monitored by a medical device (see figure 3). This is performed with an electrocardiography (ECG) monitor that is able to record long-term ECGs up to 24 hours. After the recording of the patient over the full period, the data is transferred to the AF prediction system. The prediction system evaluates the data with an artificial intelligence approach into three already existing categories: low risk for AF, high risk for AF and the presence of manifest AF. The report of the evaluation is cached to a tentative result which can be reviewed by a medical doctor on a user interface. If the prediction of the system is different from the doctor's opinion, the result is corrected by the doctor, and the prediction of the system is overwritten. After the doctor's review, the prediction is no longer a report. Instead, it is a result which has to be added to the patient's health record in the hospital information system (HIS). Different from the current solution in the hospital, the AF prediction system and the HIS are able to communicate directly which enables an automatic integration of the result. Apart from the integration in the HIS, it is also possible to use the verified diagnosis of the doctor for retraining the model. It ensures an improvement of the algorithm over time adjusted to the needs of the hospital (see thesis chapter 5.1).

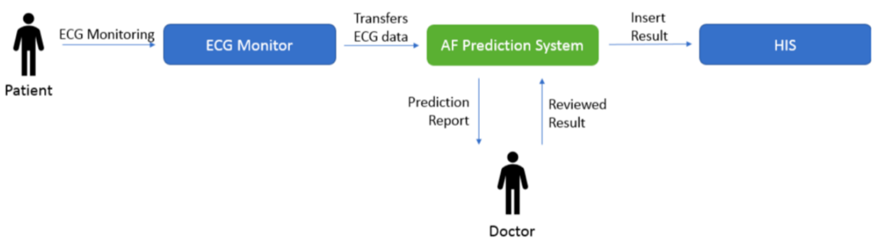

Figure 3: System Context Diagram

2 Implementation Prototype

The previous section specifies the system context and use cases for an overall solution integrated into the hospital environment. As there is currently no clinical data of the hospital available, the implementation of an overall solution is not possible. Therefore, the following sections illustrate the implementation of an AF identification prototype to demonstrate the capabilities and feasibility of an executable solution in production.

The deployment of the prototype mainly consists of three phases concerning *data processing*, *modeling* and *building the web application* as a user interface. Figure 4 is used to give an overview of all associated components and techniques. The components of the phases will be described in detail in the following section (see thesis chapter 5.2).

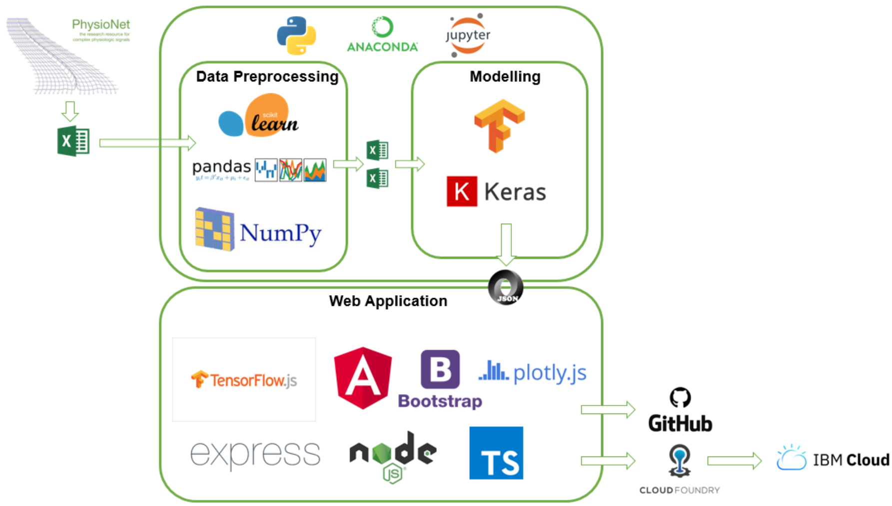

Figure 4: Architecture overview prototype

2.1 Data Preprocessing

Because of the lack of clinical data at the beginning of the project an alternative for the implementation of the prototype has to be found. According to many comparable studies (Limam & Precioso, 2017; PhysioNet, 2016; Shashikumar, Shah, Li, Clifford & Nemati, 2017; Sujadevi, Soman, & Vinayakumar, 2018; Yuan, Yan, Zhou, Bai, & Wang, 2016) PhysioNet provides an open source collection of physiologic signals including atrial fibrillation samples. Therefore, the MIT-BIH AF database as well as the MIT-BIH normal sinus rhythm database from PhysioNet are used to replace the currently missing clinical data (see thesis chapter 5.1.2).

From eighteen up to ten-hour examples respectively one hour is exported as a CSV file. One CSV file has three columns regarding a time stamp and two ECG measurements in millivolts which result in a different positioning of the ECG sensors. Every AF CSV file has 900.000 points of measurement in an interval of four milliseconds. As healthy samples, the MIT-BIH normal sinus rhythm database with eighteen samples is used and also exported as CSV files from one hour. The structure of the file has the same columns but differs in the intervals with a point of measurement only every eight milliseconds. It reduces the overall amount of monitored points to 450.000.

For preprocessing of the data, the open-source Python environment Anaconda in association with the web-based notebook environment Jupyter is used. For reading and manipulating of the CSV files the Python libraries pandas, NumPy and scikit-learn are in use. From both CSV files only the first ECG measurement column is extracted. As a result of the step of preprocessing a stacked array of both AF and healthy data with values assigned to milliseconds fitting to the demanded data format of the model is provided. Additionally, two classes are labeled concerning healthy with zero and AF with one.

The scikit-learn library also provides an interpolation function which is able to find values of new points. It is applied to gain an equal frequency of healthy and AF data (see thesis chapter 5.2.2). After the preprocessing step one labeled dataset is available. Because a training dataset and a test dataset is needed, the set is split randomly with the test dataset consisting of 20 percent of the original data. Then again both datasets are exported as CSV files for further usage.

2.2 Modeling

As Deep Learning algorithms outperform other techniques when large datasets are in use, and there is no need for feature extraction, it is entirely fitting for complex problems like sequence classification (Mahapatra, 2018). One common deep learning algorithm class are recurrent neural networks (RNN) which add the aspect of memory to algorithms. With atrial fibrillation sometimes occurring only in a few seconds of a 24-hour record and the frequent detection refers to the R-R intervals, it is essential that the algorithm is able to remind the previous sequences of the ECG for comparison. Because traditional RNNs are only able to remind a few steps back, in this use case the long short-term memory (LSTM) algorithm which is able to keep information for extended periods is used (see thesis chapter 5.2.3). The algorithm decides between essential or less essential information with selectively remembering or forgetting, which enables it to have a long-term memory. With this, it keeps the essential aspects of the time steps that need to remember this information (Olah, 2015; Kanber, 2018; Srivastava, 2017).

Regarding the LSTM the study of Sujadevi, Soman & Vinayakumar (2018) is also using the LSTM algorithm to detect atrial fibrillation in PhysioNet sample data. As the from-scratch implementation of an LSTM is out of the scope, we are using the TensorFlow Deep Learning framework Keras for the implementation of the LSTM as Sujadevi, Soman & Vinayakumar (2018) do as well. With this it is possible to prove the reliability of their accuracy of 100 percent. Similar to the preprocessing of the data, the model is implemented in a Jupyter notebook. It is a sequential model with a linear stack of layers with an LSTM layer that accepts an input dimension of 15000 corresponding to the dimension of our training dataset. An additional dropout helps to prevent overfitting by dropping fractions of the input. The output layer is a dense layer. As an activation function, the sigmoid function is applied. After the network architecture of the Keras paradigm the model needs a fitting which determines the test and training set as well as the epoch the model has to run through. In this case, the model runs through 20 epochs. As a loss function a binary cross entropy is used. After fitting and compiling the model is trained with the training dataset prepared during the data preprocessing. With the second dataset on which the model has not been trained, the model is tested. The last step of modeling is saving the trained model with the generated weights for further usage in a JSON format needed for TensorFlow.js (see thesis chapter 5.2.4).

2.3 Web application

For visualization a web application written in *TypeScript*, which is an extension of *JavaScript* and uses the *express.js* server-side framework with *Node.js* as a runtime container, is developed. The Front-End (see figure 5) is implemented in *Angular 6* and *Bootstrap*. From the previously generated datasets eight examples are chosen to be shown in the prototype. These are converted from the CSV files to a JSON file which consists of arrays of the samples. Plotly.js enables a dynamic zoomable plot of each sample. By clicking a button, a predict function is called. This function uses the *Tensorflow.js* package for making predictions with the model. The previously trained model can be accessed by the function as a JSON file which also has references to the weights that have been calculated during training. Based on the current classification scheme of the hospital, the prediction is divided into three types: low risk for AF, high risk for and the presence of manifest AF. The design of the front-end is plain to guarantee a fast understanding for the doctors. The web application is deployed in the IBM Cloud using a *Node.js runtime* and *Cloud Foundry* (see thesis chapter 5.2.5).

Figure 5: Front End prototype web application

2.4 Evaluation of the prototype

Even though these databases are also used in further studies (Limam & Precioso, 2017; Shashikumar, Shah, Li, Clifford & Nemati, 2017; Sujadevi, Soman, & Vinayakumar, 2018; Yuan, Yan, Zhou, Bai, & Wang, 2016), there are reluctance to believe in the quality of the data. First of all, the AF and normal sinus rhythm database differ in their frequency with AF having 250 Hz and Normal Sinus Rhythm having 125 Hz which was solved with interpolation for the healthy database. It cannot be guaranteed that the interpolation has found the matching points for the missing ones. Moreover, the positioning of the leads of the sensors seems to be different for AF. Plotting sequences of the AF database not only shows a different positioning of the leads, furthermore some of the plots look like the underlying data is broken. Because on this data the training is based, later the model could not feature the AF but rather the disturbances or the varying frequency. As the PhysioNet data is only for testing purposes of the feasibility of a prototype, it is well for first experiences regarding AF identification and testing the compilation of the components of a future application. In order to train the model for production clinical data where the origin is clearly known is absolutely and urgently needed.

The next step of the prototype is the deployment of a Machine Learning model regarding an LSTM. According to the quality measures for algorithms the LSTM model achieves the following values:

- Loss: 0,53
- Accuracy: 0,87
- Precision: 0,88
- Recall: 0,88
- F1 Score: 0,88

The accuracy of the model is well for a first try but needs further optimization also owing to the high loss of 0,53 which generally should have a value towards zero. Compared to other Deep Learning solutions in AF identification Shashikumar, Shah, Li, Clifford & Nemati (2017) have reached a bit higher accuracy value with 91,8 percent in using CNNs. Limam & Precioso (2017) on the other hand, describe an F1 score of 0,77 for their Calculational RNN solution. They highlight that this value could be increased with more training data which could also be useful for the model of the prototype. At last the current solution from Schaefer, Leussler, Rosin, Pittrow & Hepp (2014) and Gentile, et al (2017) used in the hospital achieves a recall of 0,99 which is a nearly perfect solution. With this, the model has to be improved to measure up to the state-of-the-art solution. With obtaining clinical data, the model will be retrained and further optimized to guarantee a comparable quality in AF detection with the Machine Learning solution.

3 Overall solution integration in a clinical setting

The following section illustrates the integration of the AF detection system in the hospital environment. Even though a production-ready solution is not yet implemented, an outlook of the AF prediction system integration system can be given. Therefore figure 6 depicts the operational overview of the system in a production-ready solution.

Similar to the current state of the art solution the process starts with the monitor measuring the patient's ECG. For access of the data, the monitor API (see 2.7) from the hospital environment is addressed. After the complete measuring, the data is transmitted to the IBM Cloud (figure 6, step 1). It is performable either over https or over messaging protocols like Message Queuing Telemetry Transport or with distributed streaming platforms like Apache Kafka. Apart from the data a patient identification number for a later allocation of the data to a patient, is added. With this, the datasets are anonymized, as the identification number is not traceable for external systems.

In the IBM Cloud, the data has to be transferred to a service conducting the preprocessing and evaluation (figure 6, step 2). The cognitive service is divided into Watson Studio where the data preprocessing is implemented, with Watson Machine Learning on top for training and evaluation of the model (figure 6, step 3). Watson Studio also supports the usage of TensorFlow and Keras in notebooks. Moreover, Watson Studio enables increasing capabilities with CPUs and GPUs for training models at scale. For later retraining of the model, there is also a continuous learning feature available.

After transmitting the data to the cognitive service, at first data preprocessing is executed to adjust the data format from the monitor for fitting to the required data format of the LSTM model. Similar to the prototype it can be implemented in a Jupyter Notebook in Watson Studio with the difference of now being able to utilize the processing power of the IBM Cloud instead of a local machine in the prototype. As a result, one dataset from every monitored patient in the required format for the model is received. After preprocessing every dataset is inserted separately into the model of the previously trained LSTM.
The model can be implemented in a notebook with Keras or TensorFlow. It has to be trained and optimized with labeled clinical data to ensure the origin of the training data. The accuracy of the new algorithm should be in range with the current solution. Apart from that, the recall of the model has to be high to ensure that a minimum of sick patients get overlooked. Also, a high precision value is required. Because if there are a lot of false positives, the doctors need to examine a lot of actual unnecessary datasets.

As a result, the prediction, as well as the dataset and the patient identification number, are transferred to the Node.js runtime. The results will be visualized in a web front-end similar to the prototype (figure 6, step 4). The predicted datasets are cached as long as they are not finally verified by a doctor and can be selected on the user interface. The front-end of the Node.js runtime can be displayed in a browser as well as mobile devices in the hospital environment (figure 6, step 5 + 6). The verification of the doctor in the front-end triggers the endorsement of the diagnosis in the hospital HIS. Along with this, the identification number is allocated to a patient in the HIS. The process is executed only in the hospital environment to ensure the privacy of the patient (figure 6, step 7). Apart from the endorsement in the HIS, it is possible to send the verification back to the cognitive service in the IBM Cloud. With this information, it is possible to retrain the model in the Watson Machine Learning service for continuous improvement of the model. According to this, cases that have less or even not been covered in the training dataset are also predictable over time.

The new overall solution integration offers an AF prediction system with no paper-based actions left. Another point concerning the verification of a doctor is that it also underlines that Artificial Intelligence has not the purpose of replacing humans. Instead, AI is just supporting them in their daily labor (see thesis chapter 5.3).

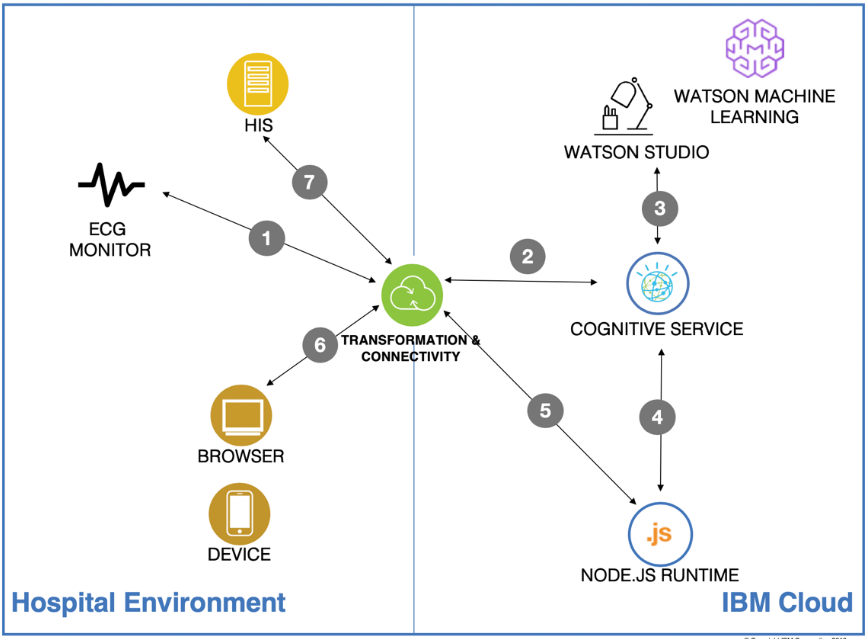

Figure 6: Operational Model Overall Solution

4 Conclusion and future work

For future work the most essential step is collecting a clinical dataset for AF and healthy ECGs to gain a clinical training dataset. According to this, the clinical data has to be evaluated by more than one doctor to ensure that the resulting training dataset is reliable. For labeling, there is the idea to provide a mobile app and to gamify the process to motivate the doctors to label as much data as possible. After gathering enough labeled data, the preprocessing and modeling for the in-production solution can be implemented, and the model can finally be trained. Against the prototype where no optimization is performed, the in-production model has to reach an accuracy which is in range with the current solution. Apart from that, it needs a high recall value to ensure that a minimum of diseased patients get overlooked. Another important aspect is the implementation of a retraining function in the Watson Machine Learning service.

Apart from the training of the model with clinical data and the integration of the AF prediction system discussed in the overall solution in 3, the system and the new process with all practical steps being digitized needs to be tested in a clinical setting before the current solution is detached. The testing should exhibit if doctors, employees and patients accept the Machine Learning approach, and if the process itself is interacting well with the hospital environment.
Another idea for a future implementation leads to the monitor being able to measure many other parameters apart from the ECG. Breathing, oxygen saturation, electroencephalography, temperature and blood pressure could also be monitored. Regarding this, the Machine Learning algorithm could be extended also to feature other parameters and not only the ECG. Considering more vital parameters of a patient could enable finding coherence between the parameters and define the AF detection more precisely.

The availability of measurements for other activities of the body like breathing and electroencephalography also enables letting the algorithm not only classify into AF or not. Rather more diseases like congestive heart failure could be detected during the evaluation of the ECG. That it is also possible to detect other diseases then AF is already proven in other studies like Choi, Schuetz, Stewart & Sun (2016). Technically the algorithm would then no longer feature on a binary classification but instead perform classification into different groups. The results of the classification can also be shown on the web-application which then summarizes the different findings in the ECG.

Having measurements of different diseases in the web application leads to the idea of a platform for evaluating different diseases with Machine Learning algorithms. The predictions would be central in one application similar to a dashboard where the doctors are able to verify the results and to fast analyze coherences between the diseases. Reutilizing one application or service for different use cases also saves costs in evaluation and time in administration concerning the direct integration into the HIS. With upcoming ideas for electronic health records, the integration of the verified diagnosis into such a record would enable a history of detected diseases from a patient. Especially when changing a doctor, information about the previous medical records will be helpful in considering previously detected diseases (see thesis chapter 6.4).

To sum up the prototype again illustrates the poosibility of an artificial intelligence AF detection and takes it further into a clinical setting. The new solution will not only digitize the process of AF detection in abandoning the paper-based steps but will also help the hospital to save a lot of monthly costs as the current solution is much more expensive then the artificial intelligence concept. According to this, more at-risk patients can get tested and with this possibly more strokes will be prevented. This is not only very beneficial for the patient him or herself but also in the interest of health insurance companies, because a stroke patient produces a huge amount of costs. To conclude, the idea of bringing artificial intelligence AF detection in a clinical setting should be further followed up, as the approach is definitely feasible in helping to find AF patients more easily and efficient.

Corresponding thesis

"Transformation of Medical Diagnostics with Machine Learning by Considering the Example of Atrial Fibrillation Identification", Schneider S., Hamburg, 2018

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The Key is not Spending but Investing Time - Students' Time Management and the Impact on Perceived Stress and Psychological Well-Being

JANA MATTERN, SIMON LANSMANN & MORITZ MERSMANN

Abstract The digital society impacts the learning and teaching environment at universities. Due to Information and Communication Technologies, current students, who are also called digital natives, have a high level of autonomy in performing their study related tasks. However, they also face challenges like being permanently online that lead to increased stress levels. Since previous research has identified time management as a coping strategy for stress, we suggest that it is helpful for students in the digital society. Based on a survey encompassing 51 students, the present study examines the impact of time management on perceived stress and psychological well-being. Our data shows that time management positively predicts psychological well-being. Surprisingly, the data does not reveal any relationship between time management and perceived stress. This study is the first to examine IS students as representatives for digital natives in the context of time management and its relation to stress and psychological well-being. Our findings suggest that universities should account for stressors of the digital society and should include time management modules for encouraging higher levels of health among students.

Keywords: • Time Management • Stress • Psychological Well-Being • Students • Impact •

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1 Introduction

In recent years, significant changes of learning and studying, amongst others due to new developments in Information and Communication Technologies (ICT), can be observed within educational institutions (Josephson, Karlsohn, & Östling, 2014; Schneckenberg & Ehlers, 2010). Commencing students are often referred to as digital natives who grew up in the 'digital society' (Lindgren, 2017) and "have spent their entire lives surrounded by and using computers, [...] cell phones, and all the other toys and tools of the digital age" (Prensky, 2001, p. 1). They expect instantaneous access to information, prefer active over passive learning, have a low acceptance for lectures and rely on mobile technologies for receiving information (Kennedy et al., 2008). These characteristics and attitudes shape the academic landscape. Virtual group meetings supported by conferencing tools, collaborating in writing theses through real-time editing and participating in online lectures are widespread elements of contemporary study practices (Kaplan & Haenlein, 2016).

The digital natives are facing the connectivity paradox (Jarvenpaa & Lang, 2005) in a similar way than employees. On one hand, new learning practices provide students with high levels of autonomy and flexibility on how, where and when they perform their study related tasks (Josephson et al., 2014). On the other hand, recent studies have addressed potential challenges of these new possibilities regarding education in the digital society. Research shows, for example, that instead of studying, students spend most of their time communicating via ICT (Hanson et al., 2010). Since they often use the same tools for study related and private communication (e.g. WhatsApp for seminar groups), they are constantly connected to their studies (Vorderer & Kohring, 2013). This constant connectivity makes it difficult to detach from stressors, which reduces the possibility to recover and has a negative impact on their well-being (Sonnentag, Unger, & Nägel, 2013). Blurred boundaries between private and study life and information and communication overload are other challenges resulting from the extended use of ICT (Yu, Shi, & Cao, 2019).

Due to recent reports about rising stress levels of students (BBC, 2015; Beiter et al., 2015), which extends previous research on this topic (Misra & McKean, 2000), it is crucial to identify coping strategies for the challenges of studying in a digital environment. One such coping strategy is *time management*. Research has discovered that time management is key to academic success (Nadinloyi et al., 2013; Prifti et al., 2017). Studies have also found that no or poor time management negatively affects psychological well-being (PWB; Sonnentag et al., 2013). Consequently, we examine whether time management helps contemporary students to reduce their stress level and increase their PWB. Our research question is thus: *Does time management have an impact on stress and psychological well-being of students in the digital society?*

The remainder of the paper is as follows: At first, we introduce the concept of time management in general and its role for students in particular. We then examine literature on students' stress and PWB. Thereafter, we describe our study design and results. Then, we discuss the findings while considering limitations, avenues for future research as well as the implications. Lastly, we conclude the paper.

2 Related Work

2.1 Time Management

Time management has been studied from multiple perspectives and disciplines for decades (Aeon & Aguinis, 2017; Claessens at al., 2007). This plurality of research has led to inconsistencies about what time management includes since different disciplines highlight different aspects and outcomes. Based on the literature reviews of Claessens et al. (2007) and Aeon and Aguinis (2017), we describe the concept of time management, before we further elaborate on research regarding how time management impacts students in the changing learning environment in higher education.

According to Macan (1994), time management can be explained by a process model. It consists of three central parts that, combined, lead to perceived control over time: (1) setting goals and priorities, (2) mechanics like scheduling and planning of activities and (3) a preference for organization. Perceived control over time reduces job and somatic tensions, increases satisfaction and is related to performance (Macan, 1994). There are several questionnaires for measuring time management. Macan's process model is based on the Time Management Behavior Scale (TMBS; Macan et al., 1990). Britton and Tesser (1991) define time management by means of short-range planning, time attitudes and long-range planning and developed the Time Management Questionnaire (TMQ). Another scale is the Time Structure Questionnaire (TSQ) from Bond and Feather (1988). They conceptualize time management alongside the five factors of sense of purpose, structured routine, present orientation, effective organization and persistence. In their literature review on time management, Claessens et al. (2007) found no agreement in the literature towards a definition of time management. They integrated earlier definitions of this concept into their understanding of time management as "behaviours that aim at achieving an effective use of time while performing certain goal-directed activities" (p. 262). A more recent review of the time management literature which explicitly builds on the review of Claessens et al. (2007) is the work from Aeon and Aguinis (2017). They aim at offering a future-oriented perspective on time management, which is valid across disciplines, and focus on the individual as a proactive and intentional agent. They define time management as "a form of decision making used by individuals to structure, protect, and adapt their time to changing conditions" (p. 311). The aspect of changing conditions is vital since environments in the digital society are constantly evolving (Lindgren, 2017). This is why we draw on the definition from Aeon and Aguinis (2017) for this paper.

Generally, empirical research on time management is focusing on performance or well-being as the main dependent variables (Aeon & Aguinis, 2017). Due to the rising problem of students' stress (BBC, 2015; Beiter et al., 2015), we are focusing on stress and well-being in our study. Though varying in effect size and operationalization, studies addressing the impact on stress and well-being largely show that time management helps students to reduce stress and to increase their well-being (Aeon & Aguinis, 2017; Claessens et al., 2007). For example, Misra and McKean (2000) found that good time management leads to less academic stress for undergraduate students. Chang and Nguyen (2011) showed that time management is positively correlated with students' well-being. The study from Al Khatib (2014) investigated the impact of time management on stress and academic performance and showed that good time management is linked to reduced stress levels and better grade point average. Next to self-reports, time management trainings and other interventions have been evaluated in experimental studies. Häfner et al. (2014) revealed that time management trainings help students to reduce procrastination behaviors. Procrastination is a self-regulation style that is characterized by postponing tasks and delaying their completion (Ferrari & Tice, 2000). Furthermore, Häfner et al. (2015) showed that time management trainings help students to increase their perceived control of time and thus reduce stress. However, student samples also yielded mixed results regarding the impact of time management on worry, which is an aspect of well-being (Kelly, 2003).

In the following two subchapters, we report in more detail on research concerning students' stress and PWB and present our hypotheses regarding the influence of time management. Based on this, we put forward the underlying research model for this paper.

2.2 Stress

Due to the emergence of ICT, stress caused by technologies has become of interest to many scholars under the term technostress (Brod, 1984). Even though technostress is mostly researched in the professional context (e.g. Ragu-Nathan et al., 2008), characteristics like information and communication overload are also valid for the private context (Yu et al., 2019). We see stress of current students as an interplay of the negative impact of technology and general stressors of university life.

According to the transactional stress model (Lazarus & Folkman, 1984), stress is the result of the perception of a situation as being stressful (primary appraisal) and the evaluation of personal capabilities to cope with the situation (secondary appraisal). Thus, a stress response is the result of an individual perception and evaluation of personal and contextual factors (Cohen, Kamarck, & Mermelstein, 1983). Accordingly, the increased flexibility of university life is either a challenge or an opportunity. For example, student A who has a part-time job, can watch lectures online and work virtually on projects without having to attend any face-to-face meetings. His primary appraisal of the situation would not result in stress since he can better integrate his studies and his job. Student B in exactly the same situation might feel overloaded. Having to deal with constant messages regarding a study project instead of having group meetings at a particular time, adds a high amount of unpredictability to her day so that she perceives this situation as stressful. Time management might help to gain control and inhibit the stress response. When student B perceives her time management skills as sufficient and thinks she is able to organize her day in a way that she is not distracted by the stream of messages, she does not experience stress (i.e. secondary appraisal).

Research has found specific elements of university life in general and of university life in the digital society in particular, that impact students' stress levels. Writing papers, preparing for exams or taking notes in class increase students' stress levels (Zajacova, Lynch, & Espenshade, 2005). A stressor inherent to the digital society that has been widely researched is problematic smartphone use which can easily turn into smartphone addiction (Haug et al., 2015). Addictive smartphone behavior has been shown to increase the stress level of students (Samaha & Hawi, 2016) as well as to lead to time management problems (Hong, Chiu, & Huang, 2012). These problems are, for example, wasting too much time on social media sites on the smartphone so that students have less time for study related work. Similar to excessive smartphone use, problematic internet use has been found to increase the stress level of students (Akin & İskender, 2011). In the digital society, students are required to have internet access for attending online courses, submitting theses or communicating with their professors (Kaplan & Haenlein, 2016). The high study related internet use adds to use for leisure activities like social media, online communities or gaming. This can impact face-to-face interactions in a way that higher internet use decreases time spent with friends and family (Nie, Hillygus, & Erbring, 2002).

Time management in general (Al Khatib, 2014; Macan et al., 1990; Misra & McKean, 2000) and time management trainings in particular (Häfner et al., 2014, 2015), are widely recognized as being helpful for reducing students' stress levels. Strategies like the Pomodoro Technique (Cirillo, 2018) can help students to stay focused on one task and to spend time on the smartphone only for a limited period. Stress management trainings based on the transactional stress model use time management practices as primary means to provide individuals with the ability to control the frequency and intensity of the stressors (Flaxman & Bond, 2010).

2.3 Psychological Well-Being

Stress is directly related to a broader concept suggesting that health and recovery are more than just being away from eventual stressors: psychological well-being. It consists of subjective, social and psychological dimensions as well as health-related behaviors and covers all areas of individuals' life (Ryff, 1989). PWB also includes taking opportunities to develop as a person and being open to new experiences (Ryff & Keyes, 1995). Individuals with a positive PWB can control their environment and the stressors that come with it. Time management can help students to make effective use of external conditions and to shape their environment according to their personal needs and values. Differentiating important from unimportant as well as urgent from not urgent tasks is important for achieving a manageable amount of workload (Kirillov et al., 2015). Setting realistic goals and prioritizing tasks can reduce the feeling of being overwhelmed and increase the perceived control over their day, which has positive effects for well-being (MacLeod, Coates, & Hetherton, 2008).

As the allostatic load concept from McEwen (1998) proposes, being constantly confronted to stressors reduces PWB. The constant activation of the autonomic nervous system leads to an inability to detach from the stressors. This in turn reduces the possibility to recover from stress and leads to detrimental long-term effects for PWB. Contemporary students have grown up with access to digital communication (Prensky, 2001). Whereas in earlier days the main goal was to retrieve and send information at a certain point in time, today, young adults are permanently online (Vorderer & Kohring, 2013). Even though students voluntarily choose the status of being permanently online and connected to others, they recognize an ambivalence in this behavior (Vorderer, Krömer, & Schneider, 2016). On one hand, they appreciate the ability to be in touch with others every time. On the other hand, this behavior results in an impaired well-being, e.g. when their social activities like having dinner with their family suffer from being constantly tied to the smartphone (Vorderer et al., 2016). We suppose that time management can help students establish time slots where they are offline and can replenish their resources.

As described above, difficulties in time management often manifest themselves in procrastination. The procrastination-health-model (Sirois, Melia-Gordon, & Pychyl, 2003) shows that procrastination has negative consequences for the individuals' well-being. Research has revealed that being permanently online is a manifestation of procrastination behavior and reduces PWB (Reinecke et al., 2018). Above all, social media sites like Facebook make students delay tasks (Junco, 2012). Meier et al. (2016) found that procrastinating via Facebook has a negative effect on students' well-being. As previous research has shown that time management reduces procrastination (Häfner et al., 2014), we suggest that this can also help students in the digital learning environment. Based on the literature findings, we suggest the following hypotheses (see Figure 1):

Hypothesis 1: Time management leads to a reduced level of perceived stress.
Hypothesis 2: Time management leads to a higher level of PWB.
Hypothesis 3: Perceived stress leads to a reduced level of PWB.

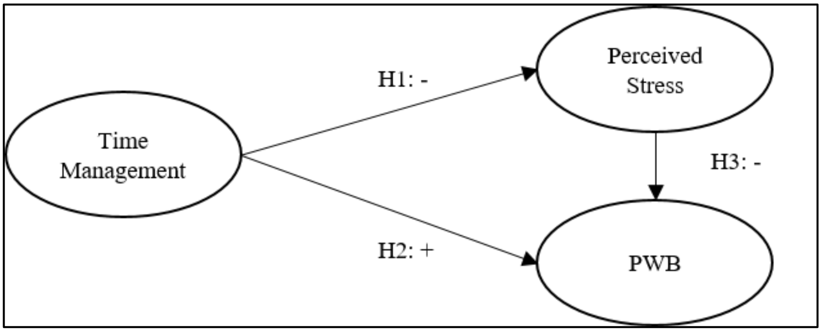

Figure 1: Research Model

Although ICT are an important driver of the changing learning environment, we do not include the direct effect of ICT in our model. We examine current students of Information Systems (IS), a study subject that directly deals with technology and makes use of extensive ICT for study projects and lectures, as well as IS-related study subjects. We treat those students as representatives of the digital natives with all challenges and opportunities that they are facing. In the following section, we explain how we operationalized this model.

3 Method

3.1 Sample

Our study was part of a project concerning time management of graduate university students, which was conducted at the department of IS at the University of Muenster. We collected the data for two weeks in November 2017. During this period, we advertised the study via social media and in several university lectures. In total, 51 students completed the survey (37% female, 63% male) ranging from 16 to 32 years (M = 23.4). The sample mostly comprised IS students (29) and students from IS-related courses such as Economics (8) and Business Administration (4) as well as other disciplines (10). We conducted the data analysis with SPSS and the lavaan package in R for the Structural Equation Model (SEM).

3.2 Measurements

We used three questionnaires to assess students' time management, perceived stress level and PWB. All questionnaires are based on existing measurements and were adapted to the university context. We calculated the composite scores for each variable by totaling the scores for all items (reversing items if necessary) and dividing that by the number of items. The complete list of items is provided in the appendix.

Time Management. We measured time management based on three established questionnaires to account for time management practices as well as time management pathologies. We used the TMQ developed by Britton and Tesser (1991) for the first four items (e.g. "I write a set of goals for myself for each day."). We utilized this scale because it appropriately reflects the changing conditions of digital natives. Additionally, shorter versions of the TMQ already showed a good reliability (Barling, Kelloway, & Cheung, 1996). For the last two items, we used Aitken's (1982) procrastination inventory (e.g. "I start to work on assignments and projects only close to deadlines.") and the work addiction risk test (Robinson, 1999) to include other aspects of the concept.

Perceived Stress. As an instrument for measuring students' overall perceived stress level, we adapted the ten item Perceived Stress Scale (PSS) developed by Cohen et al. (1983) to the university context (e.g. "Last semester, I was upset because something happened unexpectedly."). This scale has been commonly used in psychological research for assessing an individual's stress level and has been empirically verified several times (Gabre & Kumar, 2012; Rice et al., 2006).

PWB. We assessed the participants' PWB by using a shortened version of the Psychological Well-Being Scale (PWBS; Ryff, 1989) (e.g. "In general, I feel I am in charge of my study situation."). Shorter versions of the PWBS have been utilized by various researchers and have been proven to be reliable (Ryff & Keyes, 1995).

Questionnaires were answered on a five-point Likert scale ranging from 'Strongly disagree' to 'Strongly agree' for agreeing to a statement, and respectively from 'Never' to 'Very often' for indicating the individual frequency of occurrence regarding a statement (Strongly disagree/Never = 0, Disagree/Almost never = 1, Undecided/Sometimes = 2, Agree/Fairly often = 3, Strongly agree/Very often = 4). All three questionnaires displayed a good internal consistency. For time management, Cronbach's alpha was 0.70, which is good compared to other scales for time management (Claessens et al., 2007), specifically for the TMQ scale (Alvarez Sainz, Ferrero, & Ugidos, 2019). For perceived stress and PWB Cronbach's alpha was 0.87 and 0.72, respectively.

4 Results

4.1 Descriptive Analysis and Bivariate Correlations

We assessed students' time management level through the sum of six items. Students' answers range from 0 to a maximum of 21 whereby a higher value indicates better time management. For stress, we used the sum of the ten PSS items, which range from 1 to 36. Accordingly, a higher value indicates a higher level of perceived stress. The score for the students' PWB consists of the sum of all seven items from the PWB questionnaire with a minimum score of 7 and a maximum score of 28. Similarly, a low score indicates a low PWB and a high score indicates a high PWB. Means, standard deviations and intercorrelations of all variables are displayed in Table 1.

We calculated Pearson correlations to analyze relations between students' perceived stress, PWB and time management. Correlations are based on z-standardized scores to account for the different length of the questionnaires. The results presented in Table 1 show that there is a significant negative correlation ($r = -0.37$, $p < 0.01$) between the students' perceived stress and PWB. The correlation between perceived stress and time management reveals no significant relation ($r = -0.02$, $p = 0.87$). However, when correlating PWB with time management a significant positive correlation is detected suggesting that a good time management is related to a high PWB ($r = 0.35$, $p < 0.01$).

Table 1. Descriptive Statistics and Bivariate Correlations

	M	*SD*	Perceived Stress	PWB	Time Management
Perceived Stress	16.98	6.38	-	**-0.37****	-0.02
PWB	19.63	4.04		-	**0.35****
Time Management	12.04	4.33			-

Note. Means and standard deviations were calculated using raw data, whereas correlations are based on z-standardized values. ** = Correlations are significant at the $p < 0.01$ level.

4.2 Multivariate Analysis

To test our hypotheses, we calculated a SEM with time management predicting perceived stress and PWB, and perceived stress predicting PWB. Path coefficients (Figure 2) show that time management significantly predicts PWB but has no influence on perceived stress and that perceived stress negatively predicts PWB.

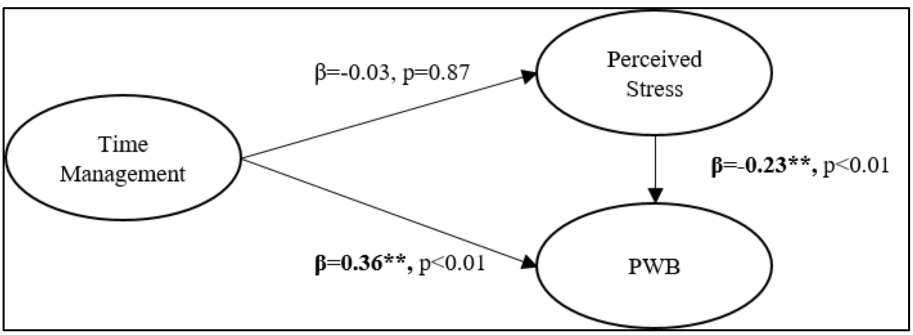

Figure 2. Effects of time management on perceived stress and PWB.
Note. ** = Coefficients are significant at the $p < 0.01$ level.

5 Discussion

Our research examined the impact of time management on perceived stress and PWB of students in the digital society. We found support for our second hypothesis that good time management increases students' PWB. This finding suggests that time management is a successful coping strategy for reducing the negative effects on well-being that scholars have found in the context of being permanently online (Vorderer et al., 2016). It seems that our sample of IS students engage in a behavior of being constantly online and thus being connected to their fellow students and study related tasks. Time management helps them to create periods in which they are disconnected and can replenish their resources. However, to prove this interpretation, further studies are needed that include measurements of technology use and constant connectivity. In line with the procrastination-health-model (Sirois et al., 2003), our findings suggest that students with good time management who are, for example, already working on projects before the deadline approaches, reduce the probability of suffering from an impaired well-being. When they are good at setting goals and priorities, they can manage their tasks and stop delaying them to the future. This decreases the probability that tasks pile up, remain uncompleted or results are of low quality due to time pressure. Apparently, being in control of their own time increases the students' PWB.

Contrarily to our first hypothesis, time management had no influence on the students' perceived stress level. This finding opposes earlier research proving the effectiveness of time management on reducing stress for students (Al Khatib, 2014; Misra & McKean, 2000). When looking on general trainings to reduce stress for students, research has identified other factors than time management that are important as well. In particular, mindfulness has been found to lead to an effective stress management training (De Vibe et al., 2013; Rosenzweig et al., 2003). Those studies examine mainly medical or psychology students, disciplines that are not as directly linked to technology as IS students. However, also in our sample, other strategies than time management, such as mindfulness, might be more helpful to reduce stress. Further studies are needed to examine different variables of stress management trainings for digital natives. Another explanation for the rejected hypothesis could be the time of the data collection. Students responded to the questionnaires during the end of November. At that time of the semester, no deadlines were close and the average of students did not show an elevated stress level. Seemingly, time management is not as advantageous as expected to reduce perceived stress at that particular point in time. It would be interesting to repeat the measurement at a different point in time closer to deadlines to see whether this leads to an increase in the influence time management has on perceived stress. Time management might become more important for stress management when time pressure has already emerged.

Lastly, we found support for our third hypothesis which corroborates existing literature (McEwen, 1998). Our results indicated that a high level of perceived stress reduces PWB. Students, who experience their situation as stressful and their coping mechanisms as insufficient, are more likely to report an impaired PWB. A perception of stress might hinder them in their ability to change the situation according to their needs which leads to a low PWB (Ryff & Keyes, 1995).

5.1 Limitations and Future Research

There are additional limitations to this study that call for future research. External validity of our findings cannot be assured. The small sample size makes it difficult to derive generalizable results. Also, since all participants were from the same university, factors inherent to life at this particular university like peer pressure or curricular expectations, might also influence the effects. Moreover, our study only examined the subjective perception of stress. The perceived stress level of an individual might differ from the objective stress level. Integrating physiological measurements like heart rate variability might improve our results (Cohen, Gianaros, & Manuck, 2016; Zajacova et al., 2005). Nevertheless, our scale of perceived stress shows a good reliability and is therefore a reasonable instrument.

To clarify whether time management has an effect on stress of IS students, a follow-up study with a bigger sample size is needed. In such a study, it might be beneficial to include individual time preferences of monochronic (doing one thing at a time) or polychronic (multitask) time perception. These preferences are acknowledged to have an impact on time management outcomes (Aeon & Aguinis, 2017). To get a deeper understanding on how different time management practices are applied by students, we agree with previous authors that the literature of time management would benefit from more qualitative studies (Aeon & Aguinis, 2017; Claessens et al., 2007).

5.2 Theoretical and Practical Implications

We contribute to literature on the influence of students' time management on stress and PWB in studying the effects in the context of students in the digital society. Stress management for students has been researched primarily with samples of medical and psychology students since these are the disciplines that are predominantly interested in stress and well-being. To the best of our knowledge, this study is the first that examines IS students in this context. Specifically, we contribute to the literature on time management by using and validating the TMQ scale drawing on IS students from Germany. So far, students' time management has been measured using the TMQ in other countries (e.g., Al Kathib, 2014; Britton & Tesser, 1991) or the TMBS (e.g. Chang & Nguyen, 2011; Misra & McKean, 2000).

Due to their study subject and personal preferences, IS students are at the forefront of digital developments and are most likely to choose a job in the IT industry after the completion of their studies. The field of IT work is constantly growing (e.g. Bitkom, 2018 for Germany) so that IT professionals are highly needed. Identifying stress and time management strategies for IS students can help to develop healthy individuals who will take a job in this field (Alvarez Sainz et al., 2019).

Next to the scientific contribution, our research has practical implications for education in the digital society. Whereas in earlier days, students' stress resulted above all from pressure regarding academic success (Zajacova et al., 2005), stress through ICT adds to current students' stress level. To make sure that students maintain a positive well-being, teachers should give them advice on time management, especially when they start their studies (Al Khatib, 2014; Prifti et al., 2017). The transition from high schools to universities is not easy. Whereas in the former environment the structure is externally set to a high degree, the latter environment is characterized by flexibility and the need for self-organization (Alvarez Sainz et al., 2019; Josephson et al., 2014). Universities might include stress management modules covering time management practices in IS curricula to help students making this transition successful.

6 Conclusion

The present study aimed at uncovering the relationship between time management, perceived stress and PWB of students in the changing environment of higher education. We contribute to the literature by examining IS students as representatives of the digital natives and examine the impact of time management in this particular environment of extended use of technology. Our results indicate a positive impact of time management for PWB. Time management seems to help students to cope with behaviours that lead to an impaired well-being like procrastination or being permanently online and connected to their studies. However, we found no impact of time management on the level of perceived stress. Ostensibly, there are other factors than time management that influence whether students feel overwhelmed. Further research is needed to examine the role of time management as a coping strategy for stress in the changing learning and teaching environment at universities in the digital society. Based on our discussion, we argue that universities might consider to teach time management strategies or to raise awareness of negative consequences of a poor time management for the PWB of their students. Time management skills like goal setting or prioritizing have not lost any of their importance in the digital society and are thus crucial for developing healthy contemporary students who are tomorrow's employees.

Appendix

Table 2. Questionnaire Time Management

Item	Wording
TM_1	I write a set of goals for myself for each day.
TM_2	I have a clear idea of what I want to accomplish for my study during the next week.
TM_3	I make constructive use of my time when I want to study.
TM_4	I regularly evaluate how I managed my time.
TM_5	I start to work on assignments and projects only close to deadlines. *
TM_6	I give myself strict deadlines for finishing my assignments.

Note. All items had to be answered on a 5-point Likert Scale (Strongly disagree = 0, Disagree = 1, Undecided = 2, Agree = 3, Strongly agree = 4). * = Reversed item.

Table 3. Questionnaire Perceived Stress

Item	Wording
	Last semester…
Stress_1	I was upset because something happened unexpectedly.
Stress_2	I felt that I was unable to control the important things in my life.
Stress_3	I felt nervous and stressed.
Stress_4	I felt confident about my ability to handle my personal problems. *
Stress_5	I felt that things were going my way. *

Stress_6	I found that I could not cope with all the things that I had to do.
Stress_7	I was able to control irritations in my life. *
Stress_8	I felt that I was on top of things. *
Stress_9	I was angry because things were outside of my control.
Stress_10	I felt difficulties were piling up so high that I could not overcome them.

Note. All items had to be answered on a 5-point Likert Scale (Never = 0, Almost never = 1, Sometimes = 2, Fairly often = 3, Very often = 4). * = Reversed item.

Table 4. Questionnaire Psychological Well-Being

Item	Wording
PWB _1	In general, I feel I am in charge of my study situation.
PWB _2	I think it is important to have new experiences that challenge how you think about yourself and the world.
PWB _3	I have the sense that I have developed a lot as a person over time.
PWB _4	I have a sense of direction and purpose in life.
PWB _5	I have difficulty arranging my studies in a way that is satisfying to me. *
PWB _6	For me, life has been a continuous process of learning, changing, and growth.
PWB _7	I enjoy making plans for the future and working to make them a reality.

Note. All items had to be answered on a 5-point Likert Scale (Strongly disagree = 0, Disagree = 1, Undecided = 2, Agree = 3, Strongly agree = 4). * = Reversed item

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Control Mechanisms for Assessing the Quality of Handmade and Artistic Products in e-Marketplace Platforms

ADE RATNASARI & MARK DE REUVER

Abstract Selling handmade and artistic goods online is challenging since buyers need to be able to assess product quality before purchase. This study aims to explore how control mechanisms aid the assessment of the product quality of handmade and artistic goods. We do so by extracting control mechanisms for e-marketplace platforms from existing literature and discussing to what extent these are suitable for handmade and artistic goods. We found that existing literature mainly focuses on reputation systems. We reshaped the findings by conducting desk research to identify how control mechanisms are applied in a number of e-marketplaces. Our results show that in e-marketplaces that focus on selling handmade artistic products, a reputation system is not sufficient to ensure product quality in an online environment. Thus, it is critical to apply other control mechanisms which are more effective in increasing the trustworthiness of the seller of artistic and handmade goods. Last, we also suggest alternative control mechanisms to be explored in future research.

Keywords: • Control Mechanisms • E-marketplace • Trustworthiness • Product quality • Reputation system •

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1 Introduction

E-marketplace platforms are an example of multi-sided platforms in which a groups of buyers and sellers exchange goods. E-marketplaces enable buyers and sellers to exchange information, products, services and payment through the internet (Chong *et al.*, 2010). Examples of e-marketplace platforms are Amazon and Alibaba, on which not only the provider's own products are sold, but a large amount of third-party sellers are also active. Buyers can choose various products from various sellers and compare the products (Barratt and Rosdahl, 2002).

E-marketplaces have attracted many sellers and buyers to transact a wide variety of goods and services. However, e-marketplaces for handmade and artistic products are still hardly used. Many sellers prefer to join local handmade e-marketplaces rather than international e-marketplaces, since local sellers often lack English language skills and are unable to use international currencies. International handmade e-marketplaces also have strict requirements for sellers to join. Thus, only qualified sellers can join the platforms. Many buyers are also reluctant to use e-marketplaces after they have experienced being sent products which were not of the quality specified by sellers (Chiu *et al.*, 2010). In e-marketplaces, buyers and sellers are geographically separated, hence the products cannot be physically examined (Ye *et al.*, 2013). When buyers interact with unknown sellers and have less knowledge about the product and the sellers, buyers cannot ascertain the product quality, which leaves them dependent on product descriptions and the honesty of sellers to deliver the products as specified (Sänger *et al.*, 2016). Generally speaking, selling products online requires buyers to have trust in the sellers because they cannot assess the products virtually, are faced with a lack of information about the products from the seller and also with the presence of dishonest sellers (Sänger *et al.*, 2016).

Existing e-marketplaces offer various mechanisms for building potential buyers' trust in sellers and their products. These are mainly reputation systems that predict seller behaviour from past transactions (Zhang *et al.*, 2012). However, to a large extent, reputation mechanisms focus on sellers, and do not give information regarding the quality of specific products (Ye *et al.*, 2013). This puts buyers at risk as they lack information about the products while opportunistic sellers can easily register and access buyers' data (Lancastre and Lages, 2006). The problem associated with remotely assessing product quality is especially great for goods that are non-standardized and difficult to inspect remotely, such as artistic or handmade goods.

The goal of this paper is to evaluate whether control mechanisms from literature on e-marketplace platforms are applicable to handmade and artistic goods, whether for the local or international handmade e-marketplace. To do so, we conduct literature review about control mechanisms that affect the trustworthiness of e-marketplace platforms. The review is done in the context of an ongoing research project on control mechanisms and quality mechanisms for e-marketplace platforms, specifically for handmade and artistic goods. The overview serves as a basis for follow-up research on evaluating the effects of the elicited mechanisms on trustworthiness in e-marketplace platforms. The research is followed by desk research to assess the implementation of control mechanisms in the local and international e-marketplace for handmade products. We have chosen Indonesia as a local market where many handcrafters produce and sell products.

This paper aims to answer the following research questions:

1. What control mechanisms that affect the trustworthiness of sellers on e-marketplace platforms have been discussed in existing literature?
2. Which trustworthiness issues in e-marketplace platforms have not been addressed, specifically in the context of handmade and artistic goods?

How are control mechanisms applied in existing e-marketplaces where handmade and artistic goods are sold, whether local or international?

2 Background

2.1 Handmade and artistic goods in e-marketplaces

Handmade products are non-commodity products that are produced by hand by trained and experienced people, without standardized production machines. Product quality relies on the crafter's experience. Some handmade products are produced by people building on experience handed down through generations and over a long time. The production of handmade goods by small firms is an important part of the economy of developing countries.

2.2 Multi-sided platforms and e-marketplaces

Whilst traditionally e-marketplaces were online stores with only one seller (e.g. the early days of Amazon), today most large e-marketplaces are open to any seller to engage in transactions with consumers. In this way, e-marketplaces have evolved into multi-sided platforms that mediate between large groups of buyers and sellers (Evans and Schmalensee, 2017). Multi-sided platforms typically exhibit network effects, which implies that they become more valuable as more users join (Katz and Shapiro, 1985). At the same time, opening up to a large group of sellers creates risks as low-quality sellers may harm the reputation and quality of a platform (Wareham *et al.*, 2013). A major challenge in such multi-sided platforms is therefore governance in general (de Reuver *et al.*, 2016) and specifically how to exercise control over the quality of different sides of a platform (Tiwana *et al.*, 2010).

2.3 Trust and Trustworthiness Conceptualization

Trust is defined as the belief that another party will perform in a way likely to bring the expected welfare or not do some unexpected harmful thing (Ažderska, 2012). In online commerce, consumer trust focuses on faith in sellers regarding product specification and quality (Gefen *et al.*, 2008).

Trustworthiness refers to the degree to which a party is considered to have ability, integrity, and benevolence (Gefen *et al.*, 2008). The ability means that the trustee has the skills, competences and characteristics to act in a specific domain (Mayer *et al.*, 1995). Integrity means that the party has a strong sense of justice as measured by the consistency between its words and actions (Mayer *et al.*, 1995). The last attribute, benevolence, means that another party will do good rather than egoistically taking profit from its partners (Mayer *et al.*, 1995).

Keeping promises to protect the other party's interests while not exploiting information asymmetries is a fundamental principle in a relationship with unknown partners. With reference to online selling, trust from buyers is needed before they decide to purchase online on an e-marketplace platform.

To build trust in e-marketplaces and sellers, there are generally three types of mechanisms:

1. Institution-Based Mechanisms (IBM): this refers to third-party institutions that provide independent information about the quality of sellers and secure the process of transaction. Examples are third-party escrow, assurance seals and privacy protection (Liu and Tang, 2018).
2. Seller-Based Mechanisms (SBM): this refers to information provided by the seller, including information on product quality and terms of service. More complete information provided by sellers can reduce uncertainty and buyer risk (Liu and Tang, 2018).
3. Experience-Based Mechanisms (EBM): this refers to sharing information from previous buyers through feedback mechanisms and reputation systems (Liu and Tang, 2018).

2.4 Control Mechanism Definition

In literature on digital platforms in general, control refers to attempts by a controller to influence an individual or group to act as the objective of control (Goldbach, 2014). (Mukhopadhyay *et al.*, 2016) meanwhile state that control mechanisms play an important role in all participants of platform ecosystems reaching the platform's goals, which confirms the previous study that said that control mechanisms can encourage the platform members to act in ways that further the platform's goals (Tiwana, 2014).

There are two types of controls, namely formal control – such as input control, output and behaviour control (Tiwana, 2014) – and informal control – such as clan and self-control (Goldbach *et al.*, 2018). Control mechanisms can be categorized as follows (Tiwana, 2014):

1. Gatekeeping refers to implementing acceptance criteria for participants for allowing them to join a platform
2. Process Control refers to the degree to which platforms reward and punish participants based on their compliance with procedures, methods and rules
3. Metrics Control refers to the degree to which platforms reward and punish participants based on the outcome of their participation on the platform
4. Relational Control refers to values and norms that are shared among participants and influence their behaviour (Goldbach *et al.*, 2018).

We will apply these four control mechanisms for platforms in general in our analysis for e-marketplace platforms.

3 Method

We follow the literature review through the typical approach in information systems (Webster and Watson, 2002). We first created a syntax to find relevant studies about control mechanisms in e-marketplaces. The syntax consists of keywords related to control mechanisms (or sub-types thereof) and marketplaces as well as popular examples of marketplaces. We used three databases: Web of Science, Scopus and Google Scholar.

The syntax is: ("control" OR "control mechanism" OR "gatekeeping" OR "metrics control" OR "outcome control" OR "output control" OR "product quality control" OR "process control" OR "control behavior" OR "platform governance") AND TITLE-ABS-KEY ("Alibaba" OR "Amazon e-commerce" OR "e-marketplace" OR "e-marketplace platform" OR "ecommerce platform")). We added additional syntax to exclude the words "cloud", "blockchain" or "payment" such that papers are closer to e-marketplace topics.

The query was executed in MONTH YEAR, resulting in 22 papers from Web of Science, and 14 papers from Scopus. After a thorough reading of the papers, we finally included 14 papers from Web of Science and 2 papers from Scopus. We also conducted snowball sampling using the function from Google Scholar, resulting in 7 more papers, leading to a total of 23 papers. Most of the papers found discuss reputation systems and the reliability of rating. Other issues discussed in the papers include trust mechanisms, product quality, purchase, and so on.

We classified the collected papers into four categories, see Table 1. The first is trustworthiness mechanisms, which subsumes factors relying on institutional, seller-based and experience mechanisms. The second category is the specific mechanism of reputation systems, which we treat separately due to its prevalence in the literature. Third, we use a product-related category of papers, which discusses how product information influences buyer trust. The final category contains papers that do not fall into the previously mentioned categories.

Table 1. Classification of 23 Papers

Topic	Sub Topic	Number of Paper
Trustworthiness mechanisms	1. Institutional mechanisms 2. Seller-based mechanisms 3. Experience mechanisms	(Liu and Tang, 2018), (Bao *et al.*, 2016), (Ou and Chan, 2014),(Hong and Cho, 2011), (Auinger *et al.*, 2016)
	Robustness of Reputation System	(Sänger *et al.*, 2016), (Lee and Shin, 2014), (Du *et al.*, 2013), (Wolf and Muhanna, 2011)(Wolf and Muhanna, 2011),(Cabral and Li, 2015)
Reputation Systems	Reputation Systems and their elements 1.Reputation 2.Online Review: 3.Rating 4.Feedback 5.Word of Mouth	(Chatterjee *et al.*, 2012), (Fajar and Sandhyaduhita, 2016) (Zhang *et al.*, 2017), (Trenz, 2013) (Dimitrios and Ghandour, 2016) (Hu *et al.*, 2012) (Lin and Heng, 2016)
Product	1. Product Information, 2. Product Quality, 3. Seller Information, 4. User-generated Photo	(Fajar and Sandhyaduhita, 2016), (Meents and Verhagen, 2018), (Bao, 2015), (Zhang, 2012), (Johnson *et al.*, 2015)
Other mechanisms	1. Favourite product sold/ sales volume 2. Historical Sales Record 3. Delivery Services Quality	(Ou and Chan, 2014) (Ye *et al.*, 2013) (Nurdani and Sandhyaduhita, 2016)

We reshaped the findings by conducting desk research to identify how control mechanisms are applied in several e-marketplaces. We selected e-marketplaces that represent local and international e-marketplaces, also e-marketplaces that sell general and handmade products. We selected Indonesia as a country of local handmade-e-marketplaces and as a country that produces handmade goods. As international e-marketplace we chose Alibaba and Etsy that represent international e-marketplaces. We conducted the desk research by visiting these e-marketplace websites, trying to buy products, reading the reviews, signing on as new customers (as far as possible), choosing the products, choosing the delivery, filling the product order form and reading the discussion forum and also going to a lot of effort to identify the control mechanisms which are applied in these e-marketplaces.

4 Finding

4.1 Trustworthiness

Regarding trustworthiness, we found 5 papers that discuss this topic in general. These papers mainly discuss institutional and social mechanisms.

Regarding institutional mechanisms, various forms are discussed in the five papers. These range from online credit card guarantees, escrow services (Liu and Tang, 2018),(Bao *et al.*, 2016),(Ou and Chan, 2014), privacy protection (Liu and Tang, 2018), intermediary protection, reputation (Ou and Chan, 2014), third party guarantee (Hong and Cho, 2011) and third party trust seal (Auinger *et al.*, 2016).

Institutional mechanisms are defined as structures provided by third parties for supporting and protecting the success of transactions (Bao *et al.*, 2016). For instance, escrow services give customers the guarantee that the payment will only be released when the specified merchandise is received. Alternatively, a credit card guarantee can protect buyers from losing the money through financial institutions (Bao *et al.*, 2016). These mechanisms protect buyers against potential risks in the e-commerce environment (Bao *et al.*, 2016). (Ou and Chan, 2014) also include reputation as an institutional mechanism, which will be discussed in more detail in Section 4.2.

(Hong and Cho, 2011) point out that third party guarantees such as Verisign can assure that customers are protected and (Auinger *et al.*, 2016) suggest putting trust seal logos on the website of vendors. They found that the display of a trust seal (i.e. recommendation from a trusted third party that the seller is trustworthy), has a strong impact on building customer trust (Bao *et al.*, 2016). The study finds that using trust seals is especially suitable for enhancing trust in new sellers and small shops (Auinger *et al.*, 2016).

The five papers have different findings regarding the implications of trustworthiness mechanisms on trust. (Hong and Cho, 2011) find that increasing trust in the e-marketplace will automatically increase trust in the sellers on that e-marketplace. In contrast, (Liu and Tang, 2018) finds that trust in e-marketplaces substitutes trust in sellers, and directly affects repurchase intention. These two studies show that seller-based mechanisms both affect trust in sellers directly as found in (Liu and Tang, 2018) but possibly also indirectly, since (Liu and Tang, 2018) find that they positively affect trust in e-marketplaces and (Hong and Cho, 2011) find that trust in e-marketplaces positively affects trust in sellers.

(Ou and Chan, 2014) combined social mechanisms and institutional mechanisms with additional mechanisms provided by sellers (i.e. return policy and repair services) to attract buyers. This holds especially for e-marketplaces which offer differentiation mechanisms (Ou and Chan, 2014) as additional mechanism. Social mechanisms refer to the popularity of sellers and products. The study finds that social mechanisms such as shop tagging and product tagging give quality signals and are the most robust predictors of sales volume in e-marketplaces. Shop tagging and product tagging refer to the number of people tagging a specific product and seller as an favourite seller and product.

(Ou and Chan, 2014) establish institutional mechanisms as an effective way to build customer trust. By adding these social mechanisms, buyers can differentiate sellers from a "quality" perspective. (Ou and Chan, 2014) find that institutional mechanisms are an effective way to build customer trust, but the study shows that social mechanisms by using shop and product tagging are more effective (Ou and Chan, 2014).

Furthermore, (Bao *et al.*, 2016) find that institution-based mechanisms have no significant impact on trust and repurchase intention. Customers rely on "interactivity with sellers" when the perceived usefulness of institution-based mechanisms is low. This implies that if customer trust has not been built, customers are likely to use communication tools to get information as additional assurance to increase their confidence in purchase decisions.

4.2 Reputation Systems

Reputation can be defined as the collective scale of trustworthiness, based on the member's opinion (Jøsang *et al.*, 2007), in a platform. The term "reputation" is always related to the term "trust". In this study we will use reputation in the context of the community's general reliability evaluation of a seller (Jøsang and Golbeck, 2009). Reputation is one of the control mechanisms that is categorized as outcome control (Tiwana, 2014) and shows the degree of platform participants' performance as measured against the achievement which was predefined by the platform owner. We found many studies about reputation, indicating that reputation is an effective way to find out more about sellers based on the experience of previous buyers. Reputation plays a role as secondary information about the product quality and seller quality. Buyers rely on the reputation that has been built by sellers, especially when they lack of information about the product itself. To build a good reputation, sellers have to deliver high-quality products (Fajar and Sandhyaduhita, 2016).

A first mechanism in building reputation is online reviews, which are popular information sources in product research for online purchase (Trenz, 2013). The quality of review information should be presented accurately to prevent buyer misinformation (Zhang et al., 2017). Furthermore, review information can enable buyers to differentiate product quality (Trenz, 2013) from the perspective of previous buyers.

A second mechanism in building reputation is consumer feedback (Hu *et al.*, 2012). The term consumer feedback is also called word of mouth in (Hu *et al.*, 2012), who find that distance between the word of mouth information presented and the real product information or sellers subsequently affects word of mouth both in volume and in valence (Lin and Heng, 2016). However, (Hu *et al.*, 2012) find that the purchase decision is also influenced by the brand or model of the product. Bad word of mouth does not influence buyer trust according to (Du *et al.*, 2013), which is in contrast to previous studies.

Studies about reputation mechanisms mainly focus on the reliability of reputation systems. Given the important role of reputation systems in signalling previous buyers' perception of products, many scholars find weakness in reputation systems, such as that sellers sell many cheap products to build a good reputation while presenting untrue information on a few expensive products. Some sellers also offer various products of which the quality varies depending on the season (Sänger *et al.*, 2016). Scholars have created tools to detect malicious sellers, and these have been shown to change buyer behaviour (Sänger *et al.*, 2016). Buyers do not decide to purchase products from several sellers, while buyers buy the products through old systems. Wolf, J. R. (2011) finds that buyers interpret the feedback information in a biased manner, based on a simulation of an online auction site comparable to eBay, with participants acting as buyers.

Several studies make suggestions on how to improve reputation systems. Buyers may also not be influenced by existing bad word of mouth in rating systems as found in (Du *et al.*, 2013), which means that the accuracy of reputation systems needs to be improved. Another study suggests improving reputation systems by including emojis and avatars, in order to improve buyers' ability to understand (Dimitrios and Ghandour, 2016). One study shows the interaction between reputation mechanisms and institution-based mechanisms, as customer feedback improves as the rebate incentive increases, both regarding speed of feedback and number of bids (Cabral and Li, 2015). Lastly, another effort to improve the reliability of reputation systems proposes using reviewer photos to increase consumer trust (Lee and Shin, 2014).

4.3 Product Information and Quality

Similarly to the previously discussed mechanisms, product information helps buyers to reduce the uncertainty of information. From five papers, we found three ways in which product information mechanisms affect trustworthiness.

Firstly, product information can reduce buyer risks and lead to purchase decisions. The accuracy of information provided by sellers proves the capability of sellers to provide good quality products (Meents and Verhagen, 2018).

However, this study has a limitation since it was conducted in a well-known e-marketplace.

Secondly, one study states that product quality information can support the reputation of sellers (Fajar and Sandhyaduhita, 2016). Product quality information also significantly impacts customer satisfaction, which in turn leads to repurchase intention (Bao, 2015). Sellers should be encouraged not only to build reputation but also to retain customer satisfaction by maintaining the actual product quality (Bao, 2015). Alibaba implemented various methods to control product quality as described in (Zhang, 2012), including consumer-oriented evaluation design, joint certification and third-party agencies. Consumer-oriented evaluation design refers to evaluation by customers based on the fit of both consumer needs and consumer feelings after receiving products. Joint certification refers to the certification and monitoring by third party agencies of both supplier and product material before they join the supply network.
Lastly, to build costumer trust, a study proposes the use of user-generated photographs to illustrate the product. User-generated photographs engender more trust in customers because these pictures can convey the quality and nature of products (Johnson *et al.*, 2015) and can also attract more bidders at online auctions than stock photographs, since user-generated photographs are less susceptible to manipulation by sellers.

4.4 Other Mechanisms

From the papers collected, we found other mechanisms that do not fit the three categories discussed so far. These mechanisms can help buyers to identify product quality and good sellers. The first mechanism is delivery services. High quality of delivery services supports customer satisfaction and trust in purchasing from e-marketplaces (Nurdani and Sandhyaduhita, 2016).

Another mechanism that can help buyers to identify product quality is the historical sales record (Ye *et al.*, 2013). This mechanism addresses a weakness of rating systems that do not represent the quality of particular products since sellers can sell a variety of product items. The quality of ratings might also be contaminated with inflation of low-priced products. Thus the historical sales record can be a credible signal for buyers about the quality of a specific product.

In addition, a similar mechanism is also found in (Ou and Chan, 2014): shop tagging and product tagging as indicators of product quality. These mechanisms refer to the number of web surfers who tag the shop and the products as favourite shop and products. Sellers who provide low-quality products have difficulty attracting attention from potential buyers in this way.

5 Desk Research Discussion

Following the literature review, we conducted desk research to assess whether and how the identified control mechanisms from literature have been applied in existing e-marketplaces in practice. We have selected e-marketplaces on two dimensions: first, we aim to have e-marketplaces which sell general products and e-marketplaces that sell handmade or craft products; and second, we aim to analyse both international and local e-marketplaces. Based on these dimensions, 8 e-marketplaces have been selected for this research: Alibaba, Amazon, Etsy, Tokopedia, Bukalapak, Inacraftmall, Batikmal and Kuka.

Table 2: E-marketplaces used in Desk Research

Products Category Sold in e-marketplace	Scale of e-marketplace	
	International	Local (Indonesia)
General Products	Alibaba, Amazon	Tokopedia, Bukalapak
Handmade	Etsy	Kuka, Inacraftmall, Batikmal

As can be seen in Table 3, most of the e-marketplaces have been implementing many types of control mechanisms. Table 3 also shows that the control mechanisms we derived from literature have been applied in most e-marketplaces. Yet, the number of transactions of handmade products remains lower than for general products. Possibly, the control mechanisms applied are not sufficient for selling handmade products. The results show that generic international marketplaces (e.g. Amazon, Alibaba) that also sell handmade products apply several control mechanisms. However, none of the e-marketplaces apply all mechanisms completely, as for instance reviews of products that Amazon provides are not provided by Alibaba.

Table 3: Control Mechanisms applied in several e-marketplaces

Dimension	Types of Control Mechanism	Types of E-marketplace							
		Local e-marketplace					International e-marketplace		
		I	II	III	IV	V	VI	VII	VIII
Trustwor-thiness	online credit card guarantees	√	√	√	-	-	√	√	√
	Escrow services	√	√	√	√	√	√	√	√
	privacy protection	√	√	√	-	√	√	√	√
	intermediary protection,	√	√	√	√	√	√	√	√
	third party guarantee	√	-	-	-	-	-		√
	third party trust seal	√	-	-	-	-	-		√
Reputati-on Systems	reviewer photos		-	-	-	-	-	√	-
	Reputation	√		-	-	√			√
	Online product review	√	√	-	-	√	√	√	-
	Rating	√	√	√	√	√	√	√	√
	Feedback	√	√	-	-	√	√	√	√
	Word of mouth	√	√	-	-	√	√	√	√
	Transaction History			-	-	√			√
Product	Product Information	√	√	√	√	√	√	√	√
	Product quality information	√	√	√	-	√	√	√	√
	Control quality product	-	√	-	-		√		√
	User-generated photo	√	√	-	-	√	√	√	√

Other Mechani -sms	Instant Messanger	√	√	-	-		√	-	√
	High Quality delivery services	√	√	√	-		√		√
	Historical sales record	√	√	-	-	√	√		
	Shop and product tagging	√	√	-	√	√	√		√
	Seller identity/ profile/			√	-				√
	Legal status of seller				-				√

Note:

I= Tokopedia
II= Bukalapak
III= Inacraftmall
IV= Batikmal
V=Kuka
VI=Etsy
VII= Amazon
VIII=Alibaba

6 Discussion

Brief desk research on the major international e-marketplace platforms shows that most of the mechanisms from the previous section have been applied in practice. However, reputational and social mechanisms, in particular, are less suitable for hand-made and artistic products since buyers are not expert enough to evaluate the product quality. Consequently, sales of handmade and artistic goods online are still low in number of transactions compared with the general products being sold in the e-marketplace. Hence, product information-related mechanisms, particularly, are promising in this specific context.

We find that for specialised e-marketplace platforms for handmade and artistic goods, for instance in the area of our follow-up study (Indonesia), most product information mechanisms are not yet being applied. We suggest that the following mechanisms warrant further study in the context of trustworthiness of sellers of handmade and artistic goods:

1. The use of user-generated photos that can build the trustworthiness of sellers and allow buyers to verify the products and quality descriptions.

These photographs have been shown to attract many bidders in online auctions (Johnson *et al.*, 2015), but have not yet been studied in the context of handmade and artistic goods.

2. Detailed Product Information (Meents and Verhagen, 2018) can reduce the risk for customers from uncertainty of information. For hand-made and artistic products, information might also describe the material, product specification and the method of production, to clearly explain the product and its production process. Such explicit, accurate information is likely to be a signal to buyers that sellers are dedicated and responsible, and will behave honestly throughout the transaction process.
3. A promise from sellers and service statements of additional after- sales service will serve as a warranty that the seller has competence, integrity and benevolence and could lead the customer to accept online shopping and to make purchases (Liu and Tang, 2018). For handmade and artistic goods, further study could examine matching the seller's statement and the product received or after sales services.
4. As explained in previous studies, reputation systems are effective as previous information about sellers and products. The use of reviewer's photo can influence buyers to accept the review quality of a product or seller and can lead to a purchase decision (Lee and Shin, 2014). The disclosure of the reviewer's identity can shape the judgment of product quality (Forman *et al.*, 2008). Future research can explore multiple attributes of the communication process such as communicator, message, channel and receiver. The use of reviewer photos can be applied to hand-made products: the reviewer's photo could be a role model for using the product and could affect the buyer's purchase decision.
5. Purchase history has a significant impact on the seller's performance (Ye *et al.*, 2013). This mechanism affects the perceived product quality of current items more than the seller's overall reputation rating or feedback score. However, this mechanism has a limitation as sellers can manipulate the transaction history by using fictitious accounts. This mechanism is not effective for well-known products since buyers already know the product quality. Many e-marketplaces have implemented this mechanism but it could be examined for handmade artistic goods.

6. A final mechanism to be examined by (Auinger *et al.*, 2016) is the trust seal as a recommendation from a third party. The study examines the impact of certain factors, namely the presence of a trust seal, contact of sellers, consumer positive-review, and negative consumer review on building trust from buyers. The study finds that only trust seals significantly influence trust.

Furthermore, the desk research showed that many control mechanisms have been applied in these e-marketplaces, but the number of handmade products sold out is low, which indicates that applying these control mechanisms is still not sufficient to build the trust of buyers vis-à-vis sellers.

7 Conclusion

In this section we get back to the research questions of the study and answer them. The questions are:

1. What control mechanisms that affect the trustworthiness of e-marketplace platforms have been discussed in existing literature?
   To answer this question, we have found papers that can be categorised into four themes:
   - Trustworthiness: institutional, experience and social mechanisms, such as escrow or warranty services
   - Reputation: online reviews, consumer feedback or word of mouth that complement information provided by sellers
   - Product and quality information: these mechanisms are information provided by sellers with reference to their products
   - Other mechanisms: we found other mechanisms that can build the trust include delivery services that can support customer satisfaction and trust in sellers of an e-marketplace, and use of the historical sales record and product tagging are also mechanisms that can be used as indicators of product quality.
2. How are control mechanisms applied in existing e-marketplaces where handmade and artistic goods are sold, whether local or international?
   The desk research shows that the implementation of control mehanisms

is still not sufficient to build trust of buyers vis-à-vis sellers for handmade products. These findings require further study in context.

3. Which trustworthiness issues in e-marketplace platforms have not been addressed, specifically in the context of handmade and artistic goods? We found six mechanisms which can address the issues that require further study in a context of artistic and handmade products, namely user-generated photos, detailed product information including the material and the method of production, promise and service statement of sellers, reviewers photo, purchase history and trust seal.

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Jumping, dumping, and pumping: Three mental principles for idea generation to activate software-based tools in business model innovation

DANIEL SZOPINSKI

Abstract Following the growing interest in business model innovation, software tools have shown great potential in supporting business model development and innovation. The highly creative task of business model innovation is, however, not effectively supported by software, and especially the cognitive processes involved in the generation of business model ideas have received little attention in software design-knowledge. Our study is the first to investigate how cognitive models can inform the development of creativity-enhancing functions to activate software-based tools in business model innovation. Specifically, we utilize three mental principles from cognitive psychology for the purpose of business model innovation. Cognitive stimuli can activate these mental principles and aid individuals by promoting perspectival changes for idea generation. This enables us to propose theoretical foundations for researching business model development tools to help practitioners and researchers in developing and evaluating software-based tools supporting innovating business models.

Keywords: • Business Model Innovation • Idea Generation • Cognitive Stimuli • Business Model Development Tool • Creativity Support System • Theory •

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1 Introduction

A business model describes the mechanisms of how a firm creates, delivers, and captures value to their customers (Teece, 2010), and as such is a cognitive model "that consists of concepts and relations among them that organize managerial understanding about the design of […] value-creation" (Martins et al., 2015, p. 105). It allows managers individually, and collectively, to innovate ways of doing business in their organizations (Baden-Fuller & Morgan, 2010; Massa et al., 2017). As successful innovation in general requires high-quality ideas (Kornish & Ulrich, 2014), so does the innovation of business models. Despite the importance of idea generation for business model innovation, prior research has largely neglected it (Schneider & Spieth, 2013), and in particular the creative aspect of business model idea generation is little understood (Martins et al., 2015). Thus, business model innovation is a cognitive as well as a creative task (Ebel et al., 2016; Eppler et al., 2011) and prior research has found that such tasks can benefit from being supported by software tools (e.g., Hender et al., 2002).

Given the creative nature of business model innovation and the success of paper-based tools like the Business Model Canvas (Osterwalder & Pigneur, 2010), software-based business model development tools (BMDTs) are seen as having great potential to support users in innovating business models (e.g., Ebel et al., 2016; Osterwalder & Pigneur, 2013; Veit et al., 2014). However, BMDTs are still in their infancy and a large part of their potential remains untapped. We found evidence of this in our systematic review of BMDTs in an earlier study where the software had been used merely as an electronic whiteboard (Szopinski et al., 2019). While these BMDTs have functions that, among others, allow to represent, share, annotate, and version business models, they fall short of those suggested by Lubart (2005) as being able to facilitate "the creative act through integrated human-computer cooperation during idea production" (Lubart, 2005, p. 365). Research lacks appropriate designs with which to purposefully evaluate the usefulness of different functions of BMDTs and – in the spirit of the Bled Manifesto 2017 – to enable researchers and practitioners to "implement novel technologies and change from traditional ways of doing business to new business models" (Bled eConference, 2017).

The study pursues three aims: first and foremost, it prepares the ground for a more theory-informed development of BMDTs with a particular focus on creativity-enhancing functions. Second, it contextualizes a cognitive model for business model idea generation. Third, it applies three mental principles derived from previous literature on general IT-based cognitive stimulations tools to BMDTs. In so doing, the study responds to calls and scholarly and practitioners' interests by addressing the following research question: How can cognitive models inform the development of creativity-enhancing functions to activate software-based tools in business model innovation?

2 Theoretical background

2.1 Business Model Development Tools (BMDTs)

Software-based tools for business model development are a new class of software that has been credited with great potential for supporting users in innovating business models (e.g., Ebel et al., 2016; Osterwalder & Pigneur, 2013; Veit et al., 2014). The potential of software-based tools to support creative tasks has been recognized in the information systems discipline for the purpose of developing not only business models, but also strategies and products (e.g., Schneider & Spieth, 2013; Kawakami et al., 2015; Kaplan, 2011). Some studies have started to explore functions that support business model innovation activities very early on in the development of BMDTs, but these functions remain at a basic, secretarial level of creativity support systems (Chen, 1999; Young, 1987), as they offer no functionality beyond that of an electronic whiteboard. One notable exception to the basic level of existing BMDTs is a decision support system for business model validation developed by Dellermann et al. (2018). Another is a BMDT which explicitly focuses on business model idea generation and implements pre-filled business models (by means of so-called solution-based patterns) to avoid idea generation having to be started from scratch (Athanasopoulou & De Reuver, 2018).

What is missing from the current literature is a theoretical foundation that enables the theory-driven implementation and evaluation of BMDTs in current and future research projects. This lack of knowledge is problematic in two respects: First, practitioners developing BMDTs lack guidance on how to implement creativity-enhancing functions. Second, researchers implementing and evaluating

BMDTs have no prescriptive (i.e., design-relevant) knowledge on the usefulness of such functions. Before the full potential of BMDTs can be realized, and BMDTs can further be developed into fully-fledged creativity support systems (e.g., Shneiderman, 2002) it is important to first address both of these gaps. The goal of this study, then, is to transfer knowledge from creativity support systems research to business model research. Thereby, this study prepares the ground for activating the next stage of the development of BMDTs for the best possible support of users who generate business model ideas by means of a software-based tool.

2.2 Search for Ideas in Associative Memory (SIAM)

Individuals search their memory for existing knowledge when trying to generate ideas (Ward, 2004). The complex, ill structured, and/or wicked nature of such creative tasks also applies to the generation of business model ideas. Business model innovation requires individuals to cognitively explore different potential business model ideas in uncertain, fast-moving and unpredictable market environments (Bojovic et al., 2018). Individuals will search their memory for relevant knowledge, such as about business models, which they may have experience of, either as a customer or as a developer.

The *Search for Ideas in Associative Memory* (SIAM) model provides a theoretical foundation for studying the research question. It has been used to elucidate the effects of other software-based cognitive stimulation tools (e.g., Knoll & Horton, 2011; Althuizen & Reichel, 2016). Two different memory systems constitute SIAM from which individuals can retrieve knowledge: long-term memory and working memory. Whereas long-term memory is permanent and has unlimited capacity, working memory is temporary and has limited capacity. SIAM posits that knowledge is structured in form of a highly interconnected multi-level network of images which in turn are composed of concepts as well as relations that link images and concepts (see Figure 1). These images build a network of knowledge that is characterized by fuzzy boundaries, overlapping parts and mutual associations (Knoll & Horton, 2011). To contextualize business models as cognitive models (Baden-Fuller & Morgan, 2010; Martins et al., 2015) we employ the Business Model Canvas (Osterwalder & Pigneur, 2010) in this study. Not only is its knowledge widely recognized by researchers and practitioners alike, but its nine components can also be considered as constituting a cognitive network of knowledge. In the sense of the SIAM model, images of an individual's associative memory (see circles in Figure 1) represent the nine components of the Business Model Canvas. Correspondingly, the images (see squares in Figure 1) represent the sticky notes that are often used to describe the individual characteristics of the components of a specific business model. The lines connecting images and concepts represent the relation between them, and the different widths of the lines their frequency (see lines in Figure 1). The widths of the connecting lines vary for different reasons such as the frequency of a line's traversal (e.g., not all business models necessarily need to have key partners, but nearly all have revenue streams), the relatedness of certain images (e.g., the components customer segments, channel, and customer relationships are often thought about together) or whether it is a more traditional, common relation (e.g., for the continuity of revenue streams, many business models use subscription fees). Together, these images, concepts and links form the mental representation of a specific business model.

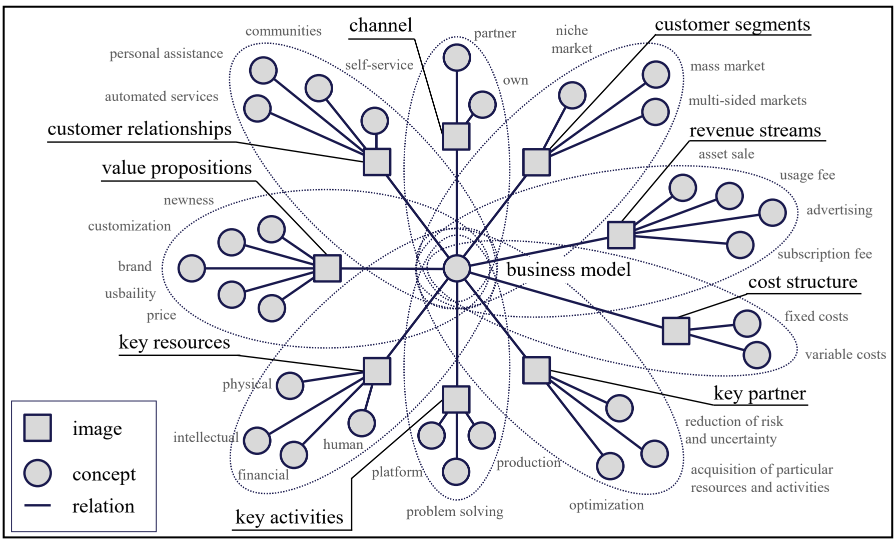

Figure 1: Network of knowledge based on Knoll and Horton (2011) applied to the context of business model innovation using the Business Model Canvas (Osterwalder & Pigneur 2010).

There are two phases in SIAM which describe the idea generation process of an individual: a knowledge activation and an idea generation phase (Nijstad & Stroebe, 2006). In the former, individuals activate and retrieve relevant existing knowledge from long-term memory by temporarily transferring knowledge from long-term memory to working memory. Which knowledge will be activated and retrieved depends on the search cues applied (e.g., knowledge already activated in working memory, previously generated ideas, understanding of the problem etc.). In the latter phase, individuals make use of knowledge now available in working memory (i.e., by applying images to a new domain) and recombine it in novel and unusual ways (i.e., by forming new relations between images). Knowledge that is already transferred to working memory is likely to be used again for idea generation. Applied to the context of business model innovation, an individual evokes the concepts of the image "business model". After transferring the image to working memory, an individual can then recombine related concepts and images with one another. Over time, individuals increasingly combine images that have already been employed for idea generation and thus business model ideas increasingly resemble each other. Thus, creating business model ideas tends to leverage the solution space only to a limited extent and mostly within the existing knowledge networks. To counteract this tendency, creativity-enhancing functions in BMDTs can be consciously used to transfer new knowledge to working memory and thus enable new (re-)combinations to be made. For BMDTs, however, it has not yet been researched whether, which, and when creativity-enhancing functions are particularly helpful. Regardless of how such creativity-enhancing functions are implemented, the additional knowledge thus elicited will be temporarily transferred to working memory and, through application and recombination, becomes available for the generation of creative ideas. Furthermore, creative tasks usually have a tremendously broad solution space as there is typically an extremely large number of alternative potential solutions. It is important to note that stimuli do not aim to make users search the entire solution space, but only a larger range of alternative potential solutions (see Figure 2). The key issue here is that, in order to be truly innovative – and hence successful – business models typically do not follow established traditional value creation, value delivery, and value capturing mechanisms (Chesbrough, 2010). For this reason, the purpose of creativity-enhancing functions in BMDTs is to get individuals to consider and explore non-traditional and unusual business model components.

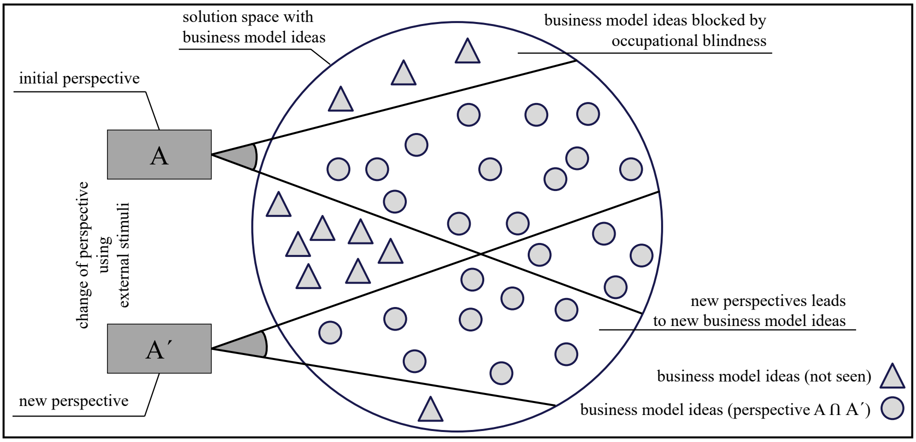

Figure 2: Change of perspective based on Knoll and Horton (2011) applied to the context of business model innovation using the Business Model Canvas (Osterwalder & Pigneur 2010).

2.3 Illustrative example: Netflix's business model

In the following, we briefly elaborate on the business model of Netflix, a firm that has used business model innovation consciously and successfully over the past years and is well known for its streaming service available in almost all countries across the globe (Abraham, 2013; Weill & Woerner, 2013; Gomez-Uribe & Hunt, 2016). In the remainder of this study, we will refer to Netflix's business model for illustration. When reading the illustrative examples, please be aware that in hindsight, business model innovation seems obvious and perhaps even trivial. It is, however, the very nature of successful business model innovations to create, deliver and capture value to customers in ways they adopt apparently seamlessly, but at the time of innovating its business model, the changes that Netflix brought about were not at all predictable. Indeed, by blurring the boundaries between television and cinema and introducing on-demand media programs (i.e., those that do not follow a schedule), its business model was seen as highly innovative and disruptive.

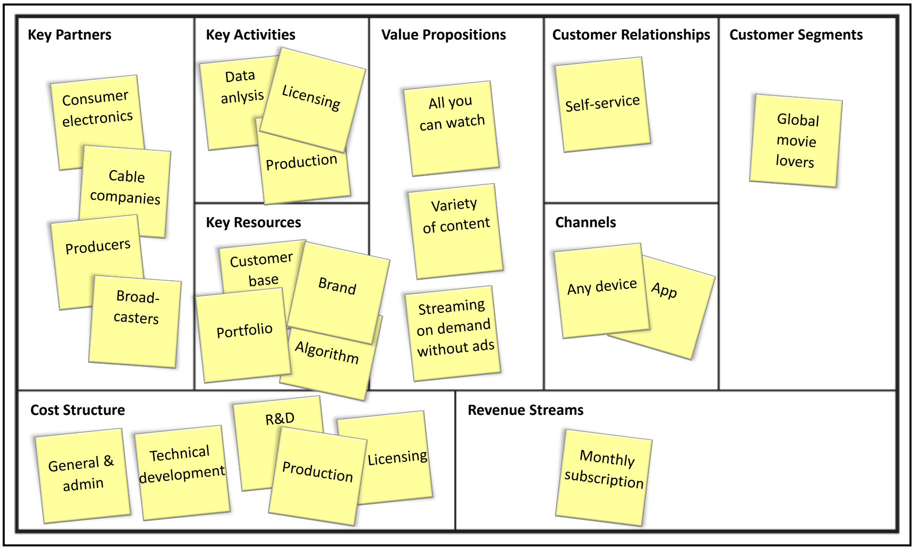

Figure 3: The Business Model Canvas for Netflix

Netflix initially started with an offline rental service and sent movies on DVDs through a postal service, before innovating its business model multiple times, each time changing its components. In this way, Netflix introduced non-established and unusual mechanisms into the movie rental industry. For example, it replaced pay-per-use by a monthly subscription (revenue stream), introduced on-demand streaming (value proposition), significantly extended the variety of content (value proposition), invented algorithms for their recommender system based on a data-driven analysis of customer needs, which pro-actively suggests movies (key resource), improved accessibility by allowing customer to use different devices (channels), and in a more recent development, even started producing films itself (key activity) (Abraham, 2013; Weill & Woerner, 2013; Gomez-Uribe & Hunt, 2016).

3 Mental principles

Grounded in cognitive psychology, the SIAM model provides a theoretical basis for researching why individuals often leverage the solution space only to a limited extent and think primarily within bounded areas of their knowledge networks. As already explained, the likelihood for generating creative ideas decreases when no new knowledge is transferred from long-term memory to working memory. External stimuli can help to activate and retrieve new knowledge and thereby increase the likelihood of generating creative ideas by allowing individuals to consider new images and corresponding concepts as well as setting up new relations among images and concepts. Based on the fact that such external stimuli can be used deliberately (Althuizen & Reichel, 2016), this study seeks to contribute a theoretical basis for implementing creativity-enhancing functions in software-based tools for business model innovation by introducing external stimuli. In a systematic review, Knoll and Horton (2011) identify and analyze more than 100 idea generation techniques that make use of external stimuli in a great variety of ways and derive three underlying mental principles. All three have in common that they support individuals in — as Knoll and Horton (2011) call it — changing perspectives. Such perspectival changes aid individuals to leverage the solution space to a larger extent by guiding them to different areas of their knowledge networks and establish unexpected and new connections to be made between images. As has been pointed out before, the ability to think outside the box and overcome occupational blindness is an important prerequisite for business model innovation.

In the following, we briefly describe the three mental principles and contextualize them for the creative task of generating business model ideas. For this, we first textually explain the underlying cognitive mechanism of each mental principle based on the previously introduced SIAM model. Second, we present the formal sequence of steps of each mental principle identified by Knoll and Horton (2011) and provide a context-specific application for business model innovation (highlighted in italics). Third, we visualize an example of each mental principle in the SIAM model, with examples borrowed from Netflix's business model.

3.1 First mental principle: Jumping

By jumping, an individual employs a mental principle that "refers to a cognitive mechanism called analogical thinking, in which the individual transfers information from different situations and uses it to generate new ideas" (Knoll & Horton, 2011, p. 93). The authors distinguish between random (task-unrelated) and analogous (task-related) "jumping", in our case the task being business model idea generation. For example, one typically "jumps" when applying value creation, delivery, and capturing mechanisms from other industries, e.g., by using business model patterns.

Applied to Netflix's business model, a formal sequence of steps for task-related jumping (Knoll & Horton 2011) involves:

1. Selecting a characteristic attribute of the creative task.
   A firm sells products/services on a daily basis.
2. Finding an analogous situation with the same attribute.
   A newspaper sells its issues on a daily basis.
3. Imagining how the task might be solved in this analogous situation.
   In order to get recurring revenue streams, the newspaper offers its customers subscriptions that are cheaper in total than the individual purchase of issues.
4. Generating ideas by applying a solution to the creative task.
   Netflix replaced pay-per-use (i.e., individually purchase each movie) by a monthly subscription.

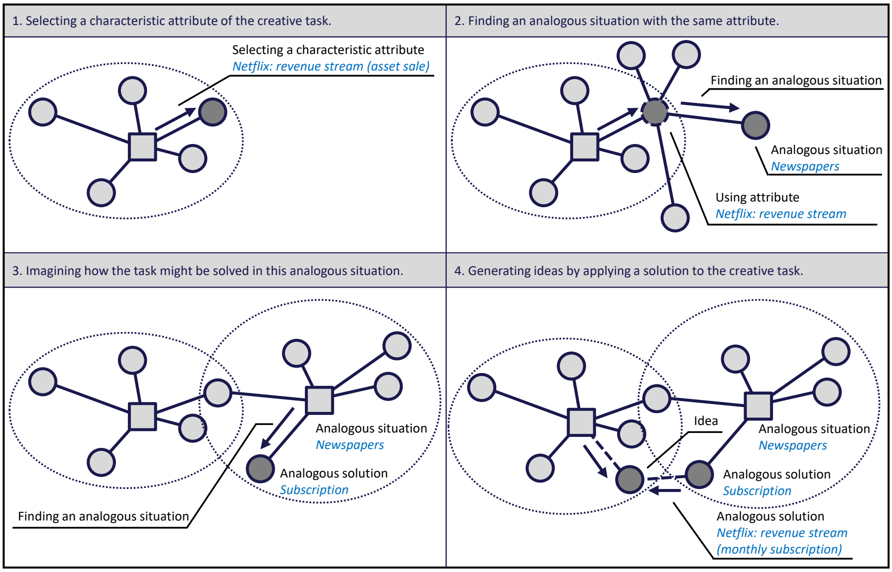

Figure 4: Mental Principle Jumping Using Task-Related Stimuli

Applied to Netflix's business model, a formal sequence of steps for task-unrelated jumping (Knoll & Horton 2011) involves:

1. Selecting a random element.
   Harry Potter.
2. Selecting a characteristic attribute of the random element.
   Harry Potter is able to read somebody's mind, as if by magic.
3. Selecting a characteristic attribute of the creative task.
   In order to be able to read customers' minds, Netflix invented a personalization algorithm as key resource of its business model. Netflix wants to be able to read customers' minds to personalize its value proposition.
4. Generating ideas by combining these attributes.
   Netflix introduced a personalization algorithm as key resource of its business model. The algorithm takes the individual customers' viewing habits, most watched movie genres and actors into account. The algorithm is not only used for the recommendation of movies, but also to provide customers' personalized thumbnails for suggested movies.

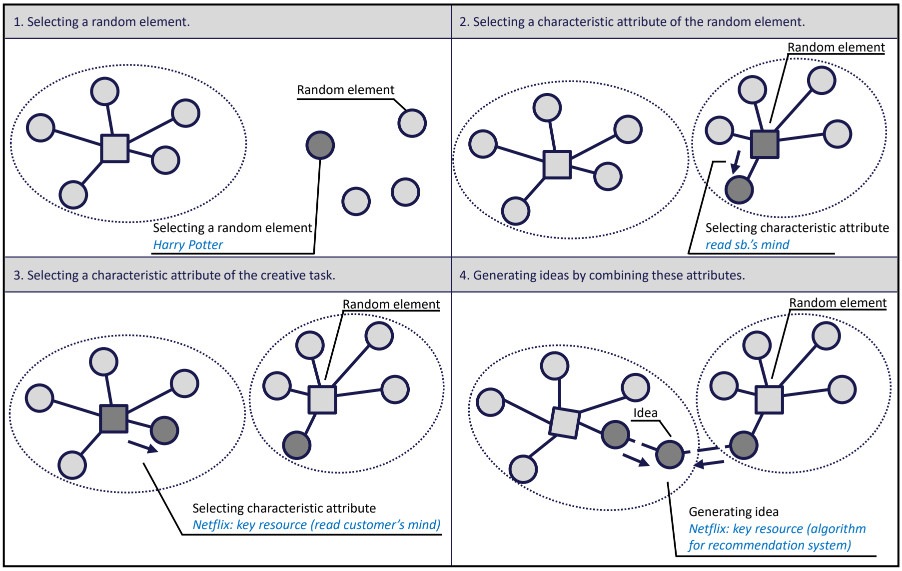

Figure 5: Mental Principle Jumping Using Task-Unrelated Stimuli

3.2 Second mental principle: Dumping

By dumping, an individual employs a mental principle that discards "assumptions contained in the creative task to generate a new perspective on the creative task" (Knoll & Horton, 2011, p. 97). Here, the external stimuli aim to question existing relations between images and concepts. As an individual focuses on one particular attribute, external stimuli are task-related. For example, one typically "dumps" the assumption that customers care about ownership of a product when generating business model ideas for the sharing economy. Usually, this kind of business model requires questioning the importance of ownership and focuses on the provision and exchange of services instead.

Applied to Netflix's business model, a formal sequence of steps for dumping (Knoll & Horton 2011) involves:

1. Selecting a characteristic attribute of the creative task.
   Customers watch movies mainly on big screens.
2. Challenging the characteristic attribute of the creative task.
   Customers watch movies also on small screens.

3. Finding consequences that result from the challenge attribute.
   Customers should be able to stream movies not only on big screens like TVs, but also on small screens such as notebooks, tablets and mobile phones.
4. Generating ideas by applying this consequence to the creative task.
   Netflix supports streaming movies on a wide range of big and small screens.

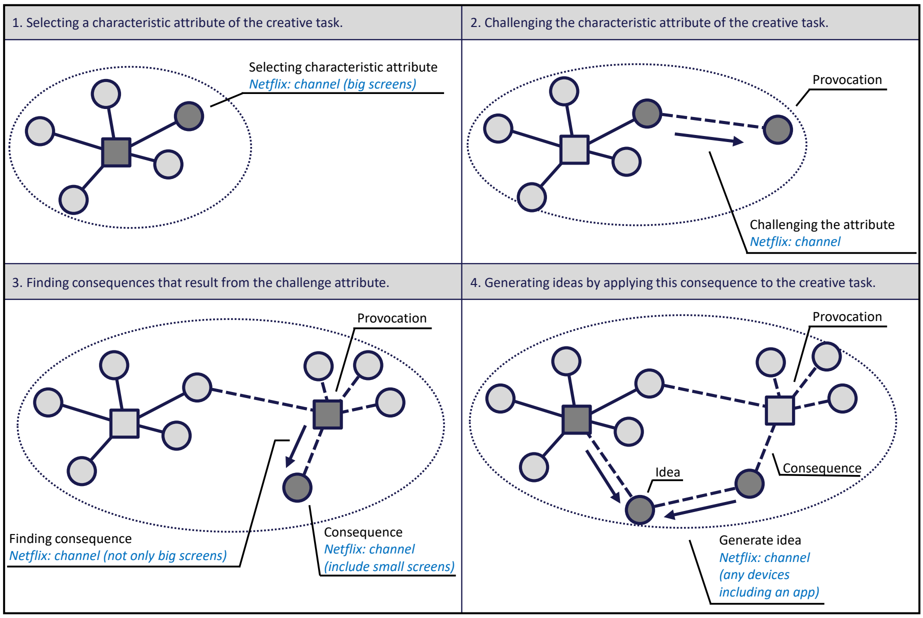

Figure 6: Mental Principle Dumping

3.3 Third mental principle: Pumping

By pumping, an individual employs a mental principle that "refers to a cognitive mechanism called application, the adaptive use of existing knowledge in its habitual context to generate new ideas." (Knoll & Horton, 2011, p. 99). For example, one typically "pumps" when going through alternatives of a particular component of a business model (e.g., to explore possible applications and usage scenarios of a technology as key resource in the context of a particular business model). External stimuli are used here to change the focus of the idea generation process to associate specific concepts within the image of a business model. For this purpose, for example, taxonomies have already been developed for various domains that present typical characteristics of specific components in industry-specific business models (i.e., possible concepts to images).

Applied to Netflix's business model, a formal sequence of steps for pumping (Knoll and Horton 2011) involves:

1. Selecting an aspect of the creative task to focus on.
   A business model's value proposition: Variety of content.
2. Repeatedly select a characteristic aspect of the previous step until it inspires an idea.
   Increase variety of content by purchasing broadcasting rights for television series.
   Increase variety of content by purchasing broadcasting rights for cinema movies.
   Increase variety of content by purchasing broadcasting rights for regionally (i.e., in certain countries) successful movies, synchronize them into English and offer them worldwide.
3. Writing down the idea for solving the creative task.
   Netflix becomes a producer and produces its own series, documentaries and movies.

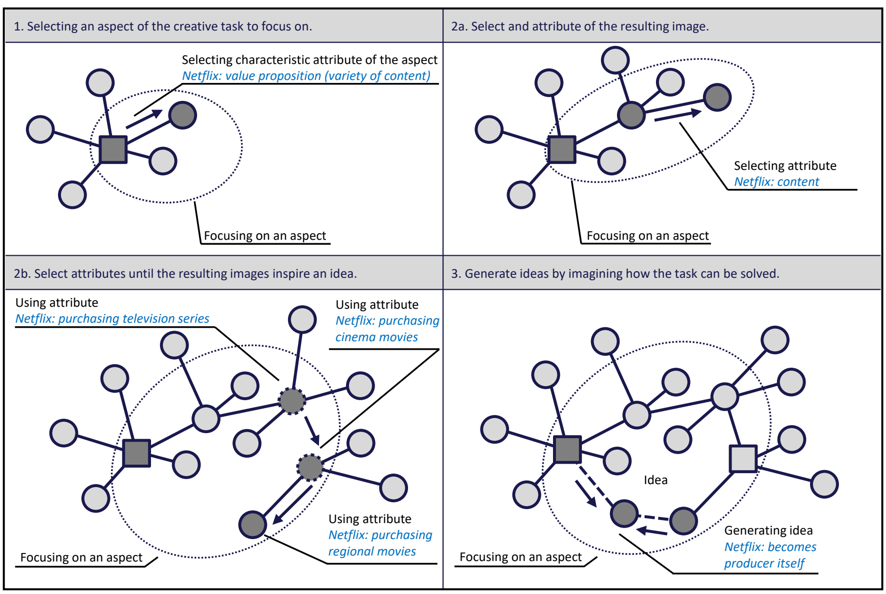

Figure 7: Mental Principle Pumping

4 Discussion and conclusion

This study aims to lay the foundation for a new stream of research by bringing together three different disciplinary perspectives for the study of idea generation in the context of software-based tools for business model innovation: a cognitive perspective, a creativity support systems perspective, and the business model perspective. In so doing we are bridging research silos as well as preparing the ground for further research. From a cognitive perspective, by applying SIAM to the Business Model Canvas, we are able to describe the process whereby individuals retrieve business model knowledge and how this process could be enhanced for the purpose of more creative idea generation, potentially leading to more innovative business model ideas. We are suggesting that stimuli can be used as part of a BMDT, as they would enable individuals to increase their available contextualized network of knowledge by combining related and unrelated business model knowledge in novel and unusual ways. The role of stimuli in the BMDT is to trigger a change perspective in individuals while they are engaged in the complex, ill-structured, and wicked challenge of business model idea generation. Our study makes several theoretical contributions. Cognition research benefits from an additional field of interest for the application of SIAM, which emphasizes its wider applicability. From a creativity support systems perspective, applying and contextualizing the three mental principles conceptualized by Knoll and Horton (2011) contributes to the future development of creativity-enhancing functions in BMDTs. The underlying mechanisms of how individuals can be cognitively stimulated while generating business model ideas can help researchers to build and evaluate software-based tools for business model innovation – in the sense of the design science research paradigm. Functions described in the creativity support systems literature are often abstract and require being translated to a particular context. For example, Shneiderman (2002) spans a broad range of generic functions that creativity support systems possess, including: to collect (search and browse information and existing examples), to relate (consult peers and mentors), to create (explore possible solutions), and to donate (disseminate results). The three mental principles by Knoll and Horton (2011) (Jumping, Dumping and Pumping) can form the starting point for formulating functions that promote creativity for business model innovation in software-based tools which lie at the interface between creativity research and computer science (Shneiderman, 2002). From a business model perspective, this study seeks to promote a theory-driven approach to the development and evaluation of BMDTs. In so doing it would bridge the research gap between the great potential of BMDTs – which is well-established in the field of IT-based cognitive stimulations tools – and the comparatively young research on business model innovation. By introducing a cognitive model and describing examples of the application of its three mental principles to business model innovation, this study aims to provide a theoretical foundation for the further development of creativity-inducing BMDTs.

This brings us to the limitations of this study. Whilst it suggests a foundation for the future exploration of creativity-enhancing functions in BMDTs, our study does not itself investigate any specific function. Furthermore, this study introduces three mental principles to business model innovation, but without explaining how creativity-enhancing functions could be implemented in BMDTs to support individuals in generating business model ideas. One key challenge for the future development of BMDTs would be to develop rigorous experimental designs with which to evaluate the usefulness of certain creativity-enhancing functions. The next challenge would be to determine what usefulness actually means. Whilst the obvious gold standard is higher firm performance, it would be hard to measure whether a function has directly or indirectly contributed to this outcome, not only because the outcome is invariably long term, but because of the almost impossible task of tracing back such an outcome to a BMDT, let alone to one of its functions. Research on strategy tools faces the same challenge and has proposed to use more immediate outcomes, such as the degree to which a tool provokes exploration (Jarzabkowski & Kaplan, 2015). Likewise, BMDT researchers need to derive a set of outcomes for measuring performance when evaluating BMDTs (e.g., in terms of the quality of a business model idea). For example, perceived creativity (Eppler et al., 2011), willingness to adopt a business model (Eppler et al., 2011), and the evaluation of business model ideas using the Consensual Assignment Technique (Amabile, 1982), in which proven experts come to a joint verdict about the quality of the generated ideas.

With this study, we seek to lay the theoretical foundation for the development of creativity-inducing BMDTs. Its purpose is not only to directly improve BMDTs, but also to indirectly improve research on how to generate business model ideas which in turn will help firms to innovate their value creation, value delivery, and value capturing mechanisms.

Acknowledgments

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A theoretical framework for research on readmission risk prediction

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Abstract On the one hand, predictive analytics is an important field of research in Information Systems (IS); however, research on predictive analytics in healthcare is still scarce in IS literature. One area where predictive analytics can be of great benefit is with regard to unplanned readmissions. While a number of studies on readmission prediction already exists in related research areas, there are few guidelines to date on how to conduct such analytics projects. To address this gap the paper presents the general process to develop empirical models by Shmueli and Koppius (2011) and extends this to the specific requirements of readmission risk prediction. Based on a systematic literature review, the resulting process defines important aspects of readmission prediction. It also structures relevant questions and tasks that need to be taken care of in this context. This extension of the guidelines by Shmueli and Koppius (2011) provides a best practice as well as a template that can be used in future studies on readmission risk prediction, thus allowing for more comparable results across various research fields.

Keywords: • Readmissions • Predictive analytics • Prediction process • Healthcare • Framework •

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1 Introduction

Hospital readmissions, especially unplanned readmissions are an important quality measure in healthcare, as they can indicate issues around treatments, rehabilitation and/or discharge management. Moreover, readmissions are often associated with increased costs resulting from penalties and regulations enforced by policy makers and insurers. At the same time, the increasing availability of healthcare data leads to an uptake in predictive analytics research conducted in the healthcare sector. The identification of patients at high risk of readmission is a significant issue in this context. The main motivation behind this research area is to identify patterns that can help to unravel high-risk patients to allow for timely interventions. The starting point of these interventions lies in the screening of individuals at high risk of discharge failure (Scott, 2010). By identifying high-risk patients, hospital resources can be allocated accordingly and interventions and discharge planning can be adapted. Multiple factors associated with a higher risk of readmission have been identified in research, including health factors (e.g., co-morbidities (Kumar et al., 2017; van Walraven, Bennett, Jennings, Austin, & Forster, 2011), social factors (e.g., marital status (Hasan et al., 2010)), clinical factors (e.g., hospital utilization (Shadmi et al., 2015)), length of stay (Heggestad, 2002)) or effective discharge management (Ohta, Mola, Rosenfeld, & Ford, 2016).

Determining the risk of readmission is an imperative and highly complicated task, relying on different risk factors for various health conditions. While some studies propose general risk scores (Donzé, Aujesky, Williams, & Schnipper, 2013; van Walraven et al., 2010) applicable for all kinds of diseases, research shows significant variation in risk factors for different health conditions. Thus, to be able to accurately predict patients at high risk of readmission, individual prediction models for different health conditions should be preferred. Even though there are a number of studies dealing with this phenomenon, currently no theoretical framework exists to guide these kinds of research projects. This leads to the issue that studies on readmission risk prediction often disregard key characteristics for this prediction task. Also, results from different studies are often difficult to compare and thus unsuitable to generalize best practices. This study proposes a theoretical framework to guide studies on readmission risk prediction by providing a structured overview of relevant definitions, tasks and questions that need to be taken care of in this context. To identify these steps previous studies are analysed to identify project characteristics specifically for hospital readmission prediction.

2 Theoretical and conceptual background

2.1 Readmissions in hospitals

While there is no standard definition for readmissions available, they can be broadly described as "a second admission to a hospital within a specified period after a primary or index admission" (Kristensen, Bech, & Quentin, 2015, p. 265). For each healthcare system, criteria concerning the index admission and the second admission to account as a readmission as well as the considered time frame, have to be defined. These criteria can include clinical characteristics (e.g., diagnosis), demographics (e.g., patient age), type of the admission (e.g., elective or emergency) or the treatment facility (Kristensen et al., 2015). To determine the applicable time frame, readmission days are counted from the discharge date of the index admission until the admission date of the second admission. Consequently, a readmission is defined by the relation between two admissions and the time frame in between. There is no international consensus considering the specified period between admissions. The time frame varies among studies from 14-day to 4-year with the most common being 30-day readmissions (Kansagara et al., 2011).

2.2 Predictive analytics

Predictive analytics methods are used in a variety of application fields to extract patterns from historical data to create empirical predictions as well as methods for assessing the quality of those predictions in practice (Shmueli & Koppius, 2011). Predictive analytics are part of data mining, which aims at deriving models that can e.g., use patient-specific information to predict a specific outcome. As opposed to descriptive models that aim to identify human-interpretable patterns and associations in existing data based on pre-defined attributes, predictive analytics tries to foresee outcomes or classifications for new input data using a special response variable, thus the classification (Bellazzi & Zupan, 2008).

Shmueli and Koppius (2011) present a general approach for conducting predictive analyses. They postulate that in general, predictive analyses consist of two components: First, the empirical predictive model, such as statistical methods or data mining algorithms and second, methods that evaluate the predictive power of a model. The latter refers to the ability of a predictive model to accurately represent new observations. The explanatory power, in turn, is related to the strength of the association induced by the statistical model (Shmueli & Koppius, 2011). Figure 1 illustrates the general process steps, which are carried out for the creation of all empirical models. The individual tasks in this process, however, differ extensively when developing an explanatory or predictive model. For example, while explanatory models investigate the explanatory power of their identified relationships (e.g., theoretical coherence, strength-of-fit, statistical significance), predictive models assess the predictive accuracy of a model, e.g., using cross-validation or split-validation measures. The individual modelling steps as proposed by Shmueli and Koppius (2011) guide the development of the readmission prediction framework presented in this paper.

Figure 1: Process to build an empirical model (Shmueli & Koppius, 2011)

2.3 Imbalanced data

A major concern in predicting readmissions is the occurrence of imbalanced data. Imbalanced data, also known as skewed data, has a strong unequal distribution of the minority and majority classes (Sun, Wong, & Kamel, 2009). In the case of hospital readmissions, this is especially true for unplanned readmissions, as rates usually vary between 1.1 to 6.7 % (Kreuninger et al., 2018). The main issue with handling imbalanced data is that traditional classifiers tend to perform best with an equal class distribution while the relevant information from the minority class might be overlooked with regards to the majority class (Sun et al., 2009, 2009). There are a number of different approaches to handle imbalanced data (Nitesh Chawla, 2005; Galar, Fernandez, Barrenechea, Bustince, & Herrera, 2012; He & Garcia, 2009; Kotsiantis, Kanellopoulos, & Pintelas, 2006; Longadge & Dongre, 2013; Sun et al., 2009), the most popular being sampling or ensemble techniques (Haixiang et al., 2017).

Sampling

Two main sampling approaches can be differentiated, namely oversampling and undersampling. Undersampling reduces the entities from the majority class, while oversampling creates additional entities of the minority class (Galar et al., 2012; Kotsiantis et al., 2006). A variety of sampling approaches are available to reach this goal, the most prominent being random over- and undersampling, informed undersampling, synthetic minority oversampling (SMOTE), adaptive synthetic sampling, sampling with data cleaning, and cluster-based sampling methods (He & Garcia, 2009). From the variety of over- and undersampling methods presented in literature (Galar et al., 2012; Haixiang et al., 2017), random undersampling (RUS) is still one of the most commonly applied undersampling techniques (Haixiang et al., 2017). In RUS, entities of the majority class are randomly removed to reduce the data imbalance (Galar et al., 2012). The most commonly used oversampling technique is SMOTE and its derivations (Haixiang et al., 2017). The SMOTE process is introduced by Chawla et al. (2011; 2003). For each entity of the minority class, the k-nearest neighbours are identified; after this, a distance vector from the minority entity to its neighbours is calculated. By randomly multiplying the vector with a number between 0 and 1, SMOTE creates a new data entity, which is added to the training data.

Ensemble learning

Hybrid methods of predicting imbalanced data include cost-sensitive learning and ensemble learning. Cost-sensitive learning follows the approach of manipulating the algorithm to weight the minority class higher and improve classifier performance. Cost-sensitive approaches have the downside that the actual costs of misclassification must be known (Sun et al., 2009). Another issue in readmission prediction as pointed out by Kansagara et al. (2011) is the poor performance of individual classifiers. Ensemble methods counter this issue by combining multiple classifiers into one classification system to produce a higher accuracy than achieved by its individual components (Galar et al., 2012). Ensemble learning can either be performed by combining different classifiers or by applying variations of the same classifier (Haixiang et al., 2017). Two main approaches that can be differentiated are bagging and boosting. Bagging, which is short for bootstrapped aggregating, is introduced by Breiman (1996) and combines several base classifiers into one classifier. In the first step, data subsets are sampled from the training data. The bagging approach bootstraps the data to create several different bags. Bootstrapping means that random samples are added to the subset until the subsets have the same number of entities as the training data. This leads to intended duplicates in the subsets. Next, for each of the bags, the base classifier is trained and applied to the application set. Subsequently, the differently trained classifiers vote as to which class a new entity belongs, and a majority vote of the classifiers determines in which class the observation fits best. A prominent bagging method are RandomForests, which combine individual decision trees into a single classifier. In boosting, the training set is again split into k subsets. The model building, however, is done sequentially as opposed to the independent training for bagging models. Here, a weight is set for each data element, where misclassified examples increase their weight for the subsequent training round. In addition, a weight is set for each classifier dependent on its individual error rate. Thus, a weighted vote from all classifiers is used for the prediction of a new example (Quinlan, 1996). The most prominent boosting method, AdaBoost (adaptive boosting) (Freund & Schapire, 1997) is based on the principle of boosting introduced by Schapire (1990) and uses the base principle of improving the algorithm in every iteration to achieve a higher performance. Here, the base classifier is applied to the entire training data set. Next, AdaBoost calculates the error rate for each individual sample and adds it to the data. In the next iteration, the algorithm selects the training data by considering the assigned weight to give misclassified samples higher attention. After each iteration, AdaBoost weights the models according to accuracy.

3 Framework development

3.1 Goal definition and study design

As a first step in any prediction project, the analysis goal has to be defined. While the main objective is to predict patients at risk of readmission to the hospital, the specific terms and criteria to successfully reach this goal need to be defined, namely the *type of prediction*, the interpretation of a *high-risk patient* as well as the parameters for an episode to count as a *readmission*.

Prediction: In supervised learning, two types of prediction tasks can be differentiated, namely classification and regression. Classification aims at predicting discrete values, i.e. predefined categories or classes, whereas regression provides continuous values. In the task of readmission prediction, a categorical value, hence a classification approach, is required. At the highest level, a dichotomous differentiation between readmitted and non-readmitted patients is chosen. If necessary, the classes can be extended to further distinguish the time of readmission (e.g., early versus late readmissions) in a specified time frame, they can be separated by the reason for readmission (e.g., complications or corrections) or the level of risk (e.g., low risk, medium risk, high risk). The main issue for each of these cases is the prior classification of examples in the historical dataset that has to be aligned with the goal of the analysis task. In the case at hand, the main goal is to find out, whether a patient will be readmitted or not. Thus, a binary variable reflecting either 1 (readmission) or 0 (no readmission) is chosen as the classification target.

High-risk: The binary distinction can further be extended by considering the probability of class memberships. This way, prediction models cannot only specify, whether a patient belongs to the predicted readmission group or not, but also the probability of belonging to a group can be determined. The lower the threshold for a required class membership is set, the more risk patients can be identified. On the other hand, this also increases the likelihood of false positives. If the costs for a false positive prediction or a false negative prediction are known, weights can be specified accordingly. The concrete value of wrong predictions, however, is difficult to determine and poses a major challenge in readmission prediction. Costs for a prolonged length of stay or intervention programs can be used as approximations (Jamei, Nisnevich, Wetchler, Sudat, & Liu, 2017).

Readmission: Another issue in readmission prediction lies in the basic definition of the readmission episode itself. Readmissions are commonly differentiated between planned or unplanned readmissions and related or unrelated to the index admission (AHA, 2011). While the identification and prediction of readmissions should primarily focus on unplanned, related readmissions, it is often difficult to assess the relationship between admissions. Also, planned readmissions are often not documented within hospitals and therefore exacerbate the distinction of unplanned readmissions. Besides the admission intent, some studies also differentiate between avoidable and unavoidable readmissions (van Walraven et al., 2011; van Walraven, Wong, & Forster, 2012). The proportion of avoidable readmissions in that context and the underlying criteria to determine whether they are indeed avoidable varies strongly between studies. For example, van Walraven et al. (2011) suggest a median proportion of around 27 % of readmissions to be avoidable, or similarly van Galen et al. (2017) propose 27-28 % be at least predictable.

To specify which episodes qualify for this definition, a variety of factors, including the timespan between admissions and the reasons for readmission have to be clarified. The timeframe can be selected based on regulations at a country or hospital-level or adhere to protocols by insurers. The reasons for readmission to be related to the index admission are highly dependent on the episodes under study. If certain diagnoses or procedures are investigated, the most common diagnoses for readmissions can be identified apriori and categorised into the presented scheme for readmissions (AHA, 2011). This task requires sufficient domain knowledge to undertake the classification for a specific procedure or diagnosis group. Alternatively, existing guidelines or regulations by insurers or governments can also be used.

3.2 Results

The data preparation process covers various steps of cleaning, visualising and reducing the available dataset in order to be suitable for the subsequent analysis. This includes dealing with missing and inconsistent data as well as creating and selecting appropriate features. To get a better understanding of the underlying data and identify noise, exploratory analysis and simple visualizations of the dataset are conducted. Figure 2 gives an overview of the individual steps that are taken to develop the appropriate feature sets in the following sections.

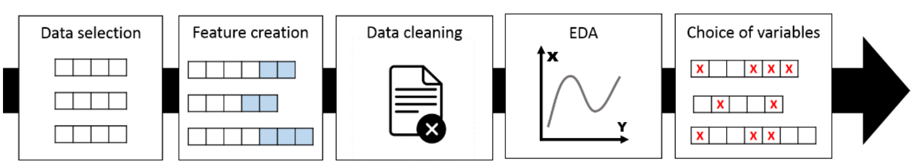

Figure 2: Data preparation steps

Data selection

As a first step, data is filtered to only include relevant admissions for the prediction task. It is imperative that the prediction model is trained on the data of the admission episodes that might have led to a readmission, not on the readmission episodes. The following criteria are important for each episode to remove irrelevant data points accordingly:

- The patient is admitted to acute care.
- The patient did not die during or after the hospital stay.
- The patient did not leave the hospital at his/her own risk.

Feature creation

To complement the data set with further relevant attributes, the availability of the identified risk factors from previous studies is assessed for each procedure group. Based on the insights from systematic reviews by Kansagara et al. (2011) and Zhou et al. (2016) relevant attributes for readmission risk prediction from previous studies can be analysed and, if applicable, integrated into the dataset. Furthermore, if no studies on predictive models are available for the diagnosis or procedure under study, explanatory models can also provide an indication of relevant risk factors.

Data cleaning

The term data cleaning describes the process of detecting and removing data errors and inconsistencies. Unclean data can either occur on attribute, record, record type, or source level. According to Rahm (2000) errors can appear on a schematic or at an instance level.

Schematic errors can consist of the following:

- illegal values in attributes (e.g., a BMI of 0),
- inconsistencies on record level (e.g., between age and date of birth),
- record type errors, such as uniqueness violations (e.g., multiple uses of patient or episode IDs), or
- referential integrity violations (e.g., missing descriptions of diagnosis codes).

On an instance level,

- missing values,
- misspellings,
- abbreviations or non-defined codes,
- embedded values (i.e., multiple attributes in one column), or
- misfielded values (e.g., age in the date of birth column) can occur.

Duplicate records or varying value representations (e.g., data types) also affect the integrity of the data set (Rahm & Do, 2000). According to Chen et al. (2014), completeness, accuracy, and timeliness of data are the major factors for data quality specifically in health information systems. To identify errors, data profiling can be performed, which provides metadata to discover errors in the data.

Missing values can be handled in different ways, where entities can either be deleted, missing values can be imputed or the missing values can present knowledge themselves (Grzyb et al., 2017). If missing values don't indicate additional insights, attributes with too many missing values are not taken into further consideration. Also, attributes contributing low or now information are identified by calculating the variance of each variable. Attributes with a variance lower than a predefined threshold can be excluded from the dataset.

Exploratory data analysis

The goal of the exploratory data analysis (EDA) is to analyse the dataset visually and numerically to ensure that the data is suitable for the prediction model. In addition, dimensions are systematically reduced in this step as too many predictors can introduce noise and thus decrease the performance of a prediction model. Depending on the type of the attribute under study, different graphical representations can be used to gain insights into the analysed records. For univariate and bivariate data (e.g., gender), simple plots, such as histograms or scatterplots can be used. The numerical distribution gives an insight into how the two cohorts differ.

Choice of variables

After reducing dimensions, the next step is to select which variables to use for the prediction models. To this end, the variables must have a measurement quality, which means variables that do not assist in predicting unplanned readmissions are not relevant for the model. A feature is seen as beneficial if it is correlated with the prediction flag but is not redundant to any other relevant feature (Yu & Liu, 2003). This means that the variables must have the ability to predict readmissions while not being highly correlated with each other. Since variables with correlations above 0.70 are seen as highly correlated (Asuero, Sayago, & González, 2007), features with a correlation above 0.70 can be removed.

An additional aspect that distinguishes prediction models from explanatory models is the time of data availability. While explanatory models can utilize all data that is available to identify relationships a posteriori, prediction models need to be based on data that is available at the time of prediction (Shmueli & Koppius, 2011). As the prediction models are usually utilized before patient discharge, only attributes that are available before a patient leaves the hospital can be considered.

3.3 Model development

According to a systematic review by Artetxe et al. (2018) on predictive models for hospital readmission risk, machine learning methods can improve the prediction ability over traditional statistical approaches. Such contributions to this academic field are aimed at first aligning complex and sensitive information across multiple sources, using, among others, administrative, insurance, clinical, and government registry data. This information is thereafter used to identify patients in need of additional healthcare resources by means of various intervention methods (Billings, Georghiou, Blunt, & Bardsley, 2013). The model development is split into several steps (cf. Figure 3) and is tightly connected to the internal evaluation and optimization of a prediction model.

Process step	Input	Output
Split dataset	Dataset	*Training set* *Validation set*
Sampling	Training set	*Sampled training set*
Feature selection	Sampled training set	*Sampled training set with relevant attributes*
Hyperparameter tuning	Sampled training set with relevant attributes	*Optimal hyperparameters*
Model building	Sampled training set with relevant attributes + Optimal hyperparameters	*Prediction model*

Figure 3: Model development process

Split the dataset

As a first step, the prepared dataset is split into a training and a validation set. The training set is further used to train, test and optimize the models, while the validation set is used in the very last step to evaluate and compare the predictive performance of the final models. The data is split in a stratified fashion, thus the distribution of readmitted and non-readmitted patients is equal in both datasets. A major issue in predictive analytics is overfitting, which refers to a model that fits the training data perfectly, but fails to generalize in order to correctly predict new examples. Different strategies can be applied during model training to avoid and test if a model overfits, namely hold-out validation and cross-validation. To perform these validations, the data is split into three subsets, a training set and a validation set for cross-validation or hold-out validation and a test set for final evaluation. Depending on the evaluation strategy, these sets are created and used in different manners.

- **Training set:** This subset is used to fit the model, i.e., derive the relationship between the input variables and the target class.

- **Validation set:** Next, the developed model is tested on unseen data, where the predicted values are compared with the real class membership to determine the error rate of the predictions.
- **Test set:** The test set is used in the last step to evaluate the final model that is built on the full dataset (training + validation) given the optimal hyperparameters previously determined by the training and validation data.

For both approaches, a test set is omitted for final testing of the developed model. The training and validation of the model, however, differs. In hold-out validation, for each parameter setting, the model is only trained once on the training set and then applied to the validation set. When the best parameter setting is found through this approach, the final model is again trained on the entire dataset (training + validation data) and then evaluated using the test set. In cross-validation, on the other hand, the data is split into k subsets, where k equals a positive integer. Next, the model is trained on k-1 subsets and validated on the remaining subset. This is repeated until every subset has been used as a training and validation set (cf. Figure 4). A special form of cross-validation, termed leave-one-out cross-validation (LOOCV), splits the data into k subset, where k equals the number of examples in the dataset. Thus, each data point is used on its own to evaluate the model that is built on the remaining dataset. This approach, however, gets extremely cost-intensive with regards to computing time the bigger the data set. While hold-out validation requires less computing time as the model only has to be trained once, sampling of the training and test set can lead to an unwanted bias. In cross-validation, on the other hand, each data point is used both as a training and a validation example, eliminating the sampling bias. Since computing time is not an imitating factor in this analysis and the size of the data sets is appropriate for cross-validation, this technique is used for evaluating the prediction models in the following sections.

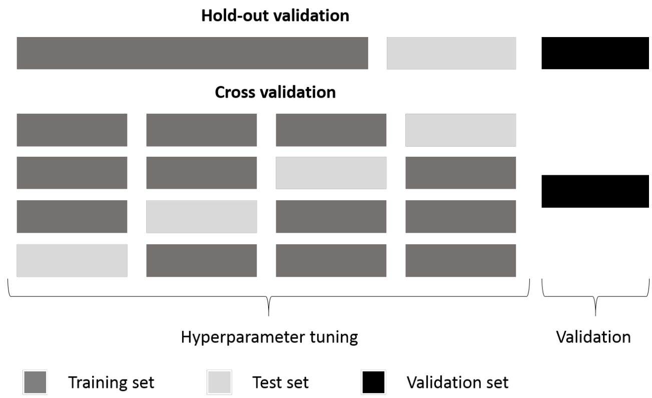

Figure 4: Hold-out validation versus cross-validation

Sampling

If the utilized algorithm doesn't support class weights, sampling can be performed on the training data set to handle an imbalanced class distribution. There is no clear suggestion, whether over- or undersampling performs better in a given prediction task, thus both approaches should be tested. In order to avoid shrinking the data set in the sampling process too extensively, the desired ratio between the minority and majority class can be specified.

Feature selection

Next, different feature selection approaches are performed for each classifier. In general, filter, wrapper and embedded methods can be distinguished (Guyon & Elisseeff, 2003). The main difference between these approaches lies in the point in time of feature selection with regards to the model development and evaluation (cf. Figure 5).

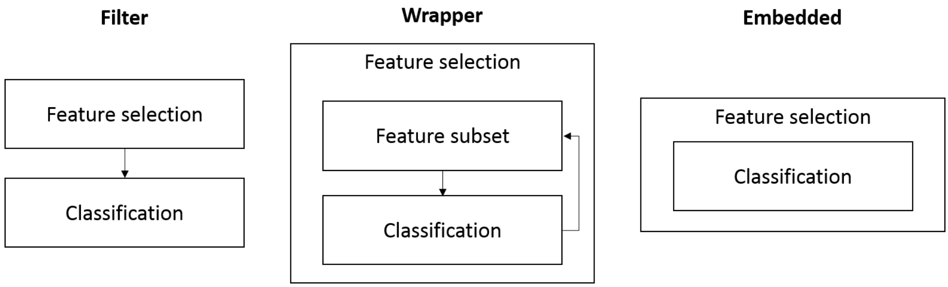

Figure 5: Feature selection approaches (cf. Suppers, van Gool, & Wessels, 2018, p. 7)

Filter methods clearly separate the feature selection and model building process. As a first step, attributes are chosen based on model-independent factors, such as variance or correlation thresholds. Wrapper methods, on the other hand, iteratively build and evaluate a model and adapt the feature set based on the results of the model evaluation until a certain threshold is reached. This adaption can be done by increasing or decreasing the number of features. In forwards selection, the initial feature set consists of one attribute that is consistently extended. The main issue with forwards selection is that features whose usefulness is dependent on other features ("feature synergy") might be lost (Kohavi & John, 1997). To overcome this issue, backwards elimination initially uses the entire feature set to build the classification model and attributes are iteratively removed. Recursive feature elimination (RFE) is a type of backwards selection, where the model is first trained on all features, which are then ranked based on their contribution to the prediction task. The lowest-ranking features are removed until the prediction accuracy of the model decreases. Lastly, embedded methods perform the feature selection task during model building. Decision trees are a prominent example of an embedded feature selection model, as the information gain of each attribute is used to choose the features for model building. Since KNN and NB can't consider varying importance of different features, the models are fitted on all attributes. L1 regularization (also termed "least absolute shrinkage and selection operator (LASSO)") also presents an embedded method for a linear regression that adds a penalty for overly complex models, i.e., the number of input factors. Since DT have an embedded method of feature selection based on the information value of attributes, RFE is performed with cross-validation (RFECV) for all other methods. In RFE, attributes are continuously excluded from the data set based on their contribution to the prediction task.

Hyperparameter tuning

As a next step, hyperparameter tuning is performed where the classifier is fitted to the sampled training set with the remaining relevant attributes. Each model can be trained using a set of hyperparameters relevant for each algorithm. The hyperparameters determine various criteria on how a model is trained, the learning speed and the structure of the model. To identify the best combination of hyperparameters, different search strategies can be applied. With sufficient computing power, formerly popular manual "trial-and-error" settings can be neglected. Instead, parameter combinations can be tested within a given scope using search algorithms, such as random search or grid search. In random search, each parameter setting is sampled from a distribution over possible parameter values. On the other hand, grid search offers an exhaustive search in a specified scope parameter value. Research has shown that random search provides a more efficient way of identifying the optimal parameter setting with at least equally satisfying results (Bergstra & Bengio, 2012).

Model building

In the last step, the prediction model is built by training the classifier on the entire training and test data set using the identified hyperparameter combination. The resulting model can then be used for the final validation. Depending on the classifier, sample weights or embedded feature selection can be employed during model building. Otherwise, the over- or undersampled data is used to build the prediction model based on the previously identified relevant features.

3.4 Evaluation, validation, and model selection

In the last step, the prediction model is applied to the final test set. Thus, the model is tested on previously unseen data that hasn't been involved in the development process. A major issue in predictive analytics is overfitting, which refers to a model that fits the training data perfectly, but fails to generalize in order to correctly predict new examples. A popular strategy to test if a model overfits is to perform cross-validation. For this purpose, the data is split into three subsets, a training set, test set and validation set. For the training and testing data sets, the data is split into k subsets, where k equals a positive integer. Next, the model is trained on k-1 subsets and tested on the remaining subset. This is repeated until every subset has been used as a training and testing set. While cross validation already aims to avoid overfitting of the model during training, it is argued that a final test on an unseen validation set should be performed in addition using data not present in the cross-validation (Ripley, 2009).

For evaluation, different metrics to investigate model performance are available. Since projects on readmission prediction usually concentrate on identifying as many risk patients as possible, the positive class should be focused on in the model evaluation. For this purpose, either the sensitivity or the F-2 score should be chosen as they put more emphasis on the positive class (cf. Table 1). Besides the resulting predictive performance stated by the evaluation metrics, model interpretability and computing time should also be considered for the final model selection.

Table 1: Evaluation metrics

Evaluation metric	Formula*
Accuracy	$\frac{TP + TN}{N}$
Sensitivity (Recall pos. class)	$\frac{TP}{TP + FN}$
Specificity (Recall neg. class)	$\frac{TN}{TN + FP}$
Precision	$\frac{TP}{TP + FP}$
F-Score	$(1+\beta^2) * \frac{precision * recall}{(\beta^2 * precision) + recall}$

* TP = True Positives, TN = True Negatives, N = All examples, FN = False Negatives, FP = False Positives

Table 2 summarizes the results of this study by defining five main process steps that are further subcategorized in relevant tasks and questions that need to be answered in any readmission prediction project.

4 Discussion and Conclusions

This study set out to identify and unpack key issues around applying predictive analytics to healthcare especially in the area of hospital readmissions. In doing so the study has several contributions for theory and practice as follows: The proposed framework can be used to perform future studies on readmission risk prediction in a more systematic and guided way. Common mistakes in these kinds of projects can therefore be avoided and results are better comparable. Furthermore, this work extends the theoretical knowledge on predictive analytics based on Shmueli and Koppius (2011). In a next step, the proposed framework will be further tested and adapted by means of a systematic literature review on readmission risk prediction. Furthermore, an exemplary prediction project is conducted based on the presented guidelines to test its applicability in practice. For this purpose, episode data from an Australian hospital group is used to predict unplanned readmissions

Table 2: Framework for research on readmission risk prediction

Process Step	Main questions	Example
Goal definition	**Prediction:** What is the main purpose of the prediction?	*Define time of prediction, e.g., identify patients at risk for readmissions at admission, before or after discharge*
	High-risk: At what level should the readmission be predicted?	***Discrete:*** *Binary prediction (readmission / no readmission) or Multinominal prediction (e.g., high risk, medium risk, low risk)* ***Continous:*** *Risk probability (0 - 100 %)*
	Readmission: How is a readmission defined?	*Reason for readmission (procedure-specific or general)* *Timeframe of readmission (28-day, 30-day, 6 months, etc.)*
	Study design: When is the data collected?	*Retrospective study versus real-time*

Data collection and study design	**Data collection:** Which episodes should be excluded from the dataset?	*Patient is admitted to acute care* *Patient died before or after discharge* *Patient left the hospital against medical advice*
Data preparation	**Selection**: Which data points (episodes) are relevant for the context at hand?	*Focus on specific procedures, diagnoses, patient groups*
	Feature creation: Which additional attributes are potentially interesting?	*Create additional attributes from collected data that are not directly reported (e.g., from previous studies on predictive or explanatory models)*
	Cleaning: Which data points are usable for the prediction task?	*Missing values* *Outliers* *Low variance* *High correlation* *High cardinality*
	Exploratory data analysis: What does the population under study look like?	*E.g., use histograms or scatterplots to compare the distribution between two cohorts (readmission, no readmission)*
	Choice of variables: What data is available at the time of prediction?	*Depends on the prediction goal (at admission, before or after discharge)*
Model development	**Split dataset:** How does the data need to be split for evaluation?	*Training + test dataset (e.g., 80 %)* *(Final) validation dataset (e.g., 20 %)* *Cross-validation (during model training) versus holdout-validation*
	Sampling: Which sampling method should be applied to reduce the issue of imbalanced data?	*Methods that support class weights (e.g., SVM)* *Undersampling (e.g., Random Undersampling)* *Oversampling (e.g., SMOTE)* *Hybrid Sampling*

	Feature selection: Which attributes contribute to the predictive performance of a model?	*Filter methods (subsequent approach, e.g., variance threshold)* *Wrapper methods (iterative approach, e.g., backwards elimination)* *Embedded methods (integrated approach, e.g., decision trees)*
	Hyperparameter tuning: Which hyperparameter combination leads to the best predictive performance?	*Random search (specify the number of parameter combinations in a given range)* *Exhaustive search (test all parameter combinations in a given range, e.g., grid search)*
	Model building	*Build the model on the entire training + test dataset using the identified optimal hyperparameters* *Use sample weights and embedded feature selection (if applicable)*
Evaluation, validation, and model selection	**Evaluation:** Which evaluation measure should be chosen?	*Focus on readmission cohort: F2-score, Precision-recall curve, AUC*
	Validation: How well does the model perform on unseen data?	*Apply the model on the validation set*
	Interpretation: How can the final model be interpreted?	*Logistic regression: Odds ratio for each attribute* *Decision tree: Deduct rules from tree*
	Selection: What model should be selected for the final prediction task?	*Predictive performance, computing time, interpretability*

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Reclaiming Control over Personal Data with Blockchain Technology: An Exploratory Study

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Abstract With the digitalization and increasing number of Internet users, more and more personal data breaches occur. Many people are not aware of their personal data rights and have not received any instructions on how to act in situations such as when their personal data is abused. This is something that illustrates the flaws of the Internet. A technology that provides solutions to some of these problems, such as trust and transparency, is the blockchain technology. Hence, the objective of this paper is to investigate knowledge about personal data rights and to explore the design of a prototype of a blockchain application for increased security and transparency. User tests were conducted, highlighting the greatest needs for users to feel secure and in control over their personal data. This knowledge provide the foundation for a prototype based on blockchain technology that gives the users increased security and forces those who store personal data to be more transparent with the usage.

Keywords: • Blockchain • Personal data • User test • Exploratory Study • Internet •

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1 Introduction

The Internet has been around since the late 1960s (as Arpanet) and has both seen a steady user growth (Leiner et al., 1997; Statista, 2018) and become a natural part of everyday life. While originally intended as a medium for peer-to-peer communication, the development of the World Wide Web, in the early 1990s, provided an easy to use platform with both high value and a significant reach and usage (Leiner et al., 1997). When the Internet was invented, the focus was to solve communication. Thus, it was not built to be a system without centralized control (Sweeney, 2015; Rainie & Anderson, 2017). This has meant that the responsibility for online security and privacy have been in the hands of the users and those providing content.

Much of the content on the World Wide Web can be accessed easily and for free. However, when using a service on the Internet, the users often leave traces that are stored in the systems, so-called digital footprints (Internet Society, 2018). This can be voluntary, by e.g. sharing personal data in a registration process, or involuntary, through e.g. the collecting of cookies that track the users' movements (Internet Society, 2018). What many users are not aware of, however, is what happens to their personal data and how companies profit from it.

There is an element of risk involved when using the Internet and users themselves have to assess whether this risk is critical or not. The perceived risk may not be easy to determine, which is why a certain amount of trust is necessary for Internet usage (Cerf, 2010). As the recently highlighted case with Cambridge Analytica show, abuse of data can have serious implications (Rosenberg, Confessore & Cadwalladrmarch, 2018). New approaches for users to feel safer and more secure on the Internet are required in order to maximize the value of the services provided on the Internet. Thus, increased transparency on how personal data is being used has to improve. There is no central authority running the Internet, therefore, there is no single person or agency regulating content abuse or personal data breaches. A solution to this could be an authority acting as a trusted third party (middleman). The middleman could then make sure that both parties uphold their bargain of not abusing personal data nor the provided service. This would be feasible but not optimal as the middleman could lose all data that they have been entrusted with in a hacker attack or the middleman could be a malicious actor. From this example, parallels can be drawn to economic transactions. Similarly, for transferring money, there is a counterparty risk, i.e. a risk that the other part will not fulfil their obligations. Today, national banks usually act as the middleman between the trading peers when we discuss transactions involving money. In exchange for removing (or at least lowering) the counterparty risk, the middleman often charges fees and dictate the rules of the transactions.

For the purpose of removing counterparty risk without having a middleman, blockchain technology can be applied and replaces the trusted third party in the transaction. It is a technology that enables instant and secure peer-to-peer transactions (Nakamoto, 2008). The blockchain has several use cases. For example, increasing productivity in supply chain management, voting and, maybe the most pronounced, economic transactions. One of the most commonly known applications to be built out of the blockchain technology is the cryptocurrency Bitcoin. Ideas of using blockchains to protect personal data and increase privacy have both been deemed important and discussed in research (Zyskind, Nathan & Pentland, 2015).

The objective of this exploratory study is to discuss how to increase personal data security through blockchain technology. This will be achieved in two steps: First, by mapping the current knowledge and perception of online personal data management. Second, from the gathered data, presenting a prototype using blockchain technology for increasing personal data security and usage transparency.

2 Theoretical Framework

In 2008, a whitepaper was released in a cryptographic community by an unknown author using the pseudonym Satoshi Nakamoto (Norman, 2017; Nakamoto, 2008). The paper proposed a solution for a decentralized electronic cash system called Bitcoin. The paper introduced the blockchain technology by proposing solutions to some complex cryptographic problems. Back in the 1990s attempts to create cryptocurrencies were made but without any significant impact. However, some of these ideas laid the foundations for this description of Bitcoin. The ripples created by the 2008 whitepaper have had wide spread impact since its release. While Bitcoin and other currencies continue to develop, blockchain technology has been used to create many new applications where trust is needed among people that do not know each other. This can be e.g. to counteract diamond theft, streamlining stock markets and verifying contracts (The Economist, 2015; Iansiti & Lakhani, 2017).

2.1 The Double Spend Problem

Since trading with cryptocurrencies does not involve any physical exchange, there is a risk of a token being spent in multiple transactions which is called the double spend problem. The problem has been one of the biggest obstacles in realizing the use of cryptocurrencies. The blockchain technology solves this problem with a combination of a distributed ledger, a public record of transactions which works as a proof of information, and adding a level of complexity for creating a new block.

Nodes are central in the blockchain technology and can be any Internet connected device. All nodes on the network keep an updated version of the same ledger. If an alteration of a previous transaction is made by one node, the blockchain would become forked because the two versions of the ledger should be identical. To prevent fraudulent branches, the longest chain is considered true. Therefore, the creation of a block was made time-consuming through hash functions, making it difficult to grow the false branch faster than the true one. For a node to create a new block, a specific value has to be found. All active nodes on the network compete to find this value in the commonly used Proof of Work method. Thus, an attacker would need to outpace the other nodes in order to create a longer chain from a new branch. This process makes it very unlikely that attacks would succeed (Nakamoto, 2008).

2.2 Incentives

A blockchain would not exist without the creation of new blocks and honest participants. Therefore, incentives are necessary for attracting participants, keeping them honest and making them create new blocks. There are several different ways to incentivize honest participants, the two most popular ways are Proof of Work and Proof of Stake, and both reward creation of a new block.

Proof of Work is essential to blockchains such as Bitcoin. It is a piece of data that is very time consuming to produce but at the same time very easy to verify if it is correct once created. In order to keep the blockchain reliable, the longest chain, i.e. with the most proof of work in it, is considered the honest chain. When creating a new block, all mining nodes on the network compete to find a specific value. Once the value is found and the block is created, the creator is rewarded with a token (e.g. crypto currency). In order to prevent improved hardware to allow faster creation of blocks over time, the difficulty of finding the value for the block is increased in correlation to creation speeds, i.e. numbers of miners (Nakamoto, 2008; Norman, 2017). Since Proof of Work is based on computing power, it is also based on the idea of using as much energy as possible as fast as possible. This is one of the major critiques against blockchains. Proof of Stake is alternative to Proof of Work and, hence, another method of giving incentives to the creators of honest nodes. Compared to Proof of Work , the nodes on the network do not compete for creating a new block. Instead, the creator of a new block is chosen from a pool of users based on their percentage of total tokens (Norman, 2017). In other words, the creators have something at stake in the system. The creator of a block is rewarded with transaction fees for the transactions that go into the block. Because the nodes are not competing for creating new blocks with the Proof of Stake method, the energy consumption required is a lot less compared to that of Proof of Work.

2.3 Digital Footprint

Digital footprints are the traces that users leave when using the Internet (Girardin, Blat & Ratti, 2008). This could be online behavior, email records or personal data. One of the problems with digital footprints is described by Internet Society (2018) as: "Every day, whether we want to or not, most of us contribute to a growing portrait of who we are online; a portrait that is probably more public than we assume". These digital footprints mean companies can gather large amounts of data about their users without their users knowing. The data sets are of commercial value and thus can be sold. It is therefore not uncommon that personal data is sold without the consent of the users. Studies conducted on British citizens made by Information Commissioner's Office in 2014 (ComRes, 2014) show that there are deficiencies in the awareness regarding personal data protection of individuals. Furthermore, more than half of the participants were concerned about organizations collecting and holding information online.

As been mentioned earlier, individuals disclose an increasing amount of information about themselves. Both in terms of data collected and in terms of sharing and user generated content (Blackshaw & Nazzaro, 2006; OECD, 2007). Therefore, privacy has certainly become a hot topic in current times. Privacy has been defined by Warren & Brandeis (1890, p. 193) as "the right to be let alone" and today privacy has been adressed mostly in terms of the choice that we make to share our information to get better services and be part of social communities as well as privacy risk (Appelgren, Leckner & Mejtoft, 2014; Acquisti, Taylor & Wagman, 2016).

2.4 Data Protection Regulation

In 2018 a new legislation called General Data Protection Regulation (GDPR) was implemented within the EU (European Union, 2016; Datainspektionen, n.d.). The legislation is a stricter version of the earlier Data Protection Act. GDPR have an impact on many companies worldwide since it is not only covering companies operating in the European Union (EU), but also companies that handle information of EU residents. The major impact of the new legislation is:

- Penalties will be more severe for misdemeanor.
- Consents must be clear and accessible.
- Rights to get personal data erased.
- Transferring data to third parties should be informed to the users.
- Increased security requirements.

3 Methodology

In order to design a blockchain solution that addresses the users' need for data security, the research was divided into two parts. An initial survey was undertaken and this was complemented by a qualitative research on a constructed prototype. These experiments were conducted during spring 2018.

3.1 Participants

An initial survey with 12 people was conducted. Since the Internet is widely used (Statista, 2018), a broad age range of participants, both in terms of age and gender, was considered important for the study. For ethical considerations, no one below the age of 18 was included. After analyzing the results of the survey, a prototype was built and tested. The users were presented with a set of instructions, thereafter they had to navigate through a hi-fi prototype, created in the digital design tool Sketch.

The survey questions were divided into two parts. The first consisted of seven questions regarding concerns, online behavior and data rights. The second part consisted of questions regarding valuation of personal data and customization. Some of the questions asked were: "Does a company that lose a customer's personal data have any responsibility to the customer?", "You are informed that a company, where you recently registered, has abused your personal data. What do you do?" and "If the quality of a service would improve with your personal data, would you be willing to share it? E.g. products with nuts would not be shown if you are allergic."

3.2 Prototype Testing

With the knowledge gathered from the desktop research of the blockchain technology and the survey data, a hi-fi prototype was created in Sketch. The purpose of testing the prototype was to investigate the participants' perception of what service the application provided and whether they felt safe using it. The method chosen was structured interview (Fontana & Frey, 2005). A scenario was presented to the participants who were supposed to navigate through an interface while the interviewer noted comments and the navigation patterns of the respondents. After the test was finished, the participants were required to answer a few questions.

> *The scenario: The user was looking for a new pair of running shoes. After searching, a suitable pair were found, although, from a previously never visited website. The user decided to buy the shoes, verifying and sharing his or her personal data with a blockchain application. When coming online, later on, the user was faced with a personal data access request from a suspicious website (Figure 1). The user could see*

what data was being requested and where the website got it from the first place. The user then made a choice of whether to accept or decline the request.

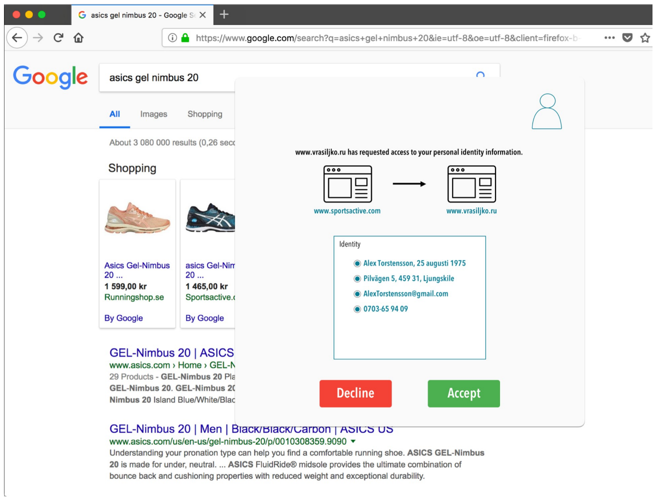

Figure 1. Access request from suspicious website.

4 Results

The results of the survey indicate that people may act very differently when there either is suspicion or confirmation of personal data abuse. In one of the questions in the survey, the respondents had to specify what level of control they perceived to possess over their personal data online. The overall responses were slightly pessimistic with most answers being neither in full control nor no control. However, the second most common answer was close to no control.

This data was collected just before the GDPR was introduced and under GDPR a company that loses a customer's personal data has certain responsibilities, including compensating for the losses. Despite being one of the alternatives in the questionnaire none of the respondents selected this answer. In fact, the responses showed a wide variance in the level of knowledge about the responsibilities of companies in the case of a data breach.

The results from the survey demonstrated that many of the respondents did not know what cause of action was open to them if their personal data was abused. This is shown by the answers to the question on what they would do if they were informed that a company abused their personal data, the answers differed a lot.

A blockchain personal data application would provide the users with a possibility to sell their personal data. However, a majority of the respondents stated that they were not willing to sell any data even if the option was available to them.

4.1 Personal Data Blockchain Application

One of the objectives with this project was to present a proposal of a blockchain application for personal data security. This was during the project prototyped based on the gathered data and tested.

From the survey, a number of key components for the prototyped blockchain application for personal data were identified. The proposed solution provides control and responsibility for personal data to its users. As a decentralized application, it exists in a layer on top of a blockchain network. Hence, the application does not need any own monetary cryptocurrency but instead use a utility token. Every user will have a personal token of their personal data. This token will be referred to as Personal Identification Token or PIT for short. For sharing single pieces of personal data, this token can be split up into minor parts. All personal data is stored locally in a token, only accessible after consent through biometric identification. Thus, every new usage of a PIT has to be confirmed by the user.

Whenever a company requests any personal data, a smart contract is enabled and the transaction is verified by the blockchain network. The smart contract will persist, which means any violations of the agreement would see the transaction revoked.

The application also offers alternative ways of identification. For example, in an online purchase, a user's identity can be verified by the network without having to be shared with the vendor. Thus, the only data that has to be provided to the vendor is the shipping address. The network verification also provides the vendor with information that the customer, in fact, is authentic. In a similar way, users could, for example, confirm that they are above a certain age in a reliable manner, without the users having to provide their social security number.

Verification. The need for valid identification will still persist with the presented solution. Even if the network removes the need for a third party identification guarantor, a trustworthy authority still has to issue the identifications. This means reliable authorities are essential to the application. Before adding any personal data to the user's token, unique and critical data such as social security number has to be verified by these authorities.

Incentives. In order to make transactions possible, new blocks have to be created. For keeping the nodes on the network honest and incentivizing block creation, Proof of Stake will be used. The block creators will be rewarded with transaction fees for the transactions stored in their block. Because the personal data blockchain does not use any monetary tokens, the transaction fees collected will be in the cryptocurrency of the underlying blockchain. The chance to be chosen to be the creator of the next block will be equal to all participants on the network. Using Proof of Stake also give the system a more sustainable approach.

Transparency. The blockchain technology allows the application to display usage of personal data more clearly, i.e. to make usage more transparent. Should a company try to sell personal data to a third party, the transaction would have to be verified by the user before the other party could access any personal data from the PIT. Furthermore, who actually transferred the PIT to the third party would be visible for the users. This increases the demand on companies to respect their customers' personal data.

The application offers an overview of whom have access to the personal data through smart contract agreements. This provides the possibility to revoke access to personal data. In terms of the smart contract, the agreement is broken if data is revoked. Thus, smart contracts should be designed to protect both parties in the case of a sudden revoke of a transaction, meaning one party should not be able to profit on behalf of the other.

Security. Local storage of personal data means the security responsibility lies in the hand of the users. Thus, users verify transactions of personal data with biometrical methods available in contemporary smart devices, such as a fingerprint scanning. This provides security against possible attacks. Unless the attacker manages to hack the biometric identification, the data will not be accessible.

Because the blockchain technology solves the problem of double spending, PIT transaction abuse is unlikely. A fraudulent company trying to distribute a PIT without consent will have to outpace the rest of the network. Because biometric identification is needed to unlock the PIT, fraudulent transactions would not be viable.

4.2 Prototype Testing

Six of the respondents from the initial survey were chosen to participate in the testing of the hi-fi prototype. A pilot test was run on one of the participants to test the prototype. The initial steps for the user to access the prototype were shown to be somewhat abundant, hence, they were removed for the other tests.

Following the suggestions of Fontana and Frey (2005), the participants were presented only with the necessary instructions. Those who encountered minor navigational confusions had to solve the problem without any support from the interviewer. After navigating through the interface, the participants were asked to describe what had happened during the navigation. This provided indications that the participants had the desired perception of what occurred during the test. The last step of the test featured a PIT usage request from a suspicious website. The users were also presented with information from what source the suspicious website actually had acquired the PIT. However, this information seemed to be bypassed with three participants, who did not register the information and took no action.

5 Discussion

The results from the user tests showed that individual's knowledge of the Internet differs significantly. Thus, applications such as the one proposed in the prototype are needed to assist people by making information accessible or subconsciously understood. The Internet was not designed to always protect the user, rather it is merely a means of communication (Sweeney, 2015; Rainie & Anderson, 2017). The decentralize nature of the Internet together with the current usage of Web 2.0 platforms such as social media mean trust is an essential component (Cerf, 2010). Even though the solution to trust does not necessarily need to be one using blockchain technology, this research illustrates that it can be used for addressing problems with online trust. Thus, a blockchain solution is of high relevance to all Internet users.

This study displayed several flaws in knowledge about what rights people possess regarding personal data. The study was performed around the time of the implementation of the GDPR directive (European Union, 2016) within the EU and the results do not show the effects of the GDPR. The old legislation, the Data Protection Act, can be said to have failed in some respects. It has not provided enough protection and many people are unaware of their rights, probably due to a lack of information around personal data security (ComRes, 2014). Because of the digitalization of business functions and the steady Internet user growth (Statista, 2018), the need for an updated version of personal data legislation has been required for quite some time. Recent developments with Cambridge Analytica (Rosenberg et al., 2018) influence in the EU referendum and the US presidential election highlight the need even further. The harvesting and usage of personal data can have major implications, something both companies and users of the Internet have to become aware of.

While a majority of the survey respondents stated that they were not willing to sell any personal data, several of them would be willing to share data for free in order to get a more customized online experience. Either the questions were unclear, making the respondents confused or the notion of selling the personal data was intimidating. Data is of great value to companies, while something that is quite intangible for users. Consider, for example, that the data sold by Facebook to Cambridge Analytica (Rosenberg et al., 2018) that, alleged, had an impact on the outcome of the US Presidential Elections in 2016. A significant amount of money goes into these campaigns for the purpose of marketing and buying data to target campaigns.

Even though the survey conducted was carried out a few months after the Cambridge Analytica case, the respondents rated their perceived control over their personal data to be high. Combining this knowledge with the widespread of answers on how to handle personal data abuse indicates that the respondents are generally secure in their handling of personal data or that they are not aware that the data is actually being abused without their consent.

The proposed Blockchain solution would limit the possibilities for companies to make money out of the users' data. It could even make them have to pay to access personal data. Furthermore, it would provide the verifiers with more money and potentially the users too. Hence, its implementation would probably encounter a lot of resistance. As with all technology, especially one that has not been thoroughly researched, there is a risk that technological advancements disrupt the application. Examples of this could be possibilities to fake biometric identification. By keeping the network participants incentivized, they will likely stay honest and the blockchain network will remain strong.
This exploratory study provides some interesting results, but to further strengthen the results and develop a useful application, more studies are needed with a wider user base.

6 Conclusion

What the effects of the GDPR legislation will be are yet to be fully observed. However, as seen with previous legislation, the environment can change which may open up loopholes in which boundaries can be pushed. Hence, solutions that offer a more thorough control that can be managed by the users themselves is therefore preferable. Furthermore, as seen in the tests with the previous legislation, many people are not aware of their personal data rights. The Internet was created for open communication for anyone (Leiner et al., 1997; Sweeney, 2015). Thus, it is difficult to make sure that every user comprehends all the legislations that covers the Internet.

This is an exploratory study of the proposed idea and further research and user studies would be required for increased significance of the findings. However, the solution addresses what was interpreted as the test participants' most pressing concerns about personal data on the Internet. Furthermore, except for minor alterations in the design, the prototype tests showed that it was easier to track and control what happened to the personal data. That is, the security and transparency of personal data usage were increased.

The blockchain technology solves many of the problems that inherently exist on the Internet to do with transparency and trust. There are many application areas and like many technologies surrounded by hype, people seek to exploit it. That is why Blockchain technology will probably need some time to be further developed and the technology to mature. It is a reasonable to assume that blockchain in the near future will change many of the current conventions around Internet use in different ways.

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User Experience Design and Digital Nudging in a Decision Making Process

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Abstract When using online nudges to steer people in the right direction while they are making a decision, there is usually one preferable outcome. What might happen if the user experience is inadequate, will the nudges still work or might they be undermined? In this paper we investigate the correlation between user experience and digital nudges in a decision making process. A user A/B test was conducted to investigate the problem. The test participants visited one of two websites that included the same nudges where they were nudged to choose option (a) instead of (b). The only difference in the websites was the quality of the user experience, one website design had a good user experience while the other one offered an inadequate user experience. The results showed that everyone who was assigned the good user experience chose (a), while two of the inadequate experience participants chose (b). The results indicate that user experience design can be used for digital nudging.

Keywords: • Digital Nudging • User Experience • Decision Making Process • Decision • User •

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1 Introduction

Every day, people make choices, good ones that support their long-term goals, and sometimes they make bad ones that go against their ethical values. Daily they scroll on their smartphones, and computers, and experience the digital content of their favorite applications and services unaware of what is being presented to them, is not neutral (Thaler & Sunstein, 2008). Companies build applications that provide wonderful user experience (UX) that will make the users stay longer on their page. When the users are about to make a choice, they might be influenced, or nudged, by the user interface (UI) design to encourage the user to make a specific choice.

In simple terms, digital nudging is when the design elements of the UI guide the user through a choice environment resulting in the user's behavior being altered. A well-designed nudge should only guide the user to make the choice that is best for their interests (Thaler & Sunstein, 2008). Being nudged to a positive outcome means that the main goal should be that the user should benefit from the choice, not that the company should make profit at the user's expense. A good UX design on the other hand, creates a product or service that meets the user's need and makes them a joy to own or use (Norman & Nielsen, 2014).

Girling (2012, p. 4) states that, "you can give people all the facts and create the most informative, attractive communications materials, which may change people's attitudes towards something, but it is very unlikely to get them to change behavior". Furthermore, Girling (2012) encourages UX design for positive outcomes instead of just focusing on a wonderful UX design. But what happens if the designer, or choice architect, only thinks about the choice architecture and forgets about the UX? Will the users still choose what is best for them, or will the nudging be overshadowed or lost in poor design? How much will the UX actually influence the nudging?

The aim of this introductory study is to investigate how UX and digital nudging are correlated. The objective is to estimate how the UX, in terms of aesthetic and minimalist design, learnability, and efficiency, will affect the outcome in decision-making processes where the user is being nudged to a positive outcome. Two different scenarios will be designed where a user have to make a decision in a UI.

The scenarios being tested will be made with insights from well-recognized nudge theory and UX guidelines.

2 Theoretical Framework

To be able to draw conclusions from the objective of this paper, two different domains need to be considered. Firstly, what is UX and how can a service or product benefit from implementing a great user experience? Secondly, what is nudging and how does it work?

2.1 User Experience

When it comes to UX it is about so much more than just usability. An engaging and complete user experience involves the whole spectra of using a service or product. For example, this means that the emotions, needs, usability, utility and overall satisfaction an end-user has, all play a role in delivering the UX (Norman & Nielsen, 2014). There are many definitions of UX including that of Hassenzahl and Tractinsky (2006) who define UX as a consequence of three factors. First comes the user's internal state, meaning the predispositions, expectations, needs, motivation and mood. The second factor is the characteristics of the designed system, e.g. complexity, purpose, usability and functionality. The third factor is the contextual (or environmental) factor, within which the interaction occurs, e.g. organizational/social setting, meaningfulness of the activity and voluntariness of use. Norman & Nielsen (2014) define UX as all aspects of the end-user's interaction with the company, its services, and its products. Their first requirement of an excellent UX is that the exact needs of the user must be met, without fuss or bother. Second comes the fact that the product must carry elegance and simplicity that makes it a joy to own and use. As a concluding statement they affirm that the company's offerings must work seamlessly over multiple disciplines, including engineering, marketing, graphical and industrial design, and interface design.

Hassenzahl and Tractinsky's (2006) definition is more about what UX consists of, while Nielsen-Norman Group's definition is more about how to achieve good UX. In this paper, the research results will be discussed in relation to both of these two definitions with the results. Nonetheless, if you remove one of the parts mentioned in the above definitions, it will affect the overall experience.

Usability in the UX Spectrum. People constantly leave websites or applications without completing the purpose for which they engaged with the interface. A major reason for this is because of inadequate usability. Nielsen (2012) states that "if a website is difficult to use, people leave. If the homepage fails to clearly state what a company offers and what users can do on the site, people leave. If users get lost on a website, they leave. If a website's information is hard to read or doesn't answer users' key questions, they leave". This means that usability plays an important role in creating good UX. Without usability, the experience of the user will be disrupted. Usability is also a very broad domain that contains more than just the heuristics of aesthetic and minimalist design, learnability and efficiency. However, since these heuristics were altered in the test scenario, further explanation of them is needed.

- **Aesthetic and Minimalist Design** explains that information that is irrelevant or rarely needed should not clutter dialogues (Nielsen, 1995). This is because the irrelevant information will compete with the important and relevant units. The visibility of the important units will be diminished.
- **Learnability** is simply defined by how fast a user can perform a basic task the first time they encounter the design (Nielsen, 2012).
- **Efficiency** is defined by how quickly a user can perform a task once they have learned the design (Nielsen, 2012).

2.2 The Nudge Theory

Thaler and Sunstein (2008) define a nudge as any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives. The intervention must also be cheap and easy to avoid. An example given is the placing of fruit at eye level in a cafeteria, which counts as nudge, while banning junk food does not. However, humans do not make choices in a vacuum, that the choice is placed in a context where many features, noticed and unnoticed, may influence their decisions (Thaler, Sunstein & Balz, 2010). The ones creating these environments are the *choice architects*. They are the ones who can alter this environment by gently giving incentive, or nudge, people into making better choices. These nudges, should not be forcing a decision upon anyone, a philosophy they call *libertarian* *paternalism*. Examples of nudges are automatic enrollment of a pension plan with an opt-out option compared to an opt-in, speed lines on the road, nutritional labels on food and putting an image of a fly in a urinal to improve aim and hence reduce spillage.

The nudge theory is derived from behavioral economics and political theory, but it can also be applied in the digital world. It is then often known as *digital nudge*. The difference is that the design elements of the UI will work as the tools to steer people in the right direction in the digital environment (Mirsch, Lehrer & Jung, 2017). There are many different ways to actually put digital nudging in use. Techniques a choice architect can use are *framing, status quo bias, social norms, loss aversion, anchoring and adjustment, hyperbolic discounting, decoupling, priming and availability heuristics* (Mirsch et al., 2017). In this research a combination of framing, loss aversion, social norms and priming was used in the test scenario.

Loss Aversion. Loss aversion is the simple mentality that it is harder to lose than it is to gain. The estimation is said that it is roughly twice as hard on people to lose something as it is to gain something with the same value (Thaler & Sunstein, 2008), people are "loss averse". An example of this is the mug experiment (Kahneman, Knetsch & Thaler, 1991). In a class of students, half of them were given a coffee mug. The mug owners could sell their mug after the non-mug owners had examined it. The results showed that those with mugs demanded roughly twice as much to give up their mug as to the non-owners were willing to pay to purchase one. A conclusion to draw from this is "once I have a mug, I don't want to give it up. But if I don't have one, I don't feel an urgent need to buy one".

Framing. Framing is basically how you choose to present a decision. Thaler and Sunstein (2008) give a great example of this. Consider the two options: (a) If you use energy conservation methods, you will save $350 per year; (b) If you do not use energy conservation methods, you will lose $350 per year. Framed in terms of losses, option (b) is a significantly better nudge if a government wants to encourage energy conservation. This is framing used loss aversion and it works because people tend to be fairly mindless, passive decision makers.

Social Norms. Social Norms can also be described as the "herd mentality", or following the herd. This means that users do what is accepted by the society, or what everyone else is doing. There are two reasons why the decisions of a user can be altered by social norms. One involves the fear of disapproval of the group, i.e. peer pressure. The other one involves information brought by other people's answers (Thaler & Sunstein, 2008). An example of the latter is the tax compliance experiment in Minnesota (Coleman, 1996). Taxpayers where told one out of four things. That the tax received by the government went towards public welfare. That they would be punished if they did not pay tax. That they could get help to pay tax. That 90 percent of Minnesota already complied to pay tax. Only the last statement had a significant effect. A digital example of the herd mentality is Amazon's product recommendation system that shows "other people who bought this, also bought..." (Mirsch et al., 2017).

Priming. Priming has a lot to do with preparation and association before a decision. Studies have shown that people, who are asked about their intentions, are more likely to act on their answers (Thaler & Sunstein, 2008). For example, asking a person the day before the election if they intend to vote, will increase the probability of their voting by 25 percent.

3 Method

When investigating the correlation between UX and digital nudging, two different platform designs were created and the users had to make a decision in the assigned UI. The designs contained the same nudges. This meant that if the decision outcomes differed between the two designs, the connection between UX quality and response to nudges was high, and if the decision outcomes were the same between the designs, the connection was low.

3.1 Participants

Ten participants performed the test. Half of them were assigned design (a) and half of them design (b). The participants were students who were randomly asked in the corridor at Umeå University if they wanted to participate and no incentive was provided for them to participate. The reason for choosing students on campus is because they are used to being involved in these kind of tests and would not be stressed or inconvenienced by participating. Therefore the results would not be compromised by having the priming effect of "having to perform good results". Half of the participants identified as female and the rest as male. Two of the male participants and three of the females got the inadequate UX design. Hence, the distribution was almost similar. The age span of the participants was quite narrow with 70 percent were between 18-24 years old, while the rest were between 25-29 years old. All tests were performed during spring 2018.

3.2 Design

The experiment used an A/B testing design (sometimes called split testing) (Kohavi & Thomke, 2017). This meant that the two different designs were pitted against each other. In this case the participant was visiting a website, either with design (a) or design (b). Both of the UI designs contained the same nudges, but the UX was inadequate in (a) whereas (b) had the recognized UX guidelines. As mentioned in the objective, some of the usability factors were modified in (a), specifically aesthetic and minimalist design, learnability and efficiency. The reason for only modifying these factors was that if more factors of the UX were made inadequate, the premise was that the UX would be too deficient.

In order to produce similar mindsets with the participants, they were assigned a very specific scenario. The scenario read: "You are building a house and need to provide your house with electricity and therefore install sockets. You have two different socket types you can choose between. Just browse through the options really quickly and then make a decision by order your preferred socket type on the website". The participant could choose between a normal socket type or a new type of socket (the Plug) that conserved energy. The Plug would cost a bit more to install but would in the long term save the buyer money. The Plug would also be environmentally friendly. Hence, in the long term, the Plug would be the best choice in both economically and in environmentally aspects.

The nudges were taken from a mix of priming, framing, loss aversion and social norms. The first nudge was asking if the buyer thought about the environment: *Do you intend to be environmentally friendly?* This was the priming nudge. The next nudge was playing on framing combined with loss aversion: *You will lose $ 350 per year if you do not use the energy saving Plug.* The last nudge was playing on social norms: 2017, *90 percent of house builders have installed the Plug.*

3.3 Materials

As mentioned before, two websites with different designs was used together and ended with a Google forms survey.

Design (a) - Inadequate UX. The inadequate UX design had confusing navigation, repeated text and a cluttered design that failed to point out the most important parts of the choice process. The information text that is shown on the first page (figure 1), is exactly the same on the pages of "Normal sockets", "The Plug" and "Sockets", which aimed to wear out the user reading the same content over and over. The content can be better read in figure 4. The navigation menu that can be seen in figure 1 aimed to confuse the user as to where the actual order page were, figure 2 shows the order page. Even though all the pages could be displayed in the blue bar, the options were slightly hidden by putting them behind the three dots. Lastly, the reason to split up the pages even though the information was the same, was to try and wear out the user by clicking around on the website without finding any useful information.

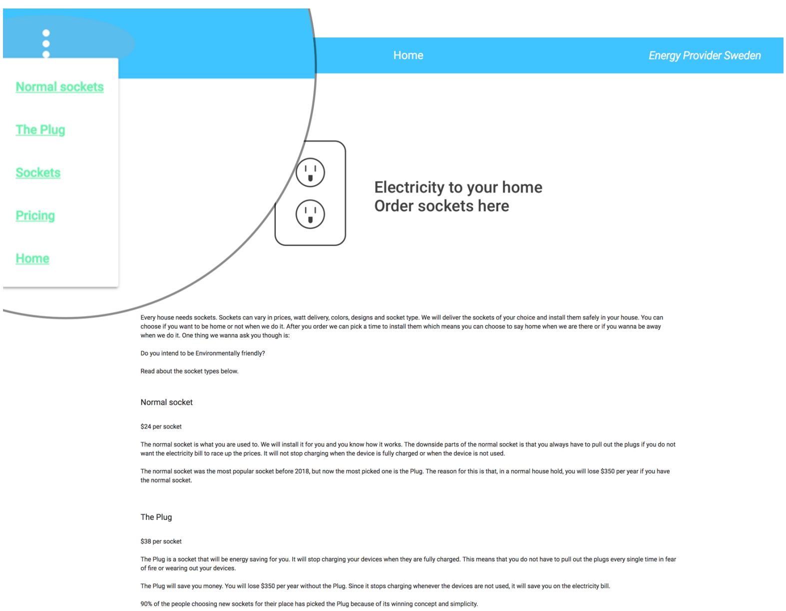

Figure 1: Inadequate UX: Home page displaying the navigation menu zoomed in.

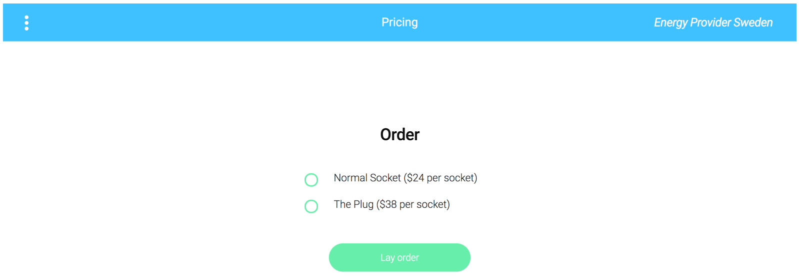

Figure 2: Inadequate UX: Pricing and order page.

The nudges were subtly located in the text. The priming nudge was located in the first paragraph on the home page. The framing nudge playing on loss aversion was located in the second paragraph under the title "Normal sockets" and the nudge playing on social norms was located in the last paragraph under the title "The Plug".

Design (b) - Good UX. The design that had a better UX was a single page website that was more straightforward to use (figure 3). The first thing the user met in the design, was the priming nudge asking if the user intended to be environmentally friendly. Next up came the two other nudges that played on framing, loss aversion and social norms.

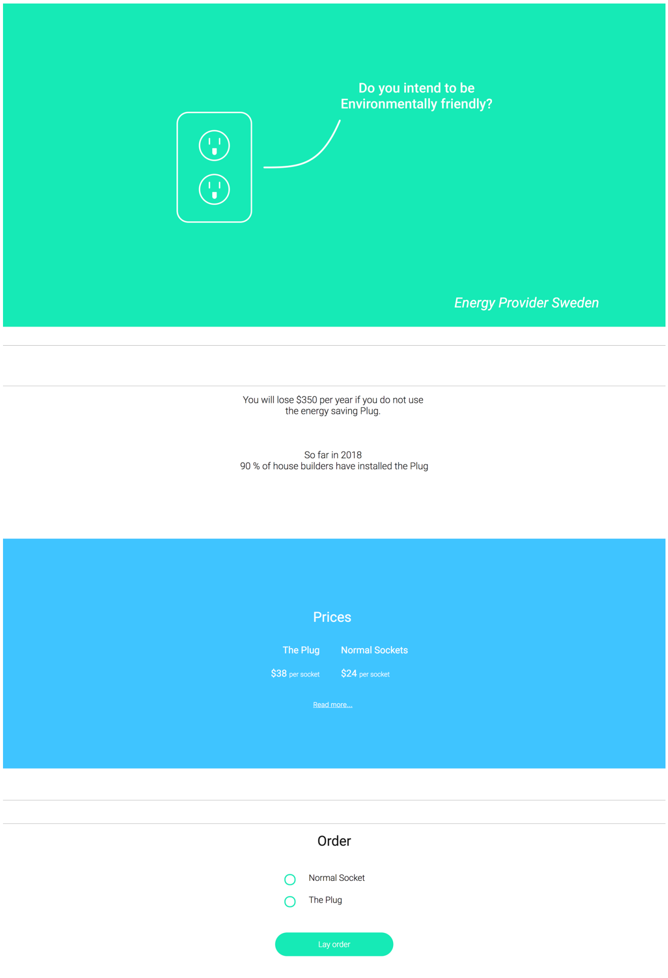

Figure 3: Good UX: Single page showing the good UX alternative.

Right after that came the prices for the two different sockets. Lastly came the order section. If the user wanted to know more about the different sockets, he or she could expand the pricing section to read more about the options (figure 4). The text that was displayed in the expanded section was the same text that could be found in the inadequate design. The aim was to make an intuitive design that pointed out the most important parts as well as making the navigation simple and natural.

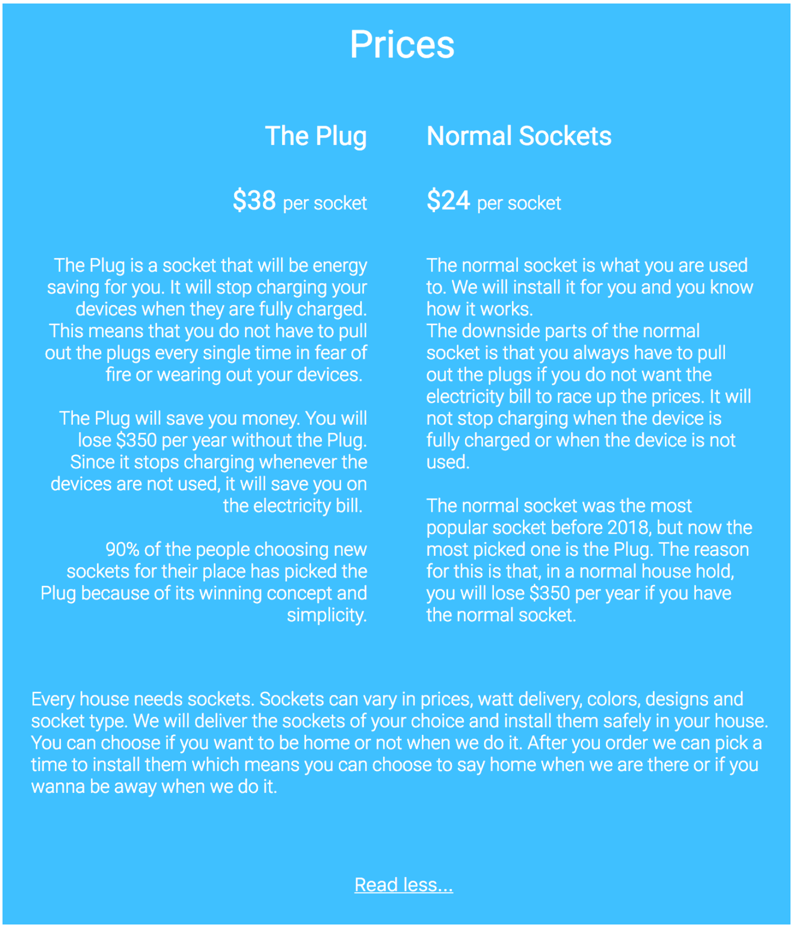

Figure 4: Good UX: Pricing information expanded.

3.4 Procedure

An examiner went through the test with the participant, one-on-one, during an average of a five minutes long session. The examiner explained the scenario to the participant and then introduced the website. The participant was then told to look through their options on the website before making a decision in the UI. After the decision was made, the examiner told the participant to fill in a Google Form survey with questions regarding basic characteristics (sex and age), why they chose the way they did and how the UX of the website felt like.

By looking at the final decision outcomes, an estimation was made to investigate the correlation between these two theories. The suggestion was that if the outcomes were the same in both designs, then UX and digital nudging were closely correlated. If the final outcomes varied a lot in the different designs, then UX and digital nudging were not closely correlated.

4 Results

The results show that when exposed to the inadequate design 60% chose the Plug and 40% the normal while among the participants exposed to the good UX design 100% chose the Plug. The reasons why the participants chose the Plug varied, some had multiple reasons and some had only one reason. The reasons and how of the many participants had them can be seen in figure 5. As for the participants that chose the normal socket, one reason was out of fear for the new Plug. One participant said that "the normal socket is safer because I know how it works. There was too little information about the Plug, therefore I did not trust it enough to buy it". The other participant that chose the normal socket as they did not really seem to read enough information about the options. The participant chose what sounded like a socket the most and since no sufficient information was read, the normal socket became the choice.

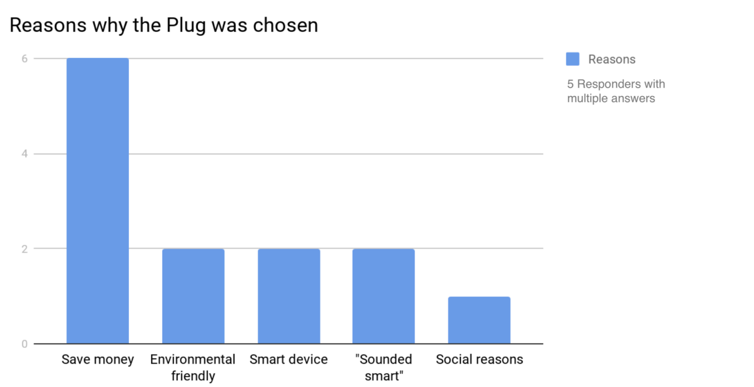

Figure 5: Reasons for choosing the Plug.

A summary of what the participants thought of the inadequate UX was that they:

- Did not like the dotted menu. It looked okay but it was confusing to guess if what you wanted to find might be there or not.
- Found it hard to understand how to add something as an order. They would have wanted to have an "add item" button in the same place as the product information.
- Found it hard to understand on what page they were going to order the sockets.
- Did like the colors.

A summary of what the participants thought of the good UX was that they:

- Thought it was very easy to navigate and find information as there were not too much distraction everywhere.
- Found the website quite trustworthy as it gave reasons and facts to why the plug was better.
- Thought it was intuitive and pleasing to the eye.
- Was confused that the Plug was on the left whole time but at the bottom on the radio button section.
- Had absolutely no difficulty in finding information. But when finding the expanded information, one participant said that he/she did not bother reading it because it was just a big wall of text.

By observing how the participants interacted with the websites, the decision came faster on the good UX website than the inadequate one. Also, the time to find the order section was significantly faster on the good UX website than the inadequate one where the participants navigated around a lot to find the right section.

5 Discussion

There are two matters in the materials used in the experiment that need to be highlighted before discussing the results. For (a) it was difficult to come up with a lot of text to fill the website. The design had to be as neutral as possible and not too informative in order to involuntarily prime or frame. Looking at the test results and how the participant reacted while picking the preferred socket, the longer text may have been a little bit too biased, in favor of the Plug. It would have been better if the text was slightly more neutral. Secondly, by observing the participants scrolling and clicking around on the websites, it could be seen that the participants did read almost all of the text on both of the sites. The participants that got the good UX website that seemed to decide faster on their option. This estimation was done by observation. A timer should have been used to see the actual time differences on deciding on their option and finding the order section.

Despite that, by reviewing the comments of the overall UX, time to decide and time to find the order section, one thing became clear. The design that was supposed to be good, actually was good, and the design that was supposed to be inadequate, actually was inadequate. This is also supported by Hassenzahl and Tractinsky (2006) since, as previously described, *the complexity, purpose, usability and functionality is vital for constructing a good UX*. The increased complexity of the navigation and disruption of the usability in the inadequate UX website supports this statement, as well as the efficiency and comments by the good UX participants. The same goes for the statements from Nielsen Norman Group (Norman & Nielsen, 2014) that *the product must carry elegance and simplicity that makes it a joy to own and use*. Just by looking at the comments from the participants from both groups, you can see the aesthetic and minimalist design was playing a role in how the participants experienced the website.

What is harder to affirm is to what extent the nudges played a role. By looking at the reasons why the participant chose the way they did, we can see in figure 5 that a lot of their answers contained the planted nudges (environmental i.e. priming, social i.e. social norm and economical i.e. framing loss aversion). This means that the nudges probably came through in a predicted way, but there is still always a chance that the participant chooses to ignore the nudge, meaning you do not know if they just ignored the nudge or did not see the nudge at all. More participants should have been tested in order to get a more definitive result. Still, because of the final outcomes, there is an indication that the nudges actually worked. The top reason for choosing the Plug was for the economical reason i.e. framing loss aversion. This, the social reason and the environmental reason, confirms that the nudges at least affected the participants' contemplation to some extent. It would have been interesting to see what would have happened if the normal socket and the Plug changed nudges. This could have confirmed that the nudges worked even better.

We know from the theory that nudges work, it has been tested in multiple studies. From the way nudges in the test scenario was formulated in such a good way that they at least changed some behavior in the participants. This means that a good UX, inadequate UX and good nudges (a requirement for this study) were created, even though some factors could have been more finely tuned. Nonetheless, the strongly favored option was the Plug, as all of the participants that had the good UX website and three of the participants that had the inadequate UX website chose this option. Only one participant that chose the normal socket did that for the justifiable reason that it felt safer to buy something when you know how it works. The other participant that chose the normal socket did not really seem to read about the Plug, and therefore might have missed the nudges all together. What still is interesting is that there actually was a difference in the final decision outcomes. The outcomes from the good UX website was exclusively the Plug, while it was not for the inadequate UX website, which is utterly interesting.

6 Conclusions

Only participants that had the inadequate UX website chose the normal socket, none of the participants that got the good UX website chose this option. The premise was that if the final decision outcomes differ, the correlation was high, i.e. the participants that got the good UX website chose the Plug and the participants that got the inadequate UX chose the normal socket. Because of the differences in the decision outcomes, this points to a correlation. It is not definitive, but it warrants further investigation.

Another interesting conclusion worth considering while designing with digital nudges, is the following. One participant that chose the normal socket expressed the feeling of tiredness while reading about the options. This resulted in her not even noticing the nudges by the result of inadequate minimalist design. This meant that the nudges in a way got affected, and invisible, that they did not even matter. As said before, this does not point to a correlation by itself, as the nudges was not read, but it stresses the importance of having a good UX in order increase visibility and to expose the nudges to the user.

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Selecting a Business Intelligence Solution that is Fit for Business Requirements

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Abstract Many companies, organizations, institutions and governments have recognized the operating advantages they can achieve by using new business intelligence (BI) technologies. However, to achieve those advantages, they need to choose a BI solution that best fits their needs. In this paper, we present an overview of twenty business intelligence solutions present on the market and describe their most essential and upcoming features. The features are presented in two groups - basic and advanced (upcoming) features. We present two tools that can facilitate the selection process of the organization's BI solution – the comparison table and the features pyramid. We detect four classes of maturity of BI tools reflected through the implementation of advanced features. Finally, we discuss obtained insights and provide some guidelines for choosing the right BI solution together with detected development trends.

Keywords: • Business Intelligence • Data Analytics • Big Data • Data Lake • Augmented Analytics •

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1 Introduction

More than two decades ago, business intelligence (BI) started as a query and reporting software module. New features such as online analytical processing (OLAP), data visualization, and mobile functionality have been added over the years, with the aim to make the use of such complex solutions as simple as possible for the end users. The growing need for BI is fueled by an explosive growth of data volume, competition in the market for customer acquisition and retention, and the growing availability of a variety of BI tools.

The market for BI is continuously evolving. Trends seasonally change, and the primary task of this work is to highlight important issues in the field and assess future areas of interest. Global BI solutions market is slated for significant technological changes. Data quality, master data management, data discovery, visualization, and self-service BI are the top points of interest. Also, technologies that BI users can expect are cloud BI deployments, mobile BI, machine learning (ML) and deep learning (DL) powered analytics, and stringent data privacy and security regulations (BARC, 2018a).

Artificial Intelligence (AI) and Machine Learning (ML) continue the process of BI software transformation. Organizations will increasingly depend on the automated data-analysis capabilities of powerful BI systems. Deep learning (DL) applications have begun to hit the markets, while AI research and ML applications have reached light maturation. In 2018, BI and analytics coupled with IoT thus rising the IoT-driven analytics. Most BI solutions offer data analysis, data visualization, ad hoc analysis, dashboards, ad-hoc query tools, ad-hoc reports, KPIs, and performance metrics which are all considered as the basic features of BI solutions. The rise of advanced business analytics across BI solutions can be directly attributed to cheap storage, high availability of massive volumes of data, and IoT devices (Dhar, 2012). All of this, supported by the rise of cloud services availability is one of the main reasons for the explosive rise of big data analytics.

At the 2018 Tableau Conference (Labbe, 2019) an approach that automates insights using machine learning and natural language processing (Gartner, 2018a) called augmented analytics was presented as the most important analytical trend. Rita Sallam, a Gartner analyst, said, "This kind of user experience will transform the market again. Augmented analytics is really about using AI. This technology enables more people to gain access to insights without having to be a data scientist". Additionally, numerous BI vendors tried to better incorporate AI technologies into their analytics products in 2018. Also, Gartner provides an overview of the latest market trends and vendor trends in 2019. Analytics and BI Gartner Magic Quadrant (Gartner, 2019). Some of them implemented AI assistants for easier queries. "They are all looking to augmented analytics" said Adam Smith, COO at Automated Insights. More startups dealing in augmented analytics can be expected as well as more partnerships/acquisitions by major BI vendors in 2019. Numerous solutions that specialize in a particular area of advanced analytics have partnership ties to BI platforms (e.g. Tableau, Qlik or Microsoft Power BI). CEO Adam Selipsky noted at the Tableau's user conference that the vendor made strides in 2018 to enable third-party developers to easily and deeply integrate their products and services into the Tableau platform. Other vendors will surely follow these trends. Cloud computing simplified the use of analytic tools and increased their popularity. Now businesses do not need to buy individual licenses for analytical programs and expensive computers for complex analytical processes because vendors offer low-cost subscriptions to use their business intelligence tools in the cloud. John Crupi, vice president of IoT analytics at IoT software vendor Greenwave Systems stressed: "Analytics is also going to be used in cloud computing and IoT, as users push for real-time analytics and analytics on connected devices, things that classic cloud computing cannot handle."(Labbe, 2019).

BI analytics exhibits the growth and development of SQL-on-Hadoop engines and solutions that provide native BI functionality inside data lakes which enable users to perform BI tasks on different types of data (structured or unstructured) either on-premises or in cloud-based data lakes. In the past, organizations have dealt with extracting, transforming, and loading data from data lakes into data warehouses for querying, reporting, and data exploration. Now, these new features reduce the need for those activities, since technology enables the data to stay in the original format. The feature which is also essential for easier and faster access to the contents of data lakes are search capabilities across all the diverse types of data. Next, it is to be expected that organizations will increase their utilization of SQL-on-Hadoop, as a native BI feature, enabling access to the data in data lakes. From technology, the focus will be shifted toward the development of interactive dashboards and other new types of visualizations (Rajesh, & Ramesh, 2016).

Streaming data and real-time analytics have also become one of the major strategic priorities for a rising number of organizations allowing a comparative advantage. Primarily this includes organizations that have deployed IoT devices as part of operational technology (Gartner, 2018g) and Industrial Internet strategies (Intrinsic Communications,2019). In cybersecurity, fraud detection, and other areas where immediate awareness is of essential importance these technologies are already relatively well established. However, it should be emphasized that BI software vendors are pursuing a range of technologies to provide BI and analytics users with ML algorithms enabling automated decision management systems from fresh data and frequent updates. Many organizations implemented operational data stores, which today may use Apache Hadoop clusters. To identify and capture data changes and data structures as they occur and inform users of those changes organizations are using change data capture (CDC) technology (Stodder, 2018).

It is a common denominator that organizations in the BI era should improve their flexibility and agility to explore and analyze data. Users are changing their information needs, and transition from dashboards toward new technologies and development methods need to be undertaken. Agile methods are used to improve how users and developers collaborate. In the same time, a significant step forward has been made in the implementation of agile, DevOps, and design thinking methods (Hani et.al., 2017) . DevOps methods have increased speed and flexibility of the implementation process, and design thinking methods help teams unleash creativity in developing requirements. BI self-service technologies fit well with agile and design thinking methods.

Following the rise of importance of BI powered decision making organizations are creating new positions such as chief data officer (CDO) or assigning "chief of data" responsibility to their CIO (chief information officer), chief analytics officer (CAO), or head of BI and data warehousing (DW). Primary responsibilities for the CDO are to improve trust, governance and usefulness of the data, adherence to regulations, oversee the protection of data assets, and increase the value of these assets. Self-service solutions allow users freedom to do more on their own, including data selection, preparation, blending, and visualization, but users still need to work with IT to expand, protect, manage and sustain what they may have achieved with self-service tools. Consequently, users better understand their information needs and IT and CDO should aim to create an environment where users are provisioned with trusted, governed data. Technology vendors will offer solutions with sophisticated capabilities to enable IT or CDO guidance.

In parallel, AI is finding its way into each facet of analytics, BI, data integration, and data management. It is expected to have a significant impact on the nontechnical user experience. The self-service BI trend enables users to become productive in the use of visualizations and data, so that analytics insights are a natural part of decision making and collaboration (Hani et al., 2017 & Umble et al. 2003). Advanced AI features will improve self-service capabilities further to let nontechnical users engage in more relevant data analysis. Advancement of ML, DL, and NLP will enable users to expand the scale and speed of analysis or reporting from larger volumes of data. BI solutions will offer continued innovation in using AI to augment BI and analytics for nontechnical users and will provide not just easier but smarter and faster usage (Victor, 2018).

The paper gives an overview of BI solutions against their basic and advanced features and provides possible directions for the integration of new BI features. Besides, two tools (a comparison matrix and a features pyramid) are presented for selecting the proper BI solution in a real setup. The matrix and pyramid enable the identification of current trends among BI tools and detailed insight into their functionalities.

This paper is organized as follows: an inventory of features in BI solutions on the market is given in Section 2. Section 3 presents the methodological framework for conducted comparison and presents the comparison matrix and the feature pyramid. Section 4 wraps up the main conclusions of this research.

2 Selecting the right business intelligence solution

To choose the right BI solution between a vast number of possible options available on the market it is necessary to decide which features are required and which ones are not necessary for the organization's needs. Does one choose a solution with basic capabilities or opt for an advanced platform with more specialized features? The answer is not straightforward, and to the end of this paper, we would like to elaborate on some of the possible answers.

Most BI solutions on the market today (>90%) offer basic (standard) features: data analysis, ad-hoc reports, dashboards, data visualization, performance metrics, ad-hoc query, ad-hoc analysis, and key performance indicators (KPIs) (Badawy et al., 2016). When choosing a BI solution, we should be cautious of the fact that some advanced platforms with more advanced or specialized functions do not cover all of the basic functionalities. Hence, some tradeoffs between the advanced functionalities and broadness of the tools are necessary. Additionally, it is possible that a product implements certain basic or advanced features from other solution vendors.

First, we present a comprehensive inventory of **advanced** features in BI solutions which users can expect/demand when looking for the right solution on the market:

- **Master Data/Data Quality Management** (MD/MDQ) - right decisions can only be based on correct data. The importance of MD/DQM stems from the need for data of high quality: complete, accurate, integral, consistent and timely. In that regard, BI solution vendors have concentrated on providing enhanced capabilities for managing master data and data quality such as data quality cycle (BARC, 2018a). Data quality cycle covers all the phases involved in providing high-quality information to business users: metric identification and definition, assessment, data repairing and cleaning, storage/cataloging/archiving, and exploration/ranking (Debattista et al., 2014 & BARC, 2018c). In this way, customers will be able to monitor and manage data quality from a single, unified source holding the master data instead of from multiple, disconnected databases.
- **Data Discovery/Visualization** - BI tools with advanced data discovery and visualization capabilities will decrease the need for involvement of data scientists during rushed preparation of data for decision-making. Exploratory data discovery coupled with visualization foster solving of sophisticated data analysis challenges. Moreover, machine learning is integrated into data discovery tools to guide business analysts through all steps from preparation to analysis to presentation (BARC, 2018a). The

solution must offer key features for connecting diverse sources, cleaning, enriching and shaping data to create new data sets to be used in the visual analysis or advanced analytics.

- **Self-Service BI** – a process in which end users design and deploy their reports and analyses within an approved and supported architecture and tools portfolio (Gartner, 2018b). Gartner predicts that the analytics output of business users with self-service capabilities will surpass that of professional data scientists. It will facilitate the learning of business users on how to use and benefit from effective analytics and BI tools, driving favorable business outcomes in the process (Gartner, 2018c). Self-service BI improves agility and speeds up the time to insight, but this should not affect the quality of results or efficiency. It must meet many requirements such as the increased speed must not compromise trust in data; enabling easy access and understanding of the data; all stakeholders and responsible parties should be involved in the restructuring process; data quality and consistency must be ensured through increased data security and governance. It is also vital to meet requirements in terms of architecture and governance and in achieving a balance between flexibility and control (Informatec, 2018 & BARC, 2018b & Henschen, 2013).
- **Data Governance** - a process that ensures that data meets precise standards and business rules when entering into a system (Experian, n.d.). In the past, lack of data protection caused considerable damage to many businesses (Norman, 2001). Hence, for the prevention of this failures data governance is implementing a data strategy, including managing of policies and frameworks, monitoring and protecting data capital while taking people, processes, and technologies into account. Data governance in compliance with regulations like General Data Protection Regulation (GDPR) (Marelli et al., 2018) is a sought hot feature for BI solutions.
- **Cloud BI/Data Management** - according to Gartner, many organizations will move a significant part of their data activities to the cloud by 2021 (Gartner, 2017). Hence, the majority of BI and data management vendors on the market offer a cloud-based solution at this time. Although cloud BI and data management have very similar functional capabilities to the corresponding on-premises product, they usually offer lower prices and reduce the burden of IT departments.

- **Augmented Analytics** - automates data insight by using ML and NLP to automate data preparation and discovery and enable data sharing. This process simplifies data to present clear results and provides access to sophisticated tools so business users can make the right decisions (Gartner, 2018a). AI and ML contributed to transforming augmented analytics into the discipline which is intuitive and comprehensible to ordinary business users, thus transforming the user experience (Victor, 2018). The expansion of augmented analytics also delivers improvement for IT decision-makers and managers.
- **Mobile BI** - organizations examine the benefits of providing decision-making opportunities to employees or managers no matter where they are located. Increased use of tablets and mobile devices are increasing the strength of mobile BI, witnessing increased business adoption, due mainly to their capacity to provide strong and clear data visualization in the form of charts and graphs as well as dashboards and scorecards (García, 2010).
- **Deep Learning-Powered Analytics** - DL is a type of ML that trains a neural model to perform human-like tasks, such as recognizing speech, answering questions in natural language or identify objects/actions in images or videos. By 2023, deep learning will take over as the preferred solution approach for data applications according to (Gartner, 2018d).
- **Real-Time Analytics** – the discipline that applies logic and mathematics to data to provide insights for making better decisions in a real time. For some use cases, real-time means the analytics is completed within a few seconds or minutes after the arrival of new data (Gartner, 2018e). Faster reporting and analysis of data is a challenge in many companies. Organizations have an increasing need to make data from transactional systems available immediately to support faster and fact-based operational decision-making. BI with real-time analytics features can complement an organization's existing BI strategy to gain new insights into data with additional, valuable findings (BARC, 2018a). To identify and capture data changes and data structures as they occur and inform users of those changes organizations have started using advanced change data capture (CDC) technology.
- **Agile BI Development** - a flexible and scalable architecture that embraces rapid, iterative development and the commoditization of data storage. It offers organizations the opportunity to swiftly adapt to changing business requirements while reducing total cost of ownership (Logi Analytics, n.d.).

Agile BI requires collaboration between business and IT, using rapid prototyping, enables organizations to increase development speed while better responding to business needs. The agile BI development approach is also supported by agile project management, by which planning, requirements collection, development, but also functional, regression and usability testing are managed in an iterative manner (BARC, 2018a).

- **Data Warehouse Modernization** - organizations are aware of new technological and business challenges. They recognize the potential of alternative methodologies to DW architecture design and utilizing other technical options like in-memory processing, cloud storage or data warehouse automation tools. IT must meet the needs for changing analytical requirements, and they must compete against new and cheaper implementation options from external service providers. Collaborative approaches are needed to cover the increasing expectations of the business to maximize the business value of the data. It is time to compare old data warehouses against present requirements and evaluate how updated hardware and technology could make the business better and easier (BARC, 2018a). Traditional data warehouses are not designed to handle the rapid growth in data and varying data types – hence big data. Also, they are not designed to keep pace with the continually changing needs of end users and the applications that rely on (Snowflake, n.d.).
- **Data-Driven Culture** - today's workforce offers more than ever before. The level of education, engagement, and know-how is higher than ever. With data-driven culture, organizations can extract all relevant data and fully utilize their values. Data-driven culture helps driving organizational culture to the next level of performance, by deriving relevant KPI's rooted in business. The transparency of data derived KPI's, is a key factor in data-driven culture approach in organizations (Data Driven Culture, n.d.).
- **Data Preparation for Business Users** - is the process of cleaning, structuring and enriching data for exploratory and advanced analytics. Data preparation aims to provide tools for shaping data to their analytical requirements without having to resort to IT technology. Intuitive and user-centric tools with sophisticated user guidance and immediate results are vital to spreading data preparation to business users (BARC, 2018a).
- **Integrated Platforms for BI and Performance Management** (PM) - supporting BI and PM on an integrated data platform with an integrated tool

is the aim of many organizations. For that reason, it has become one of the most stable and present trends in the BI market (BARC, 2018a).

- **Embedded BI and Analytics** - embedding intelligence in operational applications. Embedded BI and analytics are usually adding features associated with BI software (dashboard reporting, data visualization, and analytics tools) to existing non-BI applications. Embedded BI provides a much cleaner and friendlier user experience for customers and therein lies its primary advantage over solutions that require two separate platforms (Bitner, 2018).
- **Data Storytelling** – is tasked with data visualizations, infographics, dashboards, data presentations, etc. It is more than just creating visually appealing charts. Data storytelling is a structured approach for communicating data insights, and it includes a combination of three key elements: data, visuals, and narrative. When combining the right visuals and narrative with the right data, a data story that can influence and drive change (Dykes, 2016).
- **Using External/Open Data** - valuable insights can be gathered from social media, customer, market, meteorological, geographical and demographic data, and even from existing analytical findings. Organizations can acquire these and many other types of data from other BI generalists, specialist service providers or data trade platforms. Open data is often used to build business models around targeted analysis (Micek, 2017).
- **Analytics Teams/Data Labs** - are separate business units, specifically designed to begin data science in an organization. They require investments in new technologies to store, process and analyze data. As analytics gains in maturity, the deployment and productivity of such solutions become more critical. It is new challenges for software solutions providers and requires revised organizational approaches to link data labs, IT departments and business units (BARC, 2018a).
- **Visual Design Standards** - the practice of presenting relevant information in a way that it can be understood in an effective and efficient manner. Due to the growing need to analyze vast amounts of data in order to stay competitive and to provide the results most directly, the trend of visual design standards is establishing and gaining attention in the last three years. Support for visual design standards is increasingly seen as a criterion which

should be fulfilled for BI vendors in software selection processes (BARC, 2018a).

- **IoT Analytics** - while new sensor, mobile, and wireless technologies are driving the evolution of the internet of things (IoT) it is real business value needs to be found in analytics rather than in hardware novelties. Vendors are starting to offer such features to their customers, thus expanding their service portfolios into new business areas. IoT data requires real-time data analysis. Moreover, the diversity of IoT data means that new architecture, tools, and processes are necessary to implement in order to process, store and run effective analysis on IoT data (Harris, n.d.).
- **Big Data Analytics** - provides the means to analyze data sets of huge volume, variety and velocity gathered from internal and external sources including text, sensor, geolocation and clickstream data, etc. In this setup, big data analytics must effectively process large datasets in real-time or near real-time - including modeling, visualization, prediction, and optimization (Hu et al., 2014). Organizations are using big data analytics to support decision-making and process optimization (Galetto, 2016). Big data analytics includes structured data analytics, text analytics, web analytics, multimedia analytics, social networks analytics and mobile analytics (Hu et al., 2014).
- **Data Lake** –a large data store in a native state of structured and unstructured data according to the original definition by James Dixon (Rajesh & Ramesh, 2016). It is possible to store and process data in its raw, original form, straight from the data sources, without any cleansing, standardization, remodeling, or transformation. Data lake enables ad-hoc queries, data exploration, and discovery-oriented analytics because data management and structure can be applied on the fly at runtime (TDWI, n.d.). Design of a data lake is to store all of the data (relational, non-relational and big data) on the same platform (Shepherd et al., 2018).
- **Edge Computing and NLP** – delivers NLP processing closer to user requests. BI is witnessing efforts toward understanding user's behavior, attitudes, and emotions (Cambria, 2016; Shi, 2016). NLP in collaboration with DL has a pivotal role in understanding written or spoken language. Recently AI has made tremendous step ahead toward this goal, and it is to expect more BI solutions with integrates speech or language understanding technologies (Chandrayan, 2017).

3 Analysis and Discussion

The features outlined in the previous Section are integrated into many BI solutions on the market. The list includes basic features that are an integral part of all the analyzed solutions and advanced features that are rarely implemented into existing solutions. Advanced features are the ones to be expected soon.

For this research, we performed a thorough analysis of BI solutions on the market and their features against the selected features. We then narrowed the list of BI tools on the market to 20. Used methodology enabled structured analysis and comparison of BI solutions, hopefully providing better insights into the current state on the market and helping to select BI solutions that offer all/subsets of the features listed above. Moreover, the conducted analysis allows identifying current trends in BI solution development. This analysis can serve as the roadmap that may be consulted when selecting a BI solution that fits well with the organization's requirements. To this end, we created a feature-to-BI-solution cross table and derived a pyramid of features that reflect the trends in BI solution development – with a particular focus on new and upcoming features.

In Table 1 we list 20 selected BI tools (solutions) that are currently present on the market with a link to their specifications. In addition to the solutions offered by leading vendors (e.g., Microsoft, IBM, SAP), we have included smaller vendors that offer some interesting features (e.g., Avlino, Sisense, QlikTech). Majority of the analyzed tools have been included in Gartner's list of leading solutions for BI (King, 2018). Some of them, such as Domo, Sisense, Tableau, Power BI and Qlik, are on the Gartner list of best business intelligence and analytics software of 2018 as reviewed by customers (Gartner, 2018h). In general, the list includes easy-to-use solutions that support a full range of analytic workflow capabilities, which do not require substantial involvement from IT specialist, allowing end users quick adoption of tools. For example, tools can predefine data models upfront as a prerequisite to analysis, and in some cases, they allow automatic generation of a reusable data model.

Note that BI vendors are frequently releasing new versions with new features, so in this work, we are analyzing the state in the second half of 2018. For this reason, when choosing a BI solution for organization, it would be advisable to inquire about current and upcoming features offered in the BI solution of a particular vendor. The pace of BI solution development/release should be taken as one of the key factors for the selection because the number of its features increases and improves rapidly monthly. For the BI solutions listed in Table 1 in the next section, we analyze by assessing their functionalities against the proposed basic and advanced features of BI tools.

Table 1: BI solutions selected for the comparison, source: authors.

BI Solutions	Web page
Tableau	https://www.tableau.com/
MicroStrategy	https://www.microstrategy.com/us
BOARD	https://www.board.com/en
Looker	https://looker.com/
Longview	https://www.longview.com/
Sisense	https://www.sisense.com/
Pentaho	https://www.hitachivantara.com/go/pentaho.html
Domo	https://www.domo.com/
Yurbi	https://www.yurbi.com/
Power BI	https://powerbi.microsoft.com/en-us/
Qlik	https://www.qlik.com/us
Birst	https://www.birst.com/
Yellowfin	https://www.yellowfinbi.com/
GoodData	https://www.gooddata.com/
Dundas BI	https://www.dundas.com/dundas-bi
SAP Crystal Cloud	https://www.sap.com/products/crystal-bi.html

IBM Cognos Analytics	https://www.ibm.com/products/cognos-analytics
Salesforce	https://www.salesforce.com/
Avlino	https://avlino.com/
Jupiter	https://jupyter.org/

3.1 Feature to BI solution comparison table

In this section, we analyze the selected 20 BI tools against their functionalities in the form of product/feature matrix depicted in Table 2. Green checkmarks indicate integrated features of tools, and red x-es are showing the missing ones. This table allows reviewing the features for a particular BI solution and comparing it to other solutions. It gives us insight into the current situation on the BI market and helps identify solutions with advanced features. We can also identify solutions that offer some features that are not standardly included in BI solutions, such as data lakes and IoT integration, augmented analytics, deep learning, edge computing, and NLP.

The analysis revealed that over 90% of the analyzed solutions offer data analysis, ad hoc analysis, dashboards, ad hoc query tools, ad hoc reports, KPIs, and performance metrics, which belong **the basic group of features**. Besides, they are offering: data quality/master data management, data discovery/visualization, self-service BI, cloud BI deployments, BI on mobile, machine learning, real-time analysis, and big data analysis. It is important to point out that although most manufacturers offer the full spectrum of features in their solutions, they may, but not necessarily be, of the same level of functionality and quality as features in other solutions. Also, manufacturers do not need to develop each functionality separately. Since there are vendors in the market that are narrowly specialized in producing specific features, it is possible for manufacturers of complete BI solutions to implement these solutions in their tools, so that they will not spend their resources in developing the already-developed features. Hence, integration, connectivity, collaboration and partnerships between BI solutions manufacturers enabled quick solution development of the BI tools market.

The analysis confirmed that the majority of solutions enable integration of specific features from other products. For instance, advanced visualization capabilities of one solution can be incorporated into other products in order to offer their customers the best visualization solution. It is expected that vendors will lean toward integration of the highest rated solutions of other suppliers into their products, rather than developing their own.

Big data analytics already has a strong penetration into BI tools, since 19 out of 20 solutions list capabilities to perform big data analytics. Other advanced features will follow this development trend in 2019.

More than 40% of solutions already offer data lakes and IoT analysis – as advanced BI features. With the implementation of these upcoming BI features, organizations reduce the need for extracting, transforming, and loading data from data lakes into data warehouses for querying, reporting, and data exploration. Also, these options offer easier and faster access to the contents of data lakes and search capabilities of all the diverse types of data. Streaming data and real-time analytics have become one of the major strategic priority for a higher number of organizations as well. IoT analysis allows the organization to monitor and integrate into analytical systems all kinds of devices like industrial machines, vehicles, and readings from personal wearables. It enables better management of operational processes through real-time data, as well as future improvements through predictive maintenance or data-driven business models (BARC, 2018b). Users now have the option to implement the Internet of Things (IoT) devices as part of operational technology and industrial internet strategies. Since these technologies are not so new in the market, we can expect that these features should shortly become the standard of modern BI solutions.

Finally, analyzed BI solutions, as well as the rest of the technological world, are geared towards bringing machine learning, NLP and AI to their clients. As Gartner notes: Until 2020., the number of users of modern business intelligence and analytics solutions that are differentiated by augmented data discovery capabilities will grow at twice the rate — and deliver twice the business value (Bauer, 2018). BI solutions market trend indicates augmented analytics as a strategic planning topic, a paradigm that includes natural language query and narration, augmented data preparation, automated advanced analytics, and visual-based data discovery capabilities.

Table 2: Business intelligence solutions and the capabilities they offer presented in a business intelligence features checklist, source: authors.

Solution Features / BI Solution	Master Data / Data	Data Discovery /	Self-Service BI	Data Governance	Cloud BI / Data	Mobile BI	Real-Time Analytics	Agile BI Development	Data Warehouse	Data-Driven Culture	Data Preparation for Business Users	Integrated Platforms for BI	Apps integration	Embedded BI and Analytics	Data Storytelling	Using External / Open Data	Analytics Teams / Data Labs	Visual Design Standards	Big Data Analytics	Data Lake	IoT Analytics	Augmented Analytics	Deep Learning - powered	Edge Computing and NLP
Tableau	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗
MicroStrategy	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗
BOARD	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✗	✗	✗
Looker	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗
Longview	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗
Sisense	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✗	✗
Pentaho	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✗	✗	✗
Domo	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗
Yurbi	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✗	✓	✓	✗	✗	✗	✗	✗	✗	✗
Power BI	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗
Qlik	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗
Birst	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗
Yellowfin	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗
GoodData	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗
Dundas BI	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗
SAP Crystal Cloud	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗
IBM Cognos Analytics	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗
Salesforce	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗
Avlino	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗
Jupiter	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗

3.2 BI features pyramid

Next, we introduce the feature pyramid, which organizes BI features based on the frequency of their occurrence in BI solutions, as shown in Figure 1. The most common features implemented in the majority of the BI tools are grouped at the bottom of the pyramid, and rear features are at the top.

The **bottom** layer contains features that we categorized as **basic** and they are common to 60% of BI tools. The **second** layer is comprised of **augmented analytics, IoT analytics and data lakes**, which are implemented in roughly 20% of BI tools. However, about 40% of analyzed solutions report that they have started with the implementation of augmented analytics – in a more or less advanced form. Solutions offer revolutionary, visual access to complex data, backed by smart recommendation algorithms which make it easy for business decision makers to uncover hidden and useful insights. Also, the time required for data preparation using automation and embedded intelligence has significantly decreased. However, the analysis indicates that all the solutions are firmly directed towards augmented analytics.

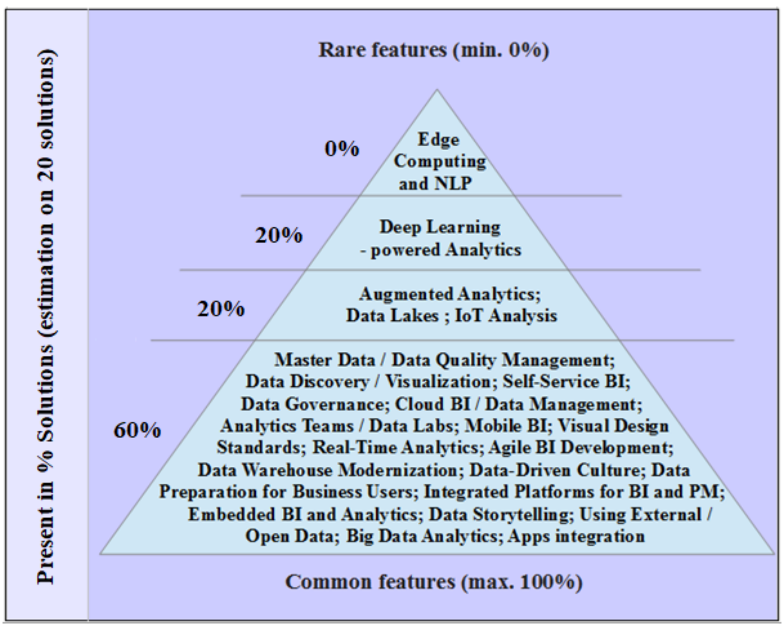

Figure 1: The pyramid of BI tools features, source: authors.

The **third** layer category contains **deep learning-powered analytics**. This analysis indicates that roughly 20% of the analyzed BI solutions offer variants of deep learning-powered analytics, where we emphasize the following examples of implementation:

- with the aim of solving complex problems the way human brains do (understand different patterns, run comparisons, understand differences across not a few, but millions of multilingual documents) we can get answers through a simple hover above the text - intelligence is embedded directly into web browsers, applications, and BI tools, and delivers results without any clicks and without delays;
- asking questions in natural language and getting instant responses - integrating solutions such as Alexa to turn analytics applications into a voice-enabled personal coach;
- personalized insights - dynamic and intelligent display that presents a personalized view of information based on who is standing nearby; or a smarter way to see - possibility use bluetooth-based identity detection to bring up data about some person or GPS technology to fetch data on a property or location.

The **top** layer contains emerging features like **edge computing and NLP**, allowing the BI solutions to understand human opinions, behavior, and emotions. The solutions we have analyzed do not offer such options yet (0%), but by reviewing trends, we can conclude that these features will soon be implemented in the next BI releases.

4 Conclusion

In order for the organization to gain the best value from its data, it is necessary to find the BI solution that best suits its needs. It is necessary to define which features the solution should have implemented whether the solution is easily adaptable, or is it easy to use, what kind of support it offers, how well it handles security issues, and finally what is the cost of such a solution. In order to help overcome all of these challenges, we have analyzed the current situation in the BI market at the end of 2018 and compared a list of 20 BI solutions against 24 features-functionalities.

The comparison matrix helps to compare the basic and advanced features of 20 analyzed BI solutions. The comparison matrix revealed that most of the BI solutions offer all the basic features, but significant differences can be found in the penetration of advanced features, present in less than 20% of tools. With the results of the analysis, we can conclude that Domo, Sisense, Tableau, Power BI and Qlik tools are on Gartner's list of best business intelligence and analytics software of 2018 as reviewed by customers because these solutions offer their customers more advanced features than other solutions. In addition to these tools included in Gartner's list, there are other tools including ones in this research that offer similar features and which should be taken into consideration. The table gives us the ability to use the same method of analyzing for any other tool and comparing it to some of the leading tools on the market and other tools analyzed in this paper. Also, if we are looking for a BI solution, this can be a starting point to gain a brief overview of the market and can help organizations in the selection process.

The feature pyramid offers insights into the current maturity on the market and indicates future trends in BI development. It gives a clear view of the standard features which are implemented in all of the solutions and clusters features that are just emerging and will be implemented in solutions in the future. Pyramid provides the general framework to assess the maturity of BI solution and enables detection of upcoming trends in provided BI features. Moreover, combined with categorization in Table 2 assess the exact position of BI solution with respect to features in competitive solutions. From the results, we have detected that none of the manufacturers have implemented edge computing and NLP in their solutions yet. However, we emphasize some of these features as a clear development direction which the most modern BI solutions will follow. Finally, BI solutions market is a very dynamic area, and it is likely that edge computing and NLP will transform future BI systems, which we plan to monitor in the future work.

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On Multi-Disciplinary Standardisation – The Case of Spatial Data on the Web

LINDA VAN DEN BRINK, ERWIN FOLMER & KAI JAKOBS

Abstract With the emergence of smart applications multi-disciplinarity is becoming an issue in standards setting, as is the need to involve a broader range of stakeholders in the process. One approach to accommodate these needs is the creation of dedicated multi-disciplinary Working Groups (WGs). Following some theoretical deliberations about today's standardisation environment in general and the need for multi-disciplinarity in standardisation we present a case study of one such joint multi-disciplinary WG. It turns out that this joint WG is seen as both necessary and helpful by those involved. It also turns out the broader organisational setting needs to be adapted to better address the needs of such joint WGs.

Keywords: • Standardisation • Open Geospatial Consortium • W3C • Multi-Disciplinarity • Spatial Data •

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1 Introduction and Some Background

In the past couple of years we have witnessed a development that is going to have major ramifications for society – the merger of Information and Communication Technologies (ICT) with well-known application areas like transport systems, manufacturing or power supply. The resulting 'smart' applications include, for example, Intelligent Transport Systems (ITS), Smart Manufacturing, e-health and Smart Cities.

While these applications represent the most popular outcomes of the injection of ICT into 'traditional' applications, similar developments are going on elsewhere as well. One example would be the educational sector, where the deployment of ICT enables new ways of teaching and learning like 'distance learning', 'blended learning' and 'e-learning'. These methods offer more flexibility to the students, allowing them to better align studying with e.g. work and family life.

Another such example, which will be discussed in more detail below, is the geospatial community and their technologies. In this field, multi-disciplinarity has a long tradition. Aerial photography started to become relevant for cartographers in the 19th century, later on followed by satellites. The use of computers and networks eventually led to geographic information systems (GISs), which may help analyse rather complex socio-economic and environmental phenomena (see e.g. [Krellenberg et al., 2013]).

The above examples show that 'no discipline is an island'. The development and thus the standardisation of smart applications requires co-operation of experts from very different disciplines. For ITS, for example, disciplines to be involved include e.g. Transport Telematics, Traffic Engineering, Power Engineering, Automotive, Computer Science and Telecommunication, but also e.g. Economics and Environmental Studies (see also Table 1 below). Contributions from just one individual discipline simply cannot adequately cover this diversity.

Likewise, in all cases globally accepted standards are a sine-qua-non for the development and eventual implementation of these systems. Standards will shape the technical development and thus, to a certain extent, the future. Therefore, a closer look at how exactly these standards emerge and if and how the standardisation process caters for multi-disciplinarity may well enable a glimpse into the future and thus (perhaps) even help avoid undesirable outcomes.

The world of ICT standards setting itself will also be affected by these developments. For one, the multi-disciplinary nature of many systems to be standardised will pose extra problems for the traditionally rather more 'mono-disciplinary' ICT standardisation process[1]. It will require co-operation between standardisation entities and individuals from very different backgrounds with equally different cultures. Standardisation experts will have to discuss the integration of technologies with very different life cycles, equally different legal boundary conditions (think Intellectual Property Rights, IPR) and diverse societal ramifications. On top of that, the latter will mandate the co-operation of societal stakeholders who are not normally represented in technical standardisation at all.
Many smart applications are highly likely to become truly omnipresent. Specifically, GISs will form an indispensable building block of the infrastructure supporting smart applications and may also serve as stand-alone applications in their own rights. This requires the widest possible participation of stakeholders in the standardisation process. This inclusiveness will also help increase the eventual standards' legitimacy and thus contribute to a higher degree of their acceptance.

The need for both multi-disciplinarity and inclusiveness raises the question whether or not the current standardisation system provides an adequate platform for such multi-disciplinary, multi-stakeholder standardisation or if new mechanisms and/or new standards setting entities need to be established and if so, which ones.

This paper focuses on the field of geospatial technologies. There are three motivations for this not exactly obvious choice. For one, these technologies represent constituents of both a smart infrastructure and (stand-alone) applications. Specifically, GISs will be crucially important for a range of smart applications (including e.g. Intelligent Transport Systems and Smart Cities) and will thus contribute to a societal impact way beyond what one would normally

[1] By way of an example: For the standardisation of IEEE 802.11 Jakobs et al. [2011, p. 98] oberved that "*Almost all the respondents have a strictly technical background, with job titles such as 'communication engineer' or 'system architect'*".

associate with geospatial data. Moreover, the level of multi-disciplinarity is rather high compared to what you will find in most standards working group (disciplines represented include cartographers, geologists, meteorologists and computer scientists), but still manageable. More importantly, the Open Geospatial Consortium (OGC) had established a co-operation with the World Wide Web Consortium (W3C) in the form of a joint working group (WG). Jakobs [2018] identifies such dedicated WGs as one potential mechanism for addressing multi-disciplinary standardisation for smart systems. This joint WG represents a real-world case in a very similar setting where effects and outcomes of such a joint endeavour may be analysed.

The remainder of the paper is organised like this: Following brief discussions of the current standardisation environment and the need for multi-disciplinarity in standards setting, respectively, the paper will study the OGC/W3C WG in detail by explaining the research approach, providing the detailed formal description of the situation and discussing the outcome of a survey held among participants. The final discussion and conclusions will integrate the respective insights.

2 The Standardisation Environment – A Very Brief Recap

Most industry sectors have a rather simple standardisation environment. A number of National Standards Organisations (NSOs) contribute to the work of ISO and IEC at the international level. An additional regional level in between has been established in Europe through the European Standards Organisations (ESOs).

The situation is different for ICT (specifically in telecommunication). This sector is characterised by a number of national/regional bodies and, particularly, by more than 250 private standards setting consortia[2] . The number of consortia and the complex links that exist between them and the Standards Developing Organisations[3] (SDOs) yield an almost impenetrable maze of Standards Setting Organisations[4] (SSOs). Figure 1 gives a rough idea of this complexity.

[2] Like the W3C or the OGC.
[3] 'Formal' or accredited bodies like ISO, IEC, ITU.
[4] Both private consortia and SDOs are SSOs.

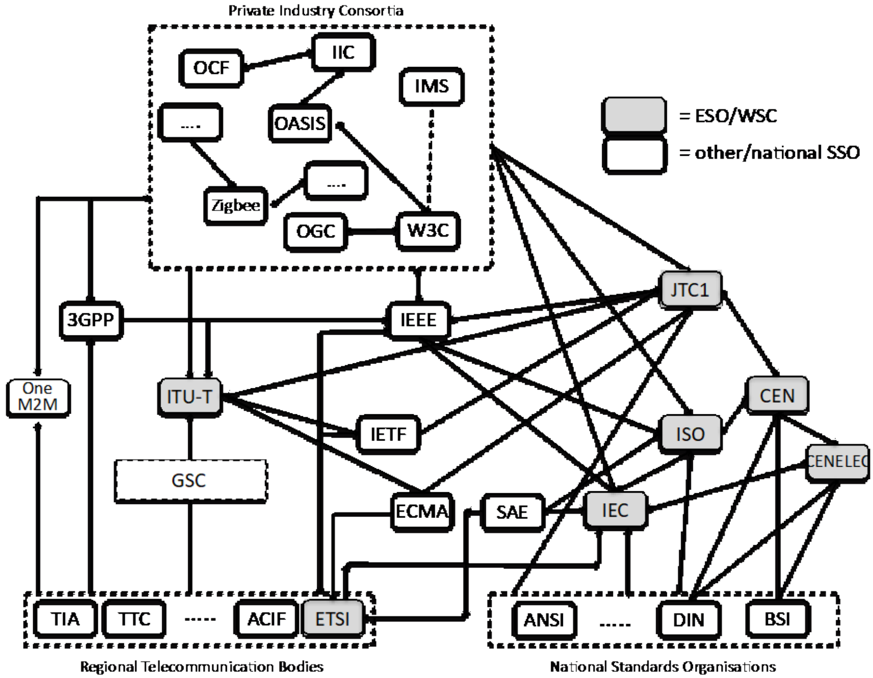

Figure 1: The web of relevant SSOs (excerpt, in terms of both entities and links; adapted from [Jakobs, 2017]).

The figure shows an excerpt of the web of the major relevant SSOs. These SSOs differ widely in terms of e.g. coverage (both topical and geographical), processes, by-laws, voting procedures, IPR policies and membership bases. ISO, for example, covers all areas of standards setting except for electro technology (covered by IEC) and telecommunication (covered by ITU); its membership base comprises national standards organisations (NSOs). In contrast, the IETF focuses on standards for the Internet (with individual 'membership'), the W3C on web standards, the Global Learning Consortium (IMS) on standards for e-learning and the OGC on standards for the geospatial community; the membership bases of the latter three are made up of companies, universities, research institutes and (in the case of OGC and W3C) governmental and other organisations.

The figure also shows some of the links that exist between SSOs. Generally speaking, such a link represents some level of formal co-operation. Such cooperation may take the form of an information exchange about planned new work items, the joint development of standards or anything in between. These links currently represent the most important (distributed) formal co-ordination mechanism in standards setting.

Not least for readability reasons the figure does not include the various national, domain-specific organisations that develop e.g. national profiles based on the international standards for individual domains. There are about thirty such organisation in the Netherlands alone. Folmer et al. [2011] discuss how to deal with and to manage this variety from a Dutch perspective.

3 The Need for Multi-Disciplinary Standardisation

Multi-disciplinarity is not an entirely new phenomenon in the ICT domain. After all, ICT itself is the outcome of a merger of Information Technology (IT) and Telecommunication. The former is mostly the domain of computer scientists, the latter of telecommunication engineers. Despite the differences that may be identified in the discipline-specific approaches and tools these disciplines are still close enough to enable a comparably seamless co-operation (similar backgrounds, terminologies and mind sets). Nevertheless, in standards setting the two domains never really converged. On the bottom left hand side of Figure 1 you will find the SSOs active in telecommunication, with rather limited links to their counterparts active more on IT or the application side.

Things become much more complex when more diverse disciplines (and stakeholders) are (or should be) involved. Table 1 gives three examples of the diversity of stakeholders that should be involved in the standardisation of Intelligent Transport Systems, e-Learning and Geospatial Technologies, respectively. Some of the disciplines identified for the latter two are not normally involved in standardisation at all. It can easily be imagined that finding a common ground in such cases will be problematic and thus time consuming.

Table 1: Disciplines involved in different application areas (no claim for completeness)

Intelligent Transport Systems	e-Learning	Geospatial Technologies
Transport Telematics	Pedagogy	Cartography
Traffic Engineering	Management Sciences	Geology
Power Engineering	Psychology	Meteorology
Automotive	Information Studies	Linguistics
Computer Science,	Computer Science	Information Systems
Telecommunication	Telecommunication	Computer Science
Logistics	…..	…..
…..		

'Disciplines' is one dimension of diversity in the standardisation activities shown above, 'stakeholders' is another one. The development of standards that are not just technically sound but also economically viable, sustainable and of societal value will necessitate the involvement of an extremely wide range of stakeholders. In addition to representatives of the numerous technical disciplines listed in Table 1, these include other groups that are not normally represented in standards setting: e.g. citizens, professional associations, NGOs and unions.

As mentioned above, standardisation has typically been rather mono-disciplinary. Moreover, at least the ICT sector has traditionally been dominated by large vendors. Accordingly, the meaningful involvement of 'non-standard' disciplines and stakeholders is a non-trivial task.

This involvement may materialise in different forms. Co-operation between different more or less 'mono-disciplinary' WGs could be an option. In this case, individual activities could continue as usual, problems would occur 'only' at the interface between the WGs. These problems might, for one, stem from different boundary conditions of the individual WGs. Those in ICT standardisation are different from those in most other areas. Reasons include, among others, ICT's typically short technology life cycle (compared to e.g. geographic information), that necessitates a speedier process. Different standardisation 'cultures' represent a related problem. In ICT, the amount of money that frequently is at stake may well lead to a more competitive environment. Plus, the inter-WG communication problem as well as the issue of broad stakeholder involvement in the individual WGs would persist.

Joint participation in a dedicated individual WG would be another option. In this case as well, problems likely to be encountered will relate to the actual active involvement of primarily the non-technical stakeholders and the lack of common ground and of mutual understanding. These are problem generally encountered in multi-disciplinary co-operation (see e.g. [Bruce et al., 2004]) and standardisation is no exception. On the other hand, once these difficulties have been overcome this setting would experience less friction losses than the one above.

4 Approach

In the previous sections we discussed multi-disciplinary standardisation from a generic, broad and rather more theoretical perspective. In this part we will dive deeper into the subject by studying a specific case in the geospatial domain. In this section we will explain why we selected this case study and which research method we applied. This is followed by a description of the situation in section 5; the results of the survey are being presented in section 6.

The research approach we applied is a case study approach, with some action research characteristics. The case study allows us to do a specific in depth qualitative study (Yin, 1984) on the standardisation process of the multi-disciplinary OGC/W3C working group (WG). This research also features some 'action research' components as one of the authors was intensively involved in this WG. Based on this involvement we had the opportunity to organise a survey among the participants of the WG. The combination of Action Research and Case Study research allowed us to gain in-depth knowledge, however the lack of repeatability and rigour is seen as disadvantage of action research (Baskerville & Wood-Harper, 1996).

The case study at hand is the OGC/W3C Spatial Data on the Web Work Group (https://www.w3.org/2015/spatial/wiki/Main_Page).

Our research goal is to learn about the need for multidisciplinary standardisation, the setting in practice, and the future plans

The questionnaire consisted of 10 open questions in 6 themes. It was sent out to the WG, a total of 90 e-mail addresses. The survey was sent to all members that had been participating in the working group at a certain point. Since the working group was quite dynamic, several people were only active for a minimum time. Others were following the work, but not participating actively. Also several e-mail addresses bounced. We received six (mostly extensive) responses, which were used for the analysis in section 6. The responses (e-mails) were anonymously processed and used, the respondents were all heavily involved in the Work Group; half of the respondents from W3C perspective, while the other half either both W3C/OGC or OGC affiliation.

5 Description of the Situation

For sections 5 and 6 we use the same structure: First, we study the problem/need for which the multi-disciplinary WG was needed. Second, we study the organisational setting in which the WG had to work, and third we look at how the WG worked in practice. Finally, we discuss the future aspects of the WG.

Problem/Need

In many ways OGC and W3C are comparable standards organisations. Both were founded in the late nineties, are concerned with technical standards, and are member driven organisations that publishing open, freely accessible standards. The OGC is focussed on standards for publishing geospatial data and services. The W3C is focussed on standards for the world wide web. As described in [Taylor and Parsons, 2015], both organisations recognised a need for co-operation when it became obvious that OGC needed input from the Web standards community in order to enable the dissemination of geospatial data to a larger audience, beyond the geospatial domain. The W3C, in turn, needed input from the geospatial standards domain in order to make spatial data a native member of the Web.

The organisational setting/construct

To address the need for co-operation, OGC and W3C created a joint working group, the Spatial Data on the Web working group (SDWWG), in 2014. On the W3C side, this was a Working Group – a group mandated to produce standards. On the OGC side, it was a subgroup of a Domain Working Group – not a group officially in charge of producing standards. The 'real' WG was thus living within the W3C organisation. To become a part of the WG, one had to be a member of either OGC or W3C. It was also possible to join without being a member of either, but this was an exception. The W3C standards creation process and tools were used. All OGC members who joined the WG were given 'invited expert' status by W3C staff so that they could access W3C member-only resources and attend meetings. Upon joining the group, participants had to declare to have reviewed the W3C process document[5] on individual participant qualifications, Invited Expert participation in a WG and good standing and to agree with the participation conditions in the charter and the W3C patent policy.

The W3C tools for a WG include two mailing lists (one public, one publicly archived but only usable by group members), a GitHub repository for file storage and issue tracking, used in combination with ReSpec for collaborative open document authoring, the WebEx conference tool, IRC to chat and mainly to record minutes during meetings, another issue and action tracker which could be easily managed using IRC during meetings, and a wiki for publishing working group minutes and group documentation.

In order to satisfy legal requirements of both SSOs, every meeting started with a patent call. The intellectual property rights policies by OGC and W3C were compatible. In the W3C process, group participants are made aware of the IPR policy when joining the group; in the OGC process attendees have to be made aware of it at the start of each (virtual or physical) meeting.

[5] The then current W3C process document can be found at https://www.w3.org/2014/Process-20140801/.

The working group in practice

The working group charter stated that every effort would be made to have at least two face to face meetings each year, one at an OGC meeting and one at a W3C meeting. The two SSOs have different meeting frequencies, and both have varying meeting locations related to member organisations who offer to host. The W3C has one annual meeting where the working groups have the opportunity of organising a face to face meeting: the TPAC (Technical Plenary / Advisory Committee) meeting. During the years the working group was active, they met each year at the annual TPAC meeting. The OGC has four meetings per year where WGs can meet: the OGC TC (Technical Committee) meetings. The working group polled its members to determine the best suited OGC meeting in each year. In practice, if TPAC was outside Europe, an OGC meeting in Europe was selected, and the other way round. In addition, a third face to face meeting was held each year. These meetings were not hosted at an OGC or W3C meeting, but by a member of the working group.

The frequency of web meetings (teleconferences) was biweekly. After a startup period it became clear that members were invested in several topics, with little overlap (i.e. members interested in one topic were often only interested in that specific topic, and less able to make active contributions on other topics). It was, therefore, decided to have a 'plenary' teleconference every other week where highlights and progress of all topics were to be discussed, and 'subgroup' teleconferences in the alternate week to discuss specific topics in depth. There were three subgroups: One working on the spatial data on the web best practice (SDWBP), one working on the Semantics Sensor Networks ontology (SSN), and one working on coverage data on the Web. Other topics, such as OWL Time[6] , were mostly collaborative efforts using e-mail and GitHub, in addition to the plenary teleconferences and face to face meetings.

The first WG meeting was a teleconference held in January 2015. The group's first product was a Use Cases and Requirements document, the first draft of which was published in July 2015; the first draft of the SDWBP followed in January of 2016. For this document, an agile process was adopted after a slow start, featuring short development cycles and many working draft releases. The

[6] Time Ontology in the Web Ontology Language (OWL).

final release was published in September 2017. SSN and OWL Time followed in October 2017. A notable detail is that these are the publication dates of these two documents as W3C standards; the same standards are going through the OGC standards endorsement process at the time of writing, after a belated start of this process.

Future

In W3C, standards WGs always have an end date. In this case, the working group got a term of two years. This was extended by six months in order to be able to finish the key deliverables, SDWBP, SSN, and OWL Time. After the closing of the working group, an 'interest group' was formed as a joint OGC/W3C group, also with a two year term. An interest group in W3C terms cannot publish standards, although it can publish other products as long as they are not 'normative'. On the OGC side this is called a domain working group. This group focuses on finding and co-ordinating standardisation topics to be addressed in the scope of spatial and web. The group can publish errata for the published standards, but cannot make other changes: in that case a new working group would have to be formed.

6 Evaluation of the Working Group

This section reports on the qualitative analysis of the survey being held among the participants of the working group. The coding of individual respondents is given in brackets.

Problem/Need

The WG originated from a workshop in which the participants made clear that the collaboration was needed. That is, the whole collaboration was driven by actual needs and bottom-up, rather than top-down, initiated by the standardisation organisations involved. From the knowledge perspective it was obvious that geospatial expertise was needed as well as Internet expertise; having both dimensions on board should be beneficial for the quality of the WG deliverables. Yet, this was also important for adoption purposes as the outcome would have the appraisal of both OGC and W3C. Interviewees' replies indicate that the collaboration was beneficial (#6) or at least necessary (#2,3,4,5).

The organisational setting/construct
Practically:

> *"In my view, the infrastructure used by W3C surpasses anything used in other standards development processes." (#1)*

which is likely the explanation why the W3C infrastructure was used and did not lead to negative remarks. Only the deviation by the WG from the W3C infrastructure, by introducing Github, was not appreciated by all:

> *"...the mess triggered by the transition to GitHub... " (#3).*

The use of the W3C infrastructure might be the obvious choice, but

> *"The environment is a bit unwelcoming for OGC members that are not W3C members though…" (#5)*

Organisationally: The original setting did not lead to major issues (at least none were mentioned), but from this response it is clear that the setting was certainly not perfect and could be improved for further collaborations:

> *"This didn't happen - thankfully - but there was always the possibility that one SDO would refuse to formally publish a document that the other one did. There is also a potential future problem of one SDO wanting to update a standard without the involvement of the other. The whole collaboration depends on goodwill and that goodwill must be institutional and not based entirely on individual relationships." (#1)*

The working group in practice

None of the respondents felt two camps of W3C and OGC members in the working group, or misunderstandings or culture issues between the W3C and OGC members. Rather, the issues mentioned relate to commitment (limited time of members and dropping in/out) and ego's as shown by the following statements:

> *"That was not a W3C - OGC split, more the presence of too many strong egos/low availability to contribute in the contributors" (#3) and*
> *"Overall experience I have to say was mixed. Mostly due to the part-timeness (of most people) and stop- start (of some people) with strong personalities." (#4)*

Although time commitment is likely to be a general problem in standardisation WGs, it might have a stronger impact for this group as both types of group members did need time to learn from the other group background:

> *"But as always, this [knowledge transfer] adds complexity and is more resource intensive." (#5).*

Future

The respondents see a future for continuation of multi-disciplinary standardisation for the spatial and web domain:

> *"It should be continued if possible. Because AR [Augmented Reality] is around the corner, and is the ultimate mix between geospatial and web concepts." (#5).*

This is also supported by the following quote:

> *"Yes, there is ample opportunity for collaboration between the W3C and OGC and also other standardisation bodies. Examples are data models/ontologies for moving objects and their environments (autonomous driving), IoT, AR/VR etc. The latter two could also involve IEEE and ISO." (#6)*

Lessons Learned

Although the respondents were critical about the process, it does not seem to have affected the produced standards as results:

> *"the group produced a set of standards and formal documents endorsed and published by two SDOs simultaneously, so that members of either community would feel comfortable using them." #1. And although our survey did not explicitly ask about quality, the first signs are positive:*

> *"the BP doco which is quite good - you should investigate how much it contributed to the adoption of linked data in Ireland (GeoHive, CSO), Switzerland ....) (#3).*

A major lesson learned is the higher resource intensity of multi-disciplinary standardisation WGs:

> *"More resource intensive overall and also individually, as more time is required to understand different domains and different processes" #6.*

This higher resource intensity leads to higher costs:

> *"the cost of running larger and more diverse groups (SDOs hubs) is higher (and possibly not sustainable for organisations like W3C). The money which could go into such initiatives is more likely to be spend through national (or European) data integration initiatives (e.g. INSPIRE, ...)" (#3)*

If improvements were made in the organisational setting, multi-disciplinary standardisation could be easier:

> *"Having been one of the people who set up the OGC/W3C collaboration I know it's much harder to do than one might imagine. But I definitely felt it was worth it and that the same principle could easily be applied elsewhere." (#1)*

and

> *"But it is hard. SDOs have membership rules, IP policies and ways of working (in public, in private, somewhere in between) and so working together does present real problems that need to be overcome." (#1)*

And then it comes down to the business model of standardisation organisations:

> *"What makes such collaborations difficult to setup or continue on a long-term basis is the business model of most standardization organizations, based on membership fees." (#5).*

By having this membership model standardisation organisations have become competitors which is not beneficial for co-operation in multi-disciplinary standardisation.

7 Brief Conclusions & Further Research

This paper touches upon the topic of multi-disciplinary standardisation by first of all providing a brief overview of the standardisation context. Multi-disciplinary standardisation will increasingly be necessary when standards are to solve real problems. A trend currently going on is that standards no longer remain within the artificial boundaries of individual SSOs. Rather, standards (will) increasingly have cross-domain characteristics. One approach to address this phenomenon are multi-disciplinary standardisation working groups through which standardisation organisations work together.

The Spatial Data on the Web Working Group is a successful example of such multi-disciplinary co-operation between the geospatial domain (OGC) and the Web domain (W3C); its outcome is widely perceived as valuable for both communities. On the one hand, this supports the call for a more centralised entity for multi-disciplinary standardisation made in [Jakobs, 2018]. On the other hand, the majority of experts surveyed there were opposed to such a new entity or new entities, typically arguing that the situation is complex enough as it is, without any additional new entities. A major difference between the two groups of experts studied in [Jakobs, 2018] and in this paper, however, is the fact that the latter have actually experienced multi-disciplinary standardisation in a new, dedicated entity (the WG). Whether or not this is the only reason for the diverging views or if other aspects are also decisive remains to be seen.

In any case, we may expect to see more multi-disciplinary standardisation WGs in the near future. With this research we hope to contribute to the knowledge base of how successful multi-disciplinary standardisation may be performed. However, from our research it also became apparent that it is not an easy task for SSOs to work together in such a way and that it may well require a rethinking of SSOs' business models. The wider organisational setting for multi-disciplinary standardisation, therefore, needs improvement. Further research on an optimal such setting is still needed. Moreover, the quality of the outcome should be studied: Did the multi-disciplinary nature of the WG lead to a better standard?

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On the Road to Telemedicine Maturity: A Systematic Review and Classification of Telemedicine Maturity Models

LENA OTTO, DIANE WHITEHOUSE & HANNES SCHLIETER

Abstract Telemedicine, seen as a solution for growing healthcare problems, is still not reaching its full potential. Telemedicine pilots can result in high costs, without successfully increasing patients' wellbeing as intended. Appropriate tools for scaling up telemedicine, like prescriptive maturity models, are needed. They can help people to assess the status quo and make progress with the scaling up process by presenting them with pre-defined improvement measures. Prior research has already led to the development of such tools, but an overview is still lacking as to which models fit which purpose and whether the measures presented are helpful and, if so, in what way. The aim of this research is to provide an overview and classification of existing prescriptive maturity models for telemedicine. A systematic literature review has been conducted and a classification scheme derived to assess the identified models. The resulting overview outlines a starting point for on-going research and presents a scheme for assessing existing models with regard to how fit they are for usage.

Keywords: • Models • Overview • Readiness • Telemedicine • Maturity •

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1 Introduction

Telemedicine, as part of eHealth, is seen as the solution to a number of problems in many healthcare systems. It promises to increase patients' access to care while decreasing costs (Hjelm, 2005). Even though first attempts at introducing telemedicine were already made in the 1960s (Thrall & Boland, 1998), the diffusion of this innovation is still hampered and telemedicine initiatives seldom reach regular care (Boonstra & van Offenbeek, 2010; van Dyk, 2014). This phenomenon is linked with the term "scaling up" that describes the process of bringing pilot projects to an increasing number of people who can benefit from them (Simmons, Fajans, & Ghiron, 2007). Without successfully scaled up telemedicine initiatives, high costs result from the development of telemedicine pilots without increasing the empowerment and wellbeing of patients, as intended. The need for scaling up has also been recognised by the European Commission (EC) and the World Health Organization (WHO), which have enlarged this expansion process, e.g. to new applications, organisations or territories (EC, 2015; Uvin, 1995) in their policy and research agendas (EC, 2015; WHO, 2009).

Maturity models are one tool that can successfully support scaling up (van Dyk & Schutte, 2012) by defining the status quo and guiding the following improvement process (Becker et al., 2010; De Bruin et al., 2005). Prior research has already reviewed existing telemedicine maturity models or tools and evaluated them from various foci (Mauco, Scott, & Mars, 2018; Yusif, Hafeez-Baig, & Soar, 2017). However, the studies do not help in identifying models which aim to proactively support the user and give substantial guidance for the improvement of the status quo. This paper, however, provides an overview of the current state-of-the-art of maturity models for telemedicine through the means of a systematic review. This should help researchers to address existing deficits in models and aspects for future research (Rowe, 2014). Furthermore, it should help practitioners to assess existing tools regarding their usage in ascertaining the readiness of a site or organisation to undertake a telemedicine initiative.

The remainder of this paper is structured as follows. In the next section, the concepts of telemedicine and maturity are introduced before the research method for identifying existing models is explained in section 3. Afterwards, the classification scheme to compare the identified models is developed (section 4) and applied (section 5). The results from the previous sections are then discussed (section 6), before conclusions – accompanied by an outlook for future work – are put forward (section 7).

2 Telemedicine and Maturity

Telemedicine, as part of eHealth, describes the location- and time-independent delivery of healthcare services and/or medical education by professionals through the use of information and communication technology (ICT) (Sood et al., 2007). Healthcare disparities, especially in rural or underserved areas, can be overcome by the use of telemedicine since it connects electronically patients and professionals who are geographically distributed (Zapka et al., 2013).
Telemedicine initiatives are highly complex, and are influenced not only by their users, their behavioural and ethical concepts, but also by surrounding factors like legal, organisational or financial conditions (Broens et al., 2007; Ly et al., 2017). To successfully scale up telemedicine initiatives, this complexity needs consideration. Addressing telemedicine initiatives' complexity is mostly done prior to implementation by referring to "telemedicine readiness". Readiness describes the "degree to which users, healthcare organisations, and the health system itself, are prepared to participate and succeed" (The Alliance for Building Capacity, 2002, p. 2) with telemedicine implementation. Supporting tools for telemedicine scaling up should include the provision of improvement measures, by helping users understand which steps could be taken in what context and by guiding them during the implementation process. As one such support tool, a maturity model describes a path to reach an advanced stage of maturity, including the definition of the current status quo, an overview of next steps, and the provision of a common understanding for different stakeholders to work on (Katuu, 2016; Klimko & Remenyi, 2001). Being mature is hereby defined as "having reached the most advanced stage in a process" (Oxford Dictionaries, n.d.). The entity under consideration can be people, processes or objects (Klimko & Remenyi, 2001).

Maturity models typically consist of dimensions – that are described and that reflect the domain to which the model refers – and levels, including a descriptor (e.g. initial, defined, optimising) and characteristics for each level (Fraser, Moultrie, & Gregory, 2002). Depending on the model's design, three types of models have been differentiated: Capability Maturity Model (CMM)-like models, Likert-like questionnaires, and maturity grids. CMM-like models are based on a formal design: a specific number of levels are described, with no further details for each activity per level. Likert-like questionnaires are seen as simple maturity models where each question displays a good practice and needs to be ranked by the respondent with a score, mostly from 1 to n. No additional information for each score is provided. Maturity grids describe each level of each dimension in a textual manner and further guide the assessment process (idem).

Independent from the type of maturity model used, each model can be descriptive, prescriptive or comparative in nature. Descriptive maturity models describe the as-is situation, while prescriptive models further add the provision of steps for improvement from that point on. Comparative maturity models permit comparison between different industries or regions but require that a wide range of adequate data is collected. This requires the development of a descriptive model first, before understanding and addressing the need for improvement in a prescriptive model (De Bruin et al., 2005).

3 Method

A systematic literature review was conducted to identify relevant maturity models. To avoid bias by exclusively searching articles in leading journals, we searched in various databases (Webster & Watson, 2002). PubMed/Medline, AISeL, Academic Search Complete (via Ebsco Host), ScienceDirect and Web of Science were considered to be relevant databases.
Some discretion had to be used with regard to the terms chosen. The search string was widened at an early stage of the research. The term "telemedicine" is not used consistently in the literature (Bashshur, Shannon, & Sapci, 2005), which led to the inclusion of related terms (Meskó et al., 2017; Otto et al., 2018) to lower the bias involved in having different understandings of terms: a number of synonyms were tested or added to the search string. The same was done for "maturity" (examples included "readiness", "scaling up", "preparedness" and "assessment") and for "model" (additional kinds of instruments were included in the search).

The following search string was applied to title, abstract and keywords because some variety of these terms should appear in these three fields if the topic is indeed a major one in the paper investigated:

- "((telemedicine OR telehealth OR ehealth OR "e-health" OR "digital health") AND
- (maturity OR readiness OR "scaling up") AND
- (model OR framework OR tool OR level))".

The literature search led initially to 291 results which were screened step by step (see Figure 1 for the PRISMA flow chart (Moher et al., 2009)). Articles were included if they focussed on an instrument to assess the maturity of a telemedicine initiative (or related technologies) as a whole. To clarify, such an instrument implies that the measurement of the status quo can be achieved through the application of a model which distinguishes different levels of maturity. Articles that solely collected factors without measuring the status quo or that explored exclusively a specific form of readiness (e.g. organisational readiness, instead of a wider focus) were excluded. Two authors read and assessed titles, abstracts and full texts independently. Inconsistencies in decisions were resolved through discussion and consensus, leading to the inclusion of seven articles.

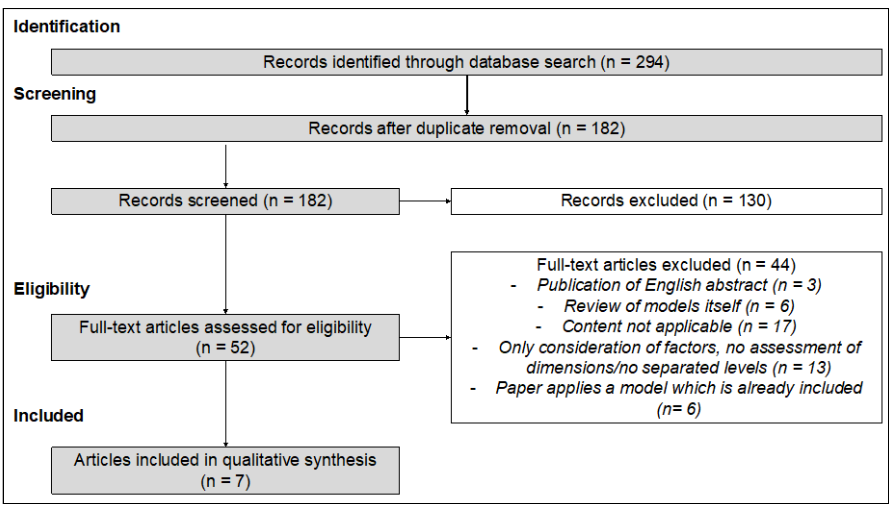

Figure 1: PRISMA flow chart

Due to the fast-moving pace in the telemedicine field and the relevance of maturity models beyond solely research, a grey literature search (Tillett & Newbold, 2006) was additionally conducted, to identify maturity models that have not yet been published in the academic literature. The search for alternative sources via the World Wide Web yielded three additional results on which all authors agreed. In the end, ten models were considered.

To assess and compare existing maturity models, classification characteristics were defined. The classification scheme for maturity models of Mettler et al. (2010) was taken as a basis as its focus is on characteristics that describe maturity models in general. Further attributes were added to the scheme, in order to obtain a more detailed impression of each model. These include, e.g., characteristics of maturity models and of telemedicine initiatives (which help selecting an appropriate tool in the complex field of telemedicine with its different stakeholders, applications and technologies).

4 Technology in Sheltered Accommodation

The proposed classification scheme was subject to a four-part examination: Research information, general model attributes, maturity model design, and maturity model use. Each **category** (displayed in bold in Table 1) consists of related *attributes* (in italics) with alternative characteristics (displayed in grey) that are described in detail below.

Table 1: Classification scheme (attributes from Mettler et al. (2010) are underlined)

Research information	**General model attributes**	**Maturity model design**	**Maturity model use**
1.1 Author *1.2 Year* *1.3 Title of publication* *1.4 Identified via review or grey literature search*	*2.1 Name of the model* *2.2 Acronym* *2.3 Addressed topic* *2.4 Origin* (academia | practice | government | combination) *2.5 Purpose* (descriptive | prescriptive | comparative) *2.6 Respondents* *2.7 Technology* (telemedicine | telehealth | eHealth | digital health) *2.8 Perspectives considered* *2.9 Country* *2.10 Disease* *2.11 Availability* (free of charge | not free of charge)	*3.1 Concept of maturity* (maturity of: processes | objects | people | combination) *3.2 Design strategy* (development of a new model | adaptation/combination of existing models) *3.3 Development method* *3.4 Composition of the model* (Capability Maturity Model-like model | Likert-like questionnaire | maturity grid) *3.5 Dimensions* *3.6 Levels* *3.7 Reliability* *3.8 Mutability* (form | function | form and function)	*4.1 Method of application* (self-assessment | third-party assisted assessment | certified professionals) *4.2 Support of application* (documentation | textual description | handbook | supporting tool) *4.3 Practicality of evidence* (general recommendations | specific improvement activities) *4.4 Further usage of the model*

Identifying attributes like *author(s), year, title of publication* and whether the text had been identified via the *review or grey literature search* belong to the category **research information.**

Furthermore, ***general model attributes*** (Mettler et al., 2010) like *name* and *acronym* of the model and the *addressed topic* (idem) were collected to obtain a first impression of the models. Other attributes include the *origin* (De Bruin et al., 2005; Mettler et al., 2010) and *purpose* of the model (De Bruin et al., 2005; Poeppelbuss et al., 2011) as well as *respondents* (De Bruin et al., 2005), i.e. who is intended to apply the model, the *technology* covered and the *perspectives considered*, i.e. factors of/around a telemedicine initiative (e.g. patients or legal aspects). Additionally, *country* or *disease* specificity and the *availability* of the model were collected (Mettler, 2011; Mettler et al., 2010).

Attributes describing the **maturity model design** (Mettler et al., 2010) concentrate on the core characteristics of each model. Firstly, the *concept of maturity* (Mettler, 2011; Mettler et al., 2010), was collected as well as *design strategy* (Leyh et al., 2017), and *development method*, e.g. process description for developing maturity models (design science or procedure models (e.g. Poeppelbuss & Roeglinger, 2011)) or other methodological approaches, like focus groups or interviews. Secondly, the model itself is represented by the attributes *composition of the model* (Mettler et al., 2010), the *dimensions* and *levels* (De Bruin et al., 2005; Lasrado, Vatrapu, & Andersen, 2015). Thirdly, *reliability* and *mutability* (regarding form, e.g. the scheme or question items included, and/or function, e.g. the assessment of maturity itself) of each model were identified (Mettler et al., 2010).

Also, the **maturity model** use is an element on which to focus. The *method of application* describes who assesses the maturity, while *support of application* examines what supporting material is provided. Furthermore, this attribute may or may not indicate how far existing material/software tools are supported or contact persons are named. The third attribute in this category is *practicality of evidence* (Mettler et al., 2010). The classification scheme of Mettler et al. (2010) focusses strongly on the retrievability and reusability of existing models, leaving aside their "real use", i.e. their application by others. However, maturity models are developed for their application in a natural setting, which is why the attribute of *further usage of the model* was added to the scheme. This attribute examines the application and further development of and whether a potential (stakeholder) community had been built around any given model.

5 Maturity Models for Telemedicine

Analysing the classification of all the identified models was done in two steps. Firstly, due to the high variety in the models' focus and structure, each model was described individually. Secondly, general statements were defined about all models. Corresponding attribute numbers are displayed in italics referring to Table 1. After the analysis, indications were identified how far each model supports its users proactively in scaling up telemedicine initiatives.

5.1 Individual Statements

Individual statements can be drawn for each model according to author and year of publication (*1.1 and 1.2*), name and acronym of the model (*2.1 and 2.2*), topic addressed (*2.3*) and country developed in (*2.9*). While some models are restricted in their use to the country they were developed in, others are more general. Detailed information can be found in Table 2.

Table 2: Individual information for each model (sorted by date of publication)

Author (Year)	Name of the model (Acronym)	Topic addressed	Country (use restricted/not)
Campbell et al. (2001)	Framework for assessing provider's readiness to adopt telemedicine	Readiness for telemedicine of health providers	Developed in Missouri, United States (no restriction reported)
Jennett et al. (2003)	Framework for rural and remote readiness in telehealth	Readiness for telehealth of different stakeholders within a community	Developed in Canada (no restriction reported)
Broens et al. (2007)	Layered implementation model	General determinants for successful telemedicine services	Western societies (restricted use)
Khoja et al. (2007)	E-Health Readiness Assessment Tools for Healthcare Institutions in Developing Countries	e-Health readiness of managers and healthcare providers in healthcare institutions	Pakistan/developing countries (restricted use)
Van Dyk and Schutte (2012)	Telemedicine Maturity Model (TMMM)	Maturity of telemedicine services and their related factors and processes	Developed in South Africa (no restriction reported)
Abera et al. (2014)	Strategy, Technology, Organization, People and Environment (STOPE) model	e-Health readiness in healthcare institutions (in Ethiopia)	Ethiopia/ Sub-Saharan Africa (restricted use)
Jensen et al. (2015)	MOMENTUM-TREAT toolkit	Readiness of telemedicine services for large-scale deployment	Developed in Europe (no restriction reported)
Sokolovich and Fera (2015)	UPMC Telehealth Adoption Model	Maturity of telemedicine services and their readiness to expand	Developed in the United States (no restriction reported)
Gholamhosseini and Ayatollahi (2016)	E-Health readiness assessment tool	e-Health readiness in healthcare institutions	Iran (restricted use)
iCOPS (2017)	Commissioning Technology Enabled Care Services	Readiness of TECS before adopting or expanding	Developed in the United Kingdom (no restriction reported)

The composition of the model with its dimensions, levels (*3.4 - 3.6*) and intended respondents (*2.6*) needs to be analysed individually. Also, reliability (*3.7*) and further usage (*4.4*), identified via forward search, are considered.

The oldest identified model was developed by Campbell et al. (2001). The six dimensions of turf, efficacy, practice context, apprehension, time to learn and ownership are crossed with the three levels of fertile soil, somewhat fertile soil and barren soil. The model is similar to a maturity grid and its focus on telemedicine providers leads to the inclusion of physicians, nurses and administrative staff as target groups of the model. Reliability tests are not reported and further development or usage of the model could not be identified.

Two years later, Jennett et al. (2003) published their model as a kind of maturity grid. The four identified stakeholder groups, patient, practitioner, public and organisation, serve as dimensions, crossed with four types of readiness: core, engagement, structural and non-readiness. Each type of readiness contains six different themes arising for all stakeholders at all times (core readiness, structural readiness, projection of benefits, assessment of risk, awareness and education, and intra-group and inter-group dynamics). Nevertheless, this initial model cannot be considered as an actual maturity model since the readiness themes do not necessarily have a relationship with each other or describe an evolutionary path (The Alliance for Building Capacity, 2002), i.e. levels are missing. The initial model was not tested by the authors, but has been further developed. In 2004, three 5-point, Likert-like questionnaires were designed for organisations, patient/public and practitioners (NSW Agency for Clinical Innovation, 2015). Each questionnaire results in one of three readiness levels (being in a good position for implementation; some items may hinder a successful implementation; and remaining barriers needing to be addressed). This survey has further been translated into and validated in various languages (Légaré et al., 2010) and applied in other countries (Muigg et al., 2018; Schwarz, Ward, & Willcock, 2014).

Broens et al. (2007) ordered their five identified determinants of technology, acceptance, financing, organisation, as well as policy and legislation, in a layered implementation model (which can be classified as a CMM-like model). Each determinant builds on the previous one, indicating that the levels increase from determinant to determinant. The authors identify different telemedicine stakeholders, but the target audience of the model is not stated explicitly. The model remains untested, and is not easily benchmarked (van Dyk and Schutte, 2012).

Khoja et al. (2007) focus on healthcare institutions in developing countries. Two 5-point, Likert-like questionnaires were provided, one for managers and another for healthcare providers. Both questionnaires included the three dimensions of core-readiness, societal readiness, and policy readiness. For managers, the dimension "technological readiness" was added; healthcare providers additionally assess the dimension "learning readiness". The authors conducted validity and reliability testing and showed good content and face validity and high reliability for both questionnaires. The tool has been applied in different settings (e.g. Chipps & Mars, 2012) and was taken up again partly in the development of the Khoja-Durrani-Scott framework (Khoja et al., 2013). Unfortunately, the surveys for the framework (referenced by Khoja et al. (2013)) are not available online anymore.

Five years later, van Dyk and Schutte (2012) presented a maturity grid in the form of a three-dimensional cube, based on existing models (e.g. by Broens et al. (2007), Jennett et al. (2003) and Khoja et al. (2007)). The cube consists of five dimensions (technology, users, finances, procedures and policy) which are crossed with the steps of the underlying telemedicine process. Each box in this matrix is then rated at one of five levels (initial; managed; defined; measured process; optimising). A target audience is not clearly stated. Nevertheless, the authors applied and validated their model with the help of workshops and focus groups, involving healthcare professionals (doctors and nurses) as well as technical staff members responsible for information technology from different regions. Later usage of the model has only been found in the further development by the same authors (van Dyk & Schutte, 2013). However, this further developed model is even more complex than the original, and contradicts the expectation that a maturity model should be easy to understand and use (Klimko & Remenyi, 2001).

Abera et al. (2014) present two 5-point, Likert-like questionnaires where the dimensions of the STOPE model (Strategy, Technology, Organisation, People and Environment) are ranked and related to a colour code from the McConnell International tool, thereby implying that the site/location has a certain level of readiness. Opinions about the three dimensions, strategy, organisation and environment, were collected from managers and administrative staff by using a single questionnaire. Another questionnaire was administered to healthcare professionals and information technology staff and included the dimensions of technology, people and environment. Validity and reliability tests were undertaken. However, the model seems not to have been used further.

Jensen et al. (2015) combined the MOMENTUM blueprint with the Telemedicine Readiness Self-Assessment Tool (TREAT) and got the MOMENTUM-TREAT toolkit. This toolkit is a 5-point, Likert-like questionnaire, assessing various indicators from 18 critical success factors which are categorised into the four areas of context, people, plan and run. The toolkit can be adapted to different settings by its users, which are described as "telemedicine doers and decision-makers" (Jensen et al., 2015, p. 32). All indicators were validated and tested and the toolkit has been applied in different settings, e.g. by Walters et al. (2016).

In the same year, Sokolovich and Fera (2015) presented the UPMC (University of Pittsburgh Medical Center) model as a conference presentation in which the development process and structure of the model were introduced. Therefore, little information is available regarding the model. A clear statement on the respondents of the model is missing, but it can be determined that the tool was based on a practitioner survey in different health facilities. The model is a CMM-like model with eight levels (from 0 to 7: governance, providers, patients, simple, complex, complete, expanded, integrated). Further statements on application or testing of the model cannot be made with the limited information publicly available.

Another 5-point, Likert-like questionnaire was published by Gholamhosseini and Ayatollahi (2016). It consists of five dimensions (e-health readiness, ICT functions, environmental readiness, human resources readiness, ICT readiness), including different indices. Each index is assessed on the Likert scale and multiplied with an additional weight for each dimension, resulting in a score between 0 and 1. A literature search for other tools on which the questionnaire can be built, e.g. Khoja et al. (2007), has been undertaken, but it is not explicit which parts of which models were considered. A clear statement about who the intended respondents are is also missing. The authors applied their model with the help of hospital employees, including managers, health professionals and technical staff. Validation was conducted during the development phase of the model. Further usage of it could not be found.

Most recently developed was the maturity grid by iCOPS (2017). It is presented as an online tool, incorporating standards from a code of practice developed by Donelly (2017). The tool contains 16 dimensions (e.g. involvement of stakeholders, users and carers; investment and funding; implementation), which can be rated using four levels (inadequate; requires improvement; good; or outstanding). Different descriptions for each dimension and level are provided. The tool can be used by "all staff responsible for planning, commissioning, procuring, project and contract managing" (iCOPS, 2017) in technology enabled care services, but it is not available free-of-charge. Information on testing or application of the model is not publicly available.

5.2 General Statements

A number of general statements can be made for each of the four categories.

Research Information

While author and year of each publication (*1.1 and 1.2*) are shown in Table 2, each publication title (*1.3*) can be found in the reference list. Publication dates for the model range from 2001 to 2017 (see Figure 2). In fact, the topic of telemedicine maturity is not a new one, but interest in it has increased over the last five years (*attribute 1.2*).

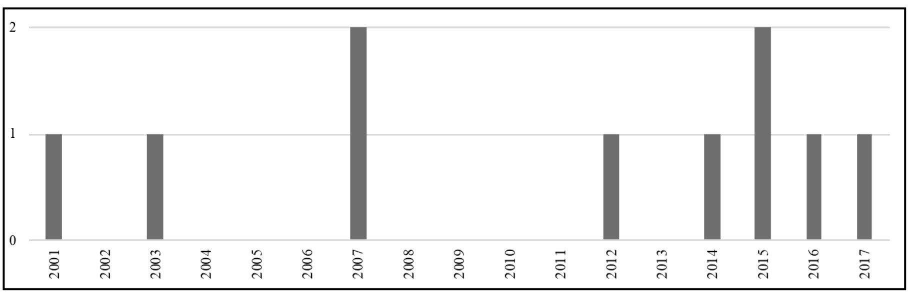

Figure 2: Number of models per year

Seven of the ten models were identified via the literature review; three, which are among the latest four to be made available, by the grey literature search *(1.4)*.

General Model Attributes

The name, acronym, topic and country developed in *(2.1 - 2.3 and 2.9)* of each model can be found in Table 2. The seven models identified via the literature review all originate from academia. From the three models identified through grey literature search, two were created by practitioners (iCOPS, 2017; Sokolovich & Fera, 2015) and one from a combination of academic, practitioner and governmental stakeholders (Jensen et al., 2015) *(2.4)*.

Regarding purpose *(2.5),* nine out of the ten models outlining the status quo are descriptive models that make no recommendations. Only one model addresses the improvement of the status quo, i.e. is a prescriptive model (Campbell et al., 2001). Intended respondents for each model *(2.6)* were analysed individually in section 5.1.

Four models are classified as being applicable to telemedicine (Broens et al., 2007; Campbell et al., 2001; Jensen et al., 2015; van Dyk & Schutte, 2012), one to telehealth (Jennett et al., 2003), and two to eHealth (Gholamhosseini & Ayatollahi, 2016; Khoja et al., 2007). Two others are applicable to telemedicine and telehealth (iCOPS, 2017; Sokolovich & Fera, 2015), and a further one to telemedicine and eHealth (Abera et al., 2014) *(2.7)*.

Each model covers various perspectives of telemedicine initiatives *(2.8)*, as displayed in Table 3. The perspectives, i.e. core readiness through to legal readiness, were derived by the authors of this article by examining the items mentioned in all ten models.

Table 3: Perspectives on telemedicine initiatives covered in each model – "x": perspective is directly included, "(x)": perspective is indirectly included in the model

	core readiness	provider readiness	patient readiness	public/ community readiness	health sector readiness	strategic readiness	technological readiness	organisational readiness	financial readiness	legal readiness
Campbell et al. (2001)	(x)	x								
Jennett et al. (2003)	x	x	x	x	x	x	x	x	x	x
Broens et al. (2007)		x	x		x	x	x	x	x	x
Khoja et al. (2007)	(x)	x	x		x	x	x	x	x	x
Van Dyk and Schutte (2012)		x				x	x	x	x	x
Abera et al. (2014)	(x)	x	x		x	x	x	x	x	x
Jensen et al. (2015)		x	x	x	x	x	x	x	x	x
Sokolovich and Fera (2015)		x			x		x	x		
Gholamhosseini and Ayatollahi (2016)	(x)	x				x	x			(x)
iCops (2017)		x	x		x	x	x	x	x	x

No clear trend can be seen in the various types of readiness having been added over time. Rather, the authors of the ten models combined different types of readiness for their own purposes, without necessarily claiming to be holistic in their approach.

None of the models are disease-specific *(2.10)*.

Eight of the models are available free-of-charge *(2.11)*, but not two of the models developed by practitioners, which limits the usability of both models (iCOPS, 2017; Sokolovich & Fera, 2015). For the iCOPS (2017) tool, users can undertake a one-month free trial to test the tool.

Maturity Model Design

In general, seven out of the ten models combine process-, object- or people-focussed elements *(3.1)*. Only three focus specifically on the maturity of people (Campbell et al., 2001; Jennett et al., 2003; Khoja et al., 2007).

Most identified models were designed as new models (6/10) or combined/extended for the first time (4/10) (see Figure 3 for *3.2 and 3.3*). However, for none of the models was a theory (e.g. regarding adoption or diffusion) incorporated to strengthen its theoretical basis.

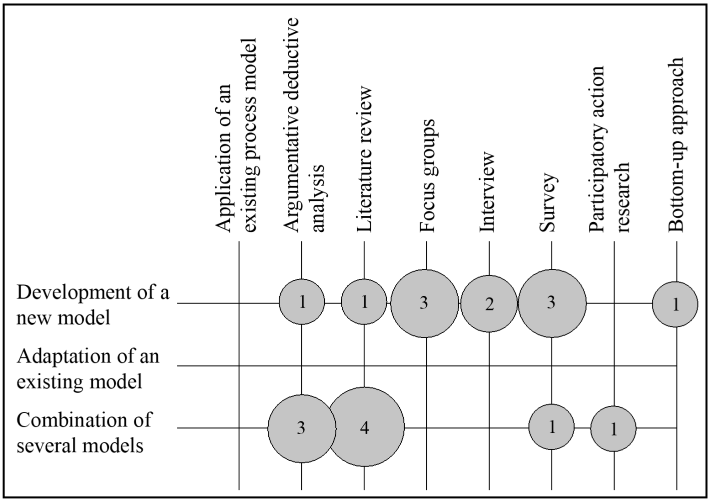

Figure 1: combination of design strategy and development method (size of and number within each bubble represent the number of times each combination was identified)

Information about model composition, dimensions, levels and reliability *(3.4-3.7)* were also discussed in section 5.1. The mutability of models *(3.8)* is not addressed in seven of the models. Jensen et al. (2015) and Khoja et al. (2007) directly report a possible mutability regarding the form of the model; Van Dyk and Schutte (2012) name a form and function mutability.

Maturity Model Use

All the models can be used as self-assessment tools *(4.1)*. Nevertheless, support/guidance for the application *(4.2)* is not given in eight out of the ten models. Even though each of the models is described in the individual publications, largely no form of additional support is provided to guide later users in the models' application. This observation also applies to the work of Abera et al. (2014), Gholamhosseini and Ayatollahi (2016) and Van Dyk and Schutte (2012), who all applied their models directly to the assessment of specific institutions/processes. These later authors only described the content of the models, and failed to offer detailed descriptions that would be helpful for reuse. Support for the application of the models is only given in two of the models. These are Jensen et al. (2015), with a step-by-step procedure to applying the model and the naming of an email address for further support, and iCOPS

(2017), where a software assessment tool is provided and an email address for further questions.

Regarding practicality of evidence *(4.3),* it can be said that only one model offers general recommendations (Campbell et al., 2001), specific improvement activities are not given in any of the models. Generally, in all of the models the description of the more mature stages of telemedicine could also offer guidelines on improvement measures (since they would explain the circumstances of higher maturity), but they do not give direct guidance. Each model was further used differently *(4.4)* as described in section 5.1.

6 Discussion

Existing models have been developed to assess a site's or an organisation's readiness for beginning a telemedicine initiative rather than to measure the maturity of telemedicine initiatives. Focussing on readiness is a necessary preliminary step in order to reach successful change and adoption (The Alliance for Building Capacity, 2002). This aligns with the focus on maturity models in this paper, where a maturity model is seen as a supporting tool that has dimensions and levels which can also incorporate the maturity of readiness. Even though some of the models focus on eHealth or telehealth instead of telemedicine, the perspectives covered in each model are similar.

While the maturity models analysed have different characteristics and foci that are identified in this paper, two main challenges remain from the analysis which will require on-going research to enhance future application of the models.

Firstly, almost all the models are descriptive: they do not provide support for applying possible improvement steps. Although higher levels of maturity can imply improvement measures by describing the circumstances of higher maturity, clear guidance is missing. Three models, i.e. Campbell et al. (2001), iCOPS (2017) and Jensen et al. (2015) provide high-level guidance or supply approaches to guide users in helping themselves (by providing measures or steps to define an improvement process), but they do not include actual assistance or specific improvement steps. A clear need can therefore be identified to explicitly address users of the models with guidance not only in how to assess the status quo but also to improve the status quo in the future through the application of specific, detailed measures.

Secondly, in eight out of the ten models (i.e. all the models except the ones by Jennett et al. (2003) and Jensen et al. (2015)), insufficient consideration has been paid to patients, as care recipients, and/or the community/public surrounding them, although they are essential partners to telemedicine adoption (Yusif et al., 2017). Therefore, incorporating adoption (e.g. Venkatesh, Thong, & Xu, 2012) and community readiness theories (Edwards et al., 2000) should be discussed in a stronger way, in order to close this identified gap. Addressing both challenges (adoption and community readiness) would help in proactively supporting telemedicine scaling up. In their current form, none of the models analysed serves the purpose of proactively supporting its users by giving substantial guidance for further improvement of the status quo.

Turning to potential study weaknesses: this review could be considered to have a number of limitations – by the search string applied, the databases selected, and by the fact that the inclusion and exclusion of literature is a highly subjective procedure. Nevertheless, to counterbalance these potential weaknesses, relevant synonyms for all terms were tested for results and a representative set of databases was chosen. Furthermore, two researchers independently assessed the inclusion and exclusion of articles, and the categorisation of identified models. Last but not least, the classification scheme developed also limited the scope of the work, since it described only a selected number of characteristics while attempting to illustrate the diversity of the topic – a difficulty also uncovered by Mettler et al (2010).

7 Conclusion

Identifying existing maturity models for telemedicine and assessing them in a structured classification scheme (which can be re-used for classifying additional or newer maturity models) led to an overview of the state-of-the-art. We pointed out the various facets and limitations of each model and the specific setting for which the models have been developed. Most of the models considered are missing important perspectives on telemedicine initiatives or ignore the need for improvement processes to be introduced for their implementors to reach a higher level of maturity. By questioning the models' feasibility to assess telemedicine initiatives proactively, our analysis shows that users are often left alone to apply any given model, since practical support for a model is seldom provided.

All in all, the need has been identified to make available a prescriptive maturity model, that proactively guides its users in assessing and improving the status quo. One aspect for future research may be the combination of existing models with adoption and community readiness theories, so as to cover all of the perspectives relevant to telemedicine in a holistic manner. In addition to the provision of e.g. a webtool, the usage of the model should be described in detail in any associated documentation. In terms of the design method, relevant stakeholders, e.g. patients and practitioners, should be included in the model's development to ensure their perspectives are represented.

With such a model and an accompanying online tool, the readiness of a site to implement a telemedicine initiative would be a goal that could be achieved in a faster way. Proactive guidance would be provided to the users on the road to telemedicine maturity, which in turn could support cost savings while increasing the wellbeing of patients through more successful telemedicine initiatives.

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Influence of Belief in a Just World on Knowledge in Game-based Learning

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Abstract The belief in a just world can have an influence on the learning success of students because students who believe in a just world are willing to invest more time in learning. Previous studies have already shown that people who believe in a just world achieve better grades. However, measuring learning success using a single indicator does not provide sufficient information, because learning success depends on many factors (e.g. prior knowledge). For this reason, the influence of belief in a just world on objective and subjective knowledge changes is measured for a game-based learning application in this study with an online survey. The results of the study show that the students achieve subjective and objective knowledge gains. Nevertheless, not many significant correlations could be identified between the students' belief in a just world and objective or subjective knowledge changes. These results contradict previous studies that reduced the measurement of learning success to a single indicator.

Keywords: • Game-based Learning • Learning Success • Belief in a Just World • Knowledge • Serious Game •

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1 Introduction

A major learning challenge is to motivate learners, so that they are concentrated during the learning session (Laurillard 2002). Game-based learning (GBL) can be used to counteract this and describes the integration of game elements in education (Prensky 2001). Two design forms can be distinguished to create a GBL application: gamification and serious game. Gamification means to integrate only a few game elements in a non-gaming context (e.g. education) and a serious game is defined by the development of a full-fledged game with rules and objectives (Deterding et al. 2011).

With the integration of game elements in education, positive results can be achieved. For example, more fun and motivation or a positive influence on learning success (Eckardt & Robra-Bissantz 2018). However, learning success depends on various factors (e.g. motivation, knowledge gain or the quality of the learning application). Consequently, measuring learning success is difficult because it is more than the retention of facts, events or processes (Kerres 2001).

For example, people's belief in a just world (BJW) can also have an influence on learning success. Belief in a just world means that people always get what they deserve and deserve what they get (Lerner 1965). Accordingly, it describes the belief in a just or unjust world. As a result, it can be assumed that a person who believes in a just world tends to put a lot of effort into learning and therefore gains a lot of knowledge. Many conducted studies report an influence of BJW on learning outcome (e.g. Dalbert and Maes 2002; Peter et al. 2012), but in the context of GBL, to the best of our knowledge, the relationship was not analysed until now.

For this reason, the aim of this work is to analyze whether the students' sense of justice has an influence on the subjective and objective knowledge changes in game-based learning.

2 Related Work

In the last years, few studies have examined the meaning of belief in a just world and student's achievement (e.g. Dalbert 2013; Dalbert & Maes 2002; Peter et al. 2012). Some studies have already shown that learners who believe in a just world and feel, for example, treated fairly by their teachers perform better (Peter et al. 2012).

Generally, people have the need to believe that the world is just. However, a just world is a hope and not always given. Nevertheless, people need to believe in a just world to prevent a loss of control and a feeling of a fundamental senselessness about one's own life. Thereby, people are able to face long-term goals, to trust other people and to assign meaning to one's own actions (Hafer 2000). This forms the basis for action decisions and evaluations (Lerner 1977). The phenomenon that people usually assume that they live in a just world is called belief in a just world. He defines this belief in a just world as a world in which everyone gets what he deserves and deserves what he gets (Lerner 1965).

Generally, the personal BJW is based on three important functions. The first one is the motivation function. Belief in a just world ensures that we ourselves show just behaviour. This motivates people to achieve their objectives only by fair means. For example, self-exercised unjust action leads to a reduction in self-esteem for people with a strong BJW (Dalbert 2013). A further function is the assimilation function, which is important to attribute meaning to one's own actions. If people experience or observe injustice, they try to defend BJW. This happens by considering the injustice partly as self-inflicted, reinterpreting it, playing it down or denying it. BJW is maintained with the help of these strategies. The last function is the trust function, which ensures that people who believe in a just world trust that they will not experience injustice. After all, the invested work and time should also be profitable in the future (Dalbert 2013).

The belief in a just world is individual different (Rubin & Peplau 1975). The understanding develops in late childhood (Jose 1990) and remains largely constant over the years (Dalbert 2000). People with a strong BJW are willing to invest more time in their future (Zuckermann 1975). This applies in particular to the achievement of long-term goals, such as graduating with a good grade (Dette et al. 2004). This means that people with a strong BJW are willing to sacrifice time from their leisure in favour of learning, so that they get better outcomes as a "fair result". This trust in fair treatment leads to a motivated willingness to learn and ideally to better grades (Peter et al. 2012). In contrast, people with a low BJW consider the use of a lot of time questionable, because it is not clear whether their investment in time is worthwhile and, for example, leads to higher learning outcomes (Peter et al. 2012).

Tomaka and Blascovich (1994) were among the first who analyzed the BJW in the achievement domain. In a laboratory experiment, participants should count backwards as quickly as possible in seven steps from a large number with as few errors as possible. The results showed that people with a high BJW initially saw this task as an interesting challenge rather than a threat. After completing the task, this group of participants reported that they felt less stressed than people with a lower BJW. As a result, the results were better, and they made fewer miscalculations. A further study supports these results. In the school context, Dalbert (2000) has found that students achieve better results in their core courses if they believe in a just world. Dalbert and Stoeber (2005) have found in two studies that a strong BJW is associated with fewer worries at school, better grades and a sense of fairly perceived assessments by teachers. Furthermore, a study of Dalbert and Maes (2002) showed a relationship between BJW and achievement motivation (pride in one's own performance, trust in success and an adequate level of ambition). The study by Peter et al. (2011) also showed that students who believe in a just world also perceive the behavior of teachers towards them as fair and receive better marks.

These results suggest the assumption that the BJW can be a great motivator and a necessary prerequisite for learning and thus decisive for knowledge gain. In the previous studies, the achieved learning success was determined by grades or retention rates. This often has a limited informative value, as it is only a snapshot of the performance. Previous knowledge or subjective knowledge gain are not considered. For this reason, this study analyzes the relationship between BJW and subjective and objective knowledge changes as part of learning success. This should lead to detailed results on the relationship between knowledge and BJW.

Probst et al. (2006) define knowledge as the whole of facts and skills that individuals use to solve problems. This includes both, theoretical and practical rules of everyday life. Knowledge is based on data and information, but in contrast to these, it is always bound to persons. Knowledge is created through the combination of information and its application. In this way, it becomes a skill (Mescheder & Sallach 2012).

In general, knowledge is distinguished between objective and subjective knowledge. Subjective knowledge means the assessment of a person's knowledge on a certain topic. This assessment can be made by a person himself or herself or by another person. The objective knowledge is the actually stored knowledge of a person, also known as factual knowledge (Brucks 1985).

There are several ways to acquire knowledge. This contribution is based on the acquisition of knowledge according to the theory of constructive alignment by Biggs (1999). Learning objectives, teaching and learning activities and an assessment of the achievement of learning objectives are thereby related.

3 Serious Game »Lost in Antarctica«

The GBL application used in the study of this paper is an open source point-and-click browser game to learn information literacy, specially designed for students of industrial engineering. The ability of a person "to recognize when information is needed and […] to locate, evaluate, and use effectively the needed information" is defined as information literacy (American Library Association 1989). In twelve levels, students learn topics of information literacy such as research strategies, scientific writing and copyright. For this purpose, students take part in a research expedition to the South Pole but their airplane crashes. Consequently, they need to repair their defective airplane in addition to their scientific work. The students get points for solving tasks. Achieving a certain number of points marks a successful level completion. Furthermore, students get a component for each completed level to repair the defective airplane. Students have the chance to exchange additional points on a market place through mini games that are just for entertaining purposes. The tasks to be solved are varying (Figure 1). Tasks to be solved alone (e.g. multiple choice, cloze texts, drag & drop, crossword puzzles, interactive system screenshots (Screen 1)) and tasks to be solved in a team (e.g. voting or case processing (Screen 2)) are integrated. This playful form of learning is realized to motivate students to actively engage with topics of scientific work (Eckardt & Robra-Bissantz 2016).

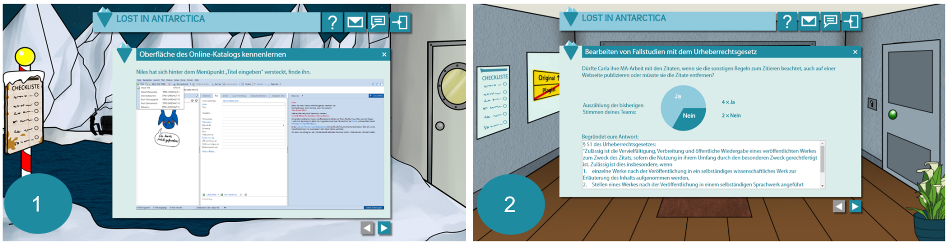

Figure 1: Screenshots of the serious game

4 Study on Belief in a Just World and Knowledge Gain

4.1 Study Design

The study will be conducted as an online survey. In the study, a data collection on subjective and objective knowledge and belief in a just world takes place in the context of a serious game. The online survey is carried out during the semester as part of a course for students of industrial engineering, in which they learn with the serious game how to work scientifically. Participation in the survey is voluntary and students receive no reward for participating. An online survey is carried out because students learn in the serious game independently of time and place and therefore a time-independent survey is necessary, e.g. to collect data about the current state of knowledge immediately after the learning process.

Before the students start with the serious game, previous knowledge of all learning contents in the serious game is checked and their personal belief in a just world is asked. In the middle and after the successful completion of the serious game, the knowledge of the students is collected again to determine changes in knowledge over the entire course. In the middle, only the contents already taught are asked and at the end again all contents.
Various methods exist for measuring BJW. In this paper, the scale of Lipkus (1991), which is based on the work of Rubin and Peplau (1975), is used and measured with a 6-point Likert scale (1 = fully disagree, …, 6 = fully agree). The reason for this is that the scale measures BJW general without limiting the focus

on a certain domain. Additionally, the scale consists of fewer items, which maybe ensures a higher response rate to the survey.

In the study, subjective and objective knowledge gain is analyzed, because the difference between the actual knowledge and what a person believes to know can be very big (Brucks 1985). According to Flynn and Goldsmith (1999), subjective knowledge is measured using a 6-point Likert scale (1 = fully disagree, …, 6 = fully agree). Students must answer questions on each topic of information literacy that is taught in the serious game for measuring objective knowledge. For each topic students are asked a question corresponding to a learning objective within the serious game, whereby the question types vary (e.g. multiple choice, free text, true/false, drag & drop).

4.2 Results of the Study

A total of 114 students took part in the study and 107 of them completed the survey at all three points of measurement. With 87 male and 20 female participants, predominantly male students took part in the survey. This is representative for the degree program of industrial engineering. All participants share approximately the same level of knowledge because they learn with the serious game how to work scientifically to write their final thesis. The age range of the surveyed students is between 18 and 32 years with an average value of 22 years and 2 months.

Belief in a Just World

Table 1 shows the mean values (MV) and standard deviations (SD) of all items of the belief in a just world scale.

Table 1: Belief in a Just World

No.	Item	MV	SD
1	I feel that people get what they are entitled to have.	4.25	1.26
2	I feel that a person's efforts are noticed and rewarded.	3.93	1.07
3	I feel that people earn the rewards and punishments they get.	4.36	1.14
4	I feel that people who meet with misfortune have brought it on themselves.	4.32	1.76
5	I feel that people get what they deserve.	4.31	1.3
6	I feel that rewards and punishments are fairly given.	4.36	1.43
7	I basically feel that the world is a fair place.	4.05	1.93

Most participants evaluate the belief in a just world as "rather agree", i.e. they tend to believe in a just world. With an average value of 3.93, the statement "I feel that a person's efforts are noticed and rewarded" achieved the worst result. Thus, not all participants believe to the same extent that the efforts of the individual are noticed. Item 3 and 6 achieved the best results. Participants therefore believe that awards and punishments are given fairly and that the people who receive them deserve them.

Subjective and Objective Knowledge

An analysis of variance with repeated measurements showed significant differences over the three measurement times for subjective knowledge ($F2,212 = 12,499$, $p = .000$, partial $\eta2 = .105$). The results are shown in Table 2. Between the first and second measurement time as well as between the first and third measurement time a significant knowledge gain on a significance level of $\alpha = .05$ can be determined. Learning information literacy took place between the measuring points exclusively with the serious game. For this reason, the knowledge gain is based on learning with the game. A twofold erroneous self-assessment could be the reason for no knowledge gain between the second and third measurement time. Incompetence often leads to an overestimation of one's own abilities and with increasing competence one's own level of knowledge is underestimated (Kim et al. 2016).

Table 2: Results Analysis of Variance Subjective Knowledge

Time of Measurement (t= I)	MW (t = I)	SD (t = I)	Time of Measurement (t = J)	Δ I-J
1	3.05	0.96	2	-.460 *
			3	-.416 *
2	3.51	0.98	1	.460 *
			3	.044
3	3.47	0.96	1	.416 *
			2	.044

Different types of questions were used to determine the objective knowledge. This means that there was no uniform answer pattern and different methods had to be used for evaluation. Altogether the students were asked twelve questions, one for each game level and topic of information literacy with regard to the achievement of certain learning objectives. For example, in the level quoting and bibliographing students have to check the correctness of a quote. Due to the different response patterns, mean values and natural numbers were available for evaluation. Mean values were evaluated using variance analysis at three measurement points and T-tests at two measurement points, natural numbers using the Qochran-Q-test between the first and second measurement points, and the McNemar-test between the second and third measurement points. Table 3 shows the results for the objective knowledge. In four topics of information literacy (internet search, research strategies, good scientific practice and time management), students did not gain any knowledge. A loss of knowledge has even occurred when quoting and bibliographing. Students may have found it too difficult to check the accuracy of a quotation or may have guessed correctly at the time of the first survey. Guessing is a general challenge in verifying factual knowledge and can lead to bias of results, especially when right-wrong questions are used, as in the case of level citation and bibliography (Johann 2008). However, incomprehensible learning materials within the serious game can also have led to the loss of knowledge. In the other topics (publishing and open access, copyright, literature management, scientific writing, scientific literature recognition, database search and catalogue search) students have significantly improved their knowledge.

Table 3: Results Objective Knowledge

Topic	t =1	t =2	t = 3	Δ_{1-2}	Δ_{1-3}	Δ_{2-3}	Values
Internet Search	0.464	0.539	0.533	x	x	x	$F_{2,212} = 2.342$, $p = .104$, partial $\eta 2 = .022$
Catalogue Search	25	72	74	□	□	x	T = 67.853, p = .000 $\hat{x}'^2_{uncorrected}$ = .250, p = .617
Research Strategies	0.457	0.514	0.490	x	x	x	$F_{2,212} = 2.373$, $p = .109$, partial $\eta 2 = .022$
Database Search	70	89	91	□	□	x	T =18.318, p = .000 $\hat{x}'^2_{uncorrected}$ = .250, p = .617
Scientific Literature Recognition	0.576	0.713	0.720	□	□	x	$F_{2,212} = 15.331$, $p = .000$, partial $\eta 2 = .126$
Scientific Writing	55	79	66	□	□	□ (-)	T =11.103, p = .004 $\hat{x}'^2_{uncorrected}$ = .250, p = .617
Literature Management	19	-	74	-	□	-	$\hat{x}'^2_{uncorrected}$ = 51.271, p = .000
Citation and Bibliography	58	-	36	-	□ (-)	-	$\hat{x}'^2_{uncorrected}$ = 8.067,

							p = .0045
Copyright	22	-	64	-	□	-	$\hat{x}'^2_{uncorrected}$ = 50.449, p = .000
Good Scientific Practice	3.196	-	4.521	-		-	T = .465, p = .643
Publishing and Open Access	-2.79	-	1.879	-	□	-	T = -8.958, p = .000
Time Management	41	-	44	-		-	$\hat{x}'^2_{uncorrected}$ = 1.089, p = .2967

In the levels catalogue search, database search and scientific literature recognition, knowledge was even stored in long-term memory, because the students had no new learning phase with the game between the second and third time of measurement and there were no significant changes in knowledge. Especially in these levels there was a frequent repetitive use of the learned skills with similar task types, which may have led to a positive objective knowledge gain (Webb 2007).

Relationship between Belief in a Just World and Knowledge

The correlations of the mean value of BJW with the knowledge differences were determined according to Spearman. Here, the actual changes in knowledge are considered, i.e. the previous value is subtracted from the later time of measurement, so that there is a knowledge gain if the difference is positive. There is no significant correlation between BJW and subjective knowledge changes between the first and second time of measurement (rSP = -.005; p = .962) and between the first and third time of measurement (rSP = -.031; p = .754). Table 4 shows the correlations of each item of BJW with knowledge differences according to Spearman.

Table 4: Correlations BJW and Subjective Knowledge

Items BJW	Differences between first and second time of measurement		Differences between first and third time of measurement	
	r_{SP}	significance	r_{SP}	significance
1	-.017	.863	.048	.622
2	.080	.413	-.029	.767
3	.047	.634	.047	.630
4	-.196 *	.043	-.117	.231
5	-.033	.738	.048	.623
6	-.006	.951	.044	.654
7	.127	.193	-.007	.944

The table shows that the correlation is significant negative between subjective knowledge and the fourth item of the BJW "I feel that people who meet with misfortune have brought it on themselves". This means that participants who agreed with this statement show a lower subjective knowledge gain.

For analyzing the relationship between BJW and objective knowledge, only topics of information literacy with significant objective knowledge changes were considered. The correlations according to Spearman between the mean value of BJW and the objective knowledge differences showed no significant correlations for all learning contents. Furthermore, also at item level almost no correlations could be identified. A significant negative correlation (rSP = -273; p = .004) could be identified between item 7 of the BJW "I basically feel that the world is a fair place" and the objective knowledge change. This means that participants who agreed with this statement have less objective knowledge gain in the field of citation and bibliography.

5 Conclusion

In this paper, not many connections between belief in a just world and the objective and subjective knowledge changes could be identified. Accordingly, students with a profound sense of justice do not seem to achieve higher subjective and objective knowledge gains.

These results are different in comparison to previous research results. Previous studies have shown that people who believe in a just world achieve better grades or have a higher retention rate (e.g. Tomaka & Blascovich 1994; Dabert & Stoeber 2006). This could not be proven in this study. One possible explanation is that in comparison to the other studies this study was conducted in the context of GBL and not in traditional course lectures. Furthermore, participants were different. In previous studies, school students participated instead of students of a university. Maybe that led to different results and should be analyzed in further studies. However, the achieved learning outcomes in this study were considered more extensively by measuring the objective and subjective changes in knowledge, because learning success was not reduced to a single indicator. Nevertheless, the results can only be generalized to a limited extent, because the interrelationships were only analyzed for a certain serious game and one learning topic. In further studies, it is therefore necessary to analyze the relationship between BJW and knowledge more detailed. This requires studies that analyze not only the changes in knowledge but also the achieved grade for the performance. This could provide more detailed information on the impact of BJW on learning outcomes. Additionally, the relationship should also be analyzed for other digital Game-based learning applications and other learning content to make the results more universal.

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Digital Transformation of SMEs: Capturing Complexity

JOHN JEANSSON & KRISTER BREDMAR

Abstract The purpose of this paper is to study the ongoing digitalisation of SMEs in order to gain a richer understanding of the complexity of digital transformation. Six Swedish SMEs have been studied using a basic qualitative research approach. Main results of the study are the identification of internal as well as external drivers of value creation, categories of digital transformation actions and the presence of a strategic tension that SMEs had to manage in order to conduct their digital transformation. One conclusion is a proposed framework which supports a rich understanding of SMEs digital transformation.

Keywords: • Digitalisation • Digital Transformation • Small and medium-sized enterprises (SME) • Digital Competitiveness • Complexity •

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1 Introduction

The ongoing digitalisation of society challenges existing business logic, models and knowledge of companies within almost every industry. In its footsteps follows both promises of great possibilities and value for those who successfully adapt and change, as well as great challenges and risk for those who lag behind (Carr, 2003). Digitalisation has thus, regardless of company size and shape, emerged as a necessity in order to stay competitive, providing strong incentives for companies to take action (Johnston, Wade, & McClean, 2007). However, successful digitalisation does not follow one recipe for all (Andal-Ancion, Cartwright, & Yip, 2003; Heavin & Power, 2018). Research within the field shows that companies need to invest in digital technologies but implement digital transformation in order to take hold of possibilities and value. This implies that competitive advantage due to digitalisation is not the result of merely technology installation, but have everything to do with how each company: (1) integrate technology, people, processes and strategies (Markus & Benjamin, 1997), and (2) capture the elusive nature of potential value from digital initiatives (Jeansson, 2014). Previous research and empirical findings depict such digital transformation as a highly complex matter, and a knowledge gap in need of further attention (Besson & Rowe, 2012; Fortune, 2018; Hess, Matt, Benlian, & Wiesböck, 2016).

This paper focus on digital transformation within the context of SMEs and this for two reasons: *one*, SMEs make up for 99.9% of all companies in Sweden and 99.8% in EU and accounts for 65.5% (Sweden) 66.4% (EU) of all employees, which speaks of relevance (Muller et al., 2018); two, characteristics of SMEs provide a complex and at times conflicting context of digital transformation, which calls for further studies (Li, Su, Zhang, & Mao, 2018; Zach, Munkvold, & Olsen, 2014). The purpose of the paper is thus to study the ongoing digitalisation of SMEs in order to gain a richer understanding of the complexity of digital transformation, so that future digital initiatives of SMEs could be supported. The paper addresses two research questions: (1) what is the character and nature of digitalisation in an SME context? (2) how do SMEs act in order to achieve their digital transformation?

2 Theoretical Lens

The paper is positioned between the phenomenon of digitalisation, the context of SMEs and the field of digital competitiveness. As these three fields converge they constitutes the theoretical lens of SMEs´ digital transformation.

2.1 The Nature of Digitalisation and Digital Transformation

As we connect digital to different social settings (e.g. digital society, digital culture, digital divide, digital disruption, digital business, digital customers) we state that there is more to digital than technology (Reed, 2014). In fact, it could be argued that it is a digital-social duality that we seek to understand and depict (Orlikowski, 1992). Within the field of organisational transformation, transformation denotes change, which could take on two main shapes: (1) continuous, slow and patchy or (2) discontinuous, fast and systemic (Besson & Rowe, 2012). When connecting digital and transformation Dehning, Richardson, and Zmud (2003, p. 654) speak of something *"fundamentally altering traditional ways of doing business by redefining business capabilities, business processes and relationships"* as well as enabling a company to enter *"a new marketspace"*, or *"enabling firm to operate in different markets, serve different customers…gain considerable competitive advantage by doing things differently"*. Lucas Jr, Agarwal, Clemons, El Sawy, and Weber (2013) further refine the degree of digital transformational in relationship to the level and nature of: business process change, creation of a new organisation, change in relationships, customer reach, and changed market position. The Global Centre for Digital Business Transformation define digital business transformation to be *"organisational change through the use of digital technologies and business models to improve performance"* (Wade, 2015). To speak of digital transformation is then to speak of: (1) the use and alignment of digital technologies within a company, (2) conducting organisational change, (3) enabling activity (4) creating and capturing new opportunities and value. To conclude and provide a definition of digital transformation for this paper: *"digital transformation is to be understood as the process of reshaping the business model of a company due to, and through, the adoption and use of digital technologies, in order to create a setting where new possibilities are enabled and value created"*.

2.2 Strategic Tension of Digital Transformation

As companies embark on their digital transformation journey there is an underlying strategic tension to pay attention to. A tension between an internal resource/capability perspective and an external market-based perspective, which have implications for why and how a company acts in order to gain competitive advantage or competitive parity. An internal resource/capability perspective stresses the importance of playing to a company´s strengths when devising strategies and digital initiatives. It emphasizes: (1) the need to build a strong and exclusive digital resource base consisting of both tangible and intangible assets (Prahalad & Hamel, 1990); (2) the need to develop hard-to-imitate competencies and digital capabilities (Peppard & Ward, 2016; Teece, Pisano, & Shuen, 1997; Wang & Ahmed, 2007). Companies with a predominantly internal drive set out to first identify their unique resources then find a suiting market or shape an existing one (De Wit & Meyer, 2010).

A market-based perspective stresses the company´s external environment as the main starting point when devising strategies and digital initiatives. It places great emphasize on understanding customers and competitors (existing as well as potential), and to adapt to emerging threats and opportunities within a company´s industry. Its main focus are: (1) to design a digital value proposition that matches the changing nature of customers' needs, demands and behaviours (Berman, 2012); (2) to use digitalisation in order to gain an advantageous market position (Carr, 2003; Porter Michael, 2001). Companies with a predominantly external drive set out to first analyse and gain insight into the attractiveness and profitability of a market, then adapt or develop needed resources and capabilities to align with market opportunities (De Wit & Meyer, 2010; Porter Michael, 1985).

2.3 Understanding SMEs going Digital

The nature of SMEs provides a specific backdrop to digital transformation. An SME is by the European commission defined as a company having: (1) less than 250 employees; (2) less than €50 million in turnover; (3) less than €43 million in balance sheet total (Muller et al., 2018). Because of their size SMEs have specific characteristics that differs from their larger counterparts (Ghobadian & Gallear, 1997; Welsh & White, 1981). Characteristics that have implications for digital transformation as they affect SMEs´ management (Cragg, Mills, & Suraweera, 2013), investment (Levy, Powell, & Yetton, 2001), adoption (Ifinedo, 2011), implementation and usage (Zach et al., 2014) of digital technologies. Table 1, provides a shortlist of characteristics to support a richer understanding of challenges and opportunities faced by SMEs during digital transformation.

Table 1: SME characteristics

SME Characteristics		
Environment	Organisation	Digitalisation
• Mostly local and regional markets-few international. • Prone to be financial sensitive to external forces and environmental changes. • Dependent on small customer base. • Close and frequent contact with customers. • Limited external contacts. • Affected by powerful partners in their supply chain.	• Time constraints of owner-mangers. • Low degree of standardisation and formalisation. • Low resistance to change. • Organic and fluid culture. • Modest financial resources. • Modest human capital and know-how.	• Limited knowledge of IS. • Lack of strategic planning. • Limited in-house IT expertise. • Emphasis on packaged applications. • Adoption driven by perceived relative advantage, competitions´ pressure and management support. • Adoption related to prior use of digital technologies.
(Ghobadian & Gallear, 1997; Wong & Aspinwall-Roberts, 2004; Zach et al., 2014)	(Ghobadian & Gallear, 1997; Wong & Aspinwall-Roberts, 2004; Zach et al., 2014)	(Ifinedo, 2011; Wilson, Daniel, & Davies, 2008; Zach et al., 2014)

2.4 Framing Digital Transformation

In order to discuss the nature and actions of SMEs digital transformation based on previous research three intertwined themes, each having a set of sub-themes, are proposed. The first theme aims to capture the degree of digitalisation within a company's external environment, and to what extent and in what way it affects the company. The nature of the environment could either enable or hinder a company's possibilities to conduct its digital transformation as well as to compete (Baker, 2012; Oliveira & Martins, 2011). The theme consists of four sub-themes, two at a macro level: (1) digital infrastructure, which is the available external digital technology and services necessary for a company to function (Tilson, Lyytinen, & Sørensen, 2010); (2) regulations and policies, which is government as well as industry provided regulations/policies and incentives (Gibbs & Kraemer, 2004); and two at a micro level: (3) industry climate, which is the competitive structure within an industry and the nature of collaboration between companies (Baker, 2012); (4) customers, which is the digital behaviour and maturity of existing as well as potential customers (Berman, 2012).

The second theme aims to capture the degree of digital transformation within a company, and to capture SMEs´ perceptions and actions of digital transformation. Companies perception of digital is very much a matter of prevailing organisational culture and strategy, which affects adoption and usage of digital technologies as well as development of digital competence (Bharadwaj, El Sawy, Pavlou, & Venkatraman, 2013; Leidner & Kayworth, 2006; Middleton & Harper, 2004). The transformation theme consists of four sub-themes: (1) culture, which is a company´s prevailing organisational and information culture (Cameron & Quinn, 2011; Choo, 2013); (2) strategy, which is the character of a company´s digital strategies (Peppard & Ward, 2016); (3) capabilities, which is a company´s digital competence and capability (Peppard, Lambert, & Edwards, 2000; Wang & Ahmed, 2007); (4) digital technology usage, which is a company´s adoption and usage of digital technologies and services (Carr, 2003; Renkema, 2000).

The third theme aims to capture the degree and nature of business value gained from investments in digital initiatives and the ongoing digital transformation. Achieving potential digital business value has proven to be a challenging task in need of a structured approach. One challenge being its elusive nature as it is:

dynamic, take on different shapes, and emerge throughout the whole company (Farbey, Land, & Targett, 1999; Jeansson, 2014; Ward & Daniel, 2006). The digital business value theme consists of two sub-themes: (1) internal performance, which is the perceived benefits and value related to internal efficiency and effectiveness (Melville, Kraemer, & Gurbaxani, 2004); (2) external relationships, which is the perceived benefits and value related to market position, customers and business partners (Porter Michael, 2001).

3 Research Method

The study is part of a larger research project and has been conducted using a basic qualitative research approach (Merriam, 2009). In such an approach, a researcher aims to paint a rich picture of the complexity of that which is to be studied, and to better understand a phenomenon from a participant's perspective (Creswell, 2007; Merriam, 2009). In our case, to gain a richer understanding of actions taken by companies within their natural environment as they make sense of their ongoing digitalisation.

3.1 Sample Selection

Participating companies were selected using a purposeful sampling strategy. The logic of such a strategy is to select: *"information rich cases for study in depth"* (Patton, 1990, p. 169). Companies were further selected using a combination of variation and criterion sampling. In order to be included in the study companies had to meet four criteria: *one*, qualify as an SME according to the employment definition of European commission (Muller et al., 2018); *two*, perceived to provide an interesting and rich picture of digitalisation; *three*, be active and have a head office within the Kalmar county of Sweden; *four*, have more than one employee. Within these four criteria companies were further selected in order to gain variation of industries, municipalities and degrees of digitalisation (Creswell, 2007; Patton, 1990). For this paper a total of six companies were selected, see table 2. In order to gain as rich information as possible interview respondents were selected based on their role within the company. In order to be selected they had to be either the CEO of the company or the person responsible for its digitalisation/digital initiatives.

Table 2: Selected companies.

Company	Industry	Employees/turnover	Respondent
Company A	Processing and wholesale of timber.	Employees: 117 Turnover: €74.7 million	CIO
Company B	Logistics and freight traffic.	Employees: 104 Turnover: €21.9 million	CEO
Company C	Conference and golf resort.	Employees: 55 Turnover: €6.2 million	CEO
Company D	Industrial cleaning and dry-cleaning.	Employees: 38 Turnover: €4.1 million	Production manager
Company E	Manufacturing of steal parts.	Employees: 56 Turnover: €8.9 million	CFO/CIO
Company F	Retailer of books and office supplies.	Employees: 12 Turnover: €1.7 million	CEO

3.2 Data Collection

Data were collected through interviews and public documents. All interviews were semi-structured, and although the same interview guide was used in all interviews the order and wording could vary between interviews depending on the situation at hand. Additional questions were asked in response to respondents' answers (Merriam, 2009). Each interview was approximately one hour long and were conducted at the facilities of each company. All respondents approved to have their interview digitally recorded, and all interviews were transcribed verbatim afterwards. In addition to interviews public documents (i.e. financial reports, news articles and company webpages) were gathered in order to gain a richer picture of the company and its environment (Merriam, 2009; Yin, 2003).

3.3 Data Analysis

The interview transcripts were analyzed by two researches both manually and using software tools (Atlas.ti). The main focus of the analysis was not to study actual words themselves, but rather the meaning they conveyed (Miles & Huberman, 1994). The analysis contained four phases. Even though the different phases were to some degree conducted in a sequential manner, the analysis process was highly iterative. During the *initial* phase transcripts were read in light of posed research questions and text segments of different sizes were coded in an inductive, open manner (Merriam, 2009; Miles & Huberman, 1994). During the *second* phase coded segments of data were grouped as categories and themes emerged. In a *third* phase themes were further analyzed in light of defining features, structures and processes, causes and consequences and participation and relationships (Lofland, Snow, Anderson, & Lofland, 2006; Miles & Huberman, 1994). In a fourth phase data was analyzed through proposed theoretical lens.

4 Results

4.1 Nature and Impact of External Environment

SMEs described their digital infrastructure as (1) access to high-speed broadband internet, (2) mobile phone connectivity and (3) access to external digital competence. A well-functioning internet connection was regarded as important, if not critical, to most companies. Company E described how they currently were using ADSL-based internet connection, which did not meet their needs, and how they joined forces with other local companies in order to put pressure on the municipality to invest in fixed high-speed internet connectivity. Apart from company E, all SMEs regarded their digital infrastructure to be sufficient and all companies were able to find sufficient external digital competence within or outside the region when needed.

SMEs perceived regulations and policies to have a limited impact on their digital transformation. Company A, however, described how strict industry regulations regarding information security affected investments. Company F described how they, when developing their website, received financial support from regional development funds due to policies aimed at encouraging companies to invest in digital initiatives.

In general, SMEs described their industry climate as highly competitive and painted picture of digitalization and the way it impacted them as dynamic. Company A and B both described a current on-going industry shift with increased digitalisation. Company F described a highly digital industry with a never-ending presence of e-commerce and with several competitors having advantages that they could not compete with. However, they also described the world of physical bookstores and how they regarded themselves to be quite in the forefront digitally compared to other physical bookstores. Company C described a similar condition, on one hand a highly digital business environment competing on several online booking platforms, on the other hand, international markets with low degree of digitalization, which required the company to be able to offer their digitally transformed processes manually. Company D and E painted a picture of digital technologies being industry standard used by all in order to do business.

Customers were perceived, in general, to be digitally mature. Customer behaviour and expectations acted at times as drivers for change and new digital initiatives. This was understood to be necessary but not always enjoyed. The CEO of company F: *"There are many customers coming to the store with their mobile phones showing a book and asking if we have it. People are very well-informed."; "If we do not have a book in store we ask the customer if they want us to order it for them. Some respond that they just as well could order it themselves online from another store. But when we tell them that we offer a twenty percent discount on ordered books then nine out of ten want the book…this is something we are a little proud of."* Company B spoke of customers expecting them to change the way they did business from physical interactions to B2B exchanges: *"I'm not really happy about this if I am to be honest. You don't get the chance to have a personal contact and prove that you are better and more than numbers and boxes. It is boring."* Company A, E and C all described, in various ways, how they were pressured by customers to have a certain level of digital transformation in order to be able to do business and to satisfy customers.

4.2 Internal Digital Transformation

Each SME had their unique organisational culture in which digital transformation took place. Two companies displayed an interesting contrast: Company E described themselves as a company with a low degree of digital maturity amongst employees, hesitating to take digital initiatives, prone to be reactive rather than pro-active to changes and demands. Company B on the other hand described themselves as a company with employees actively suggesting digital initiatives, managers curious and interested to try out new technologies, a willingness to change and to improve. There were characteristics that SMEs spoke of as favourable related to digital transformation, such as: a family-like culture where everyone helped each other; a solution-oriented approach where employees were not afraid to step up and take initiatives; a willingness to change and to improve; the ability to identify more efficient and effective ways of performing tasks; curiosity and interest in new technologies. There were also characteristics that SMEs spoke of as challenging related to digital transformation: lack of management support; lack of understanding or digital competence; lack of alignment between digital and business strategies; negative or non-existing experience of digital initiatives.

SMEs tended to have a limited approach to strategies of digital initiatives and digital transformation. Company A was the only company with a formal and communicated strategy. Despite lack of formal strategies SMEs made strategic choices related to their digital transformation. Company C and F both decided to scale down digital and instead enhance non-digital, physical attributes. Company C made a strategic decision to associate themselves with attributes such as the local nature, outdoors, health and recreation rather than being perceived as a high-tech, digital resort; company F made a strategic decision to be a physical bookstore where customers could connect with authors, enjoy events and explore local artists rather than to offer all their products online and become an e-commerce, multichannel company. Company B, on the other hand, made a strategic decision to scale up digital and expand their third-party logistics service, working with drop-shipping and to develop their own e-commerce platform. As a result, they collaborated with fellow logistics companies and competitors in order to offer their customers third-party logistics services. No SME undertook a structured benefits management approach. The CIO of company A expressed lack of incentives as reasons to why they did not evaluate their digital initiatives.

SMEs acted in different ways to make sure they had access to sufficient digital competence. In general, SMEs´ combined in-house competence of more or less digitally skilled employees with outsourcing. Company A combined a full-time CIO and a full-time employee dedicated to technical support with external competence. Company B recruited their own systems and software developers in order to pursue new digital initiatives, and company F gained social media skills when company owners´ daughter moved back to join the company. Company E decided to let go of a full-time employee responsible for digital technologies and appointed the CFO to be responsibility for overseeing everything digital. The CEO of Company C described how they, as they grew, decided to stop using a local restaurant owner who offered technical support on the side, and to instead outsource most of their needed digital competence to established companies. Company D, having groups of employees with a low degree of digital competence, devised a solution limiting the amount and character of work these groups needed to do in the digital application to a minimum - *"so that nothing could go wrong."* (Production manager company D). Even though SMEs recognized the importance of digital competence none worked intentionally to develop digital skills and competence of existing employees.

SMEs described different drivers that initiated their digital technology usage. Dominant drivers were: increasing efficiency, enhancing customer communication, improving performance measurement, responding to external pressure and changed customer demands, and integrating processes. Less dominant, but not insignificant, drivers were: acting environmentally friendly and reducing information security threats. All SMEs used a plethora of digital technologies. Some digital technologies were cross-industry technologies and used by a majority of SMEs (e.g. websites, mobile devices, social media platforms, cloud computing, enterprise systems, EDI, data analytics, online third-party platforms), some were used by only one SME (e.g. CRM-applications, company E; internet of things applications, company B; intranet, company C), and some being industry specific (e.g. laundry software solutions, company D; vehicle management applications, company B; golf course watering systems, company E). SMEs main investment approach was to purchase standard applications and then pay for some level of individual configuration. However, company A and C both developed custom-made applications with support from external competence, and company F collaborated with other physical bookstores on a national level in order to develop needed technical solutions.

4.3 Creating and Capturing Business Value

Perceived benefits and value of internal performance mainly related to: (1) increased efficiency; (2) doing things better. Company D spoke of their digital applications supporting capacity growth as they expanded their physical production location: *"The system has no limits so it has nothing to do with it, it is all about how much capacity we (physically) could manage."* (Production manager, company D). Company B described how they were able to grow without having to recruit due to their enterprise system usage and digital procurement and invoice processes.

Company A spoke of value in terms of reducing the number of employees but still be able to maintain a high level of capacity. SMEs described benefits and value in terms of being able to do things better. Company C could access the same product data and price information throughout all locations due to integrated information systems, reducing data redundancy. The CEO of company B was able to do his job better as he had access to information no matter his geographical location. Company A spoke of several benefits such as better logistics, increased control of shipments, increased inventory control and improved decision making. Company D and E both perceived an increased ability to measure performances.

Three categories of perceived external value emerged. Category one: increased competitive advantage and market position. Company A pointed out the integration and alignment of digital technologies, people and business processes as the main reason for their advantage: *"Yes, I can see that the way we work, because there are many sawmills that have the same digital applications as we have. But the way we work and use (the digital application) enables us to follow a package all the way from production which I feel provides a competitive advantage - as we have made that change, which I do not think the others have done yet, even if they have the opportunity to do so."* (CIO company A). Company B pointed out the digital communication between their trucks and the head office as a source of competitive advantage. Company C spoke of digital initiatives as a hygiene factor and how it enabled competitive parity. Category two: increased customer value. Company F perceived online communication channels as strong customer value creators. The CEO described how working with newsletters and email lists created tangible benefits in terms of increased sales, and intangible benefits in terms of increased customer satisfaction, engagement and commitment. Company E described increased customer value as digital technologies enabled them to provide higher information quality. Category three: new products/services. Company B gained new customers, new business opportunities and increased revenues as a result of participating on online exchange platforms. Company C perceived increased bookings with 23% due to online booking platform participation and a new branding approach. Company A described how digital applications enabled relationships and transactions with international customers. Company B described how developing new digital products and services made it possible to: enter a new market, reach new customers, provide a new range of services to existing customers, and gain new revenues.

5 Discussion and Conclusions

Overall, the results painted a picture of the nature of SME digital transformation as a complex, dynamic, and on-going phenomenon (figure 1). Digital transformation does not follow a set of pre-determined steps for all SMEs to follow, instead participating SMEs had to find their own way of combining digital technologies, people and processes. As stated by previous research, digital transformation requires companies to alter traditional ways, redefine competencies, processes and relationships with business partners as well as customers (Lucas Jr et al., 2013). This held true in all studied companies and indicates the presence of a deep structure change where SMEs have to re-think business models and key processes. Most SMEs spoke of change as continuous and rather slow in contrast to a discontinuous, fast change (Besson & Rowe, 2012). Most SMEs displayed a low resistance to change, which acted as an enabler (Zach et al., 2014). When employees displayed resistance towards change initiated by digital initiatives, managers tended to find a solution and follow through with intended digital initiatives.

The results indicate that SMEs need to manage the impact of their external digital environment at the same time as they manage internal digital transformation in order to create and capture potential digital business value. In doing so SMEs tend to have two sets of drivers: (1) external drivers of strategic benefits to (a) increase reach and richness of offered value proposition and (b) adapt to customer and competitor pressure; (2) internal drivers of operational/management benefits to (a) increase capacity and (b) do things better.

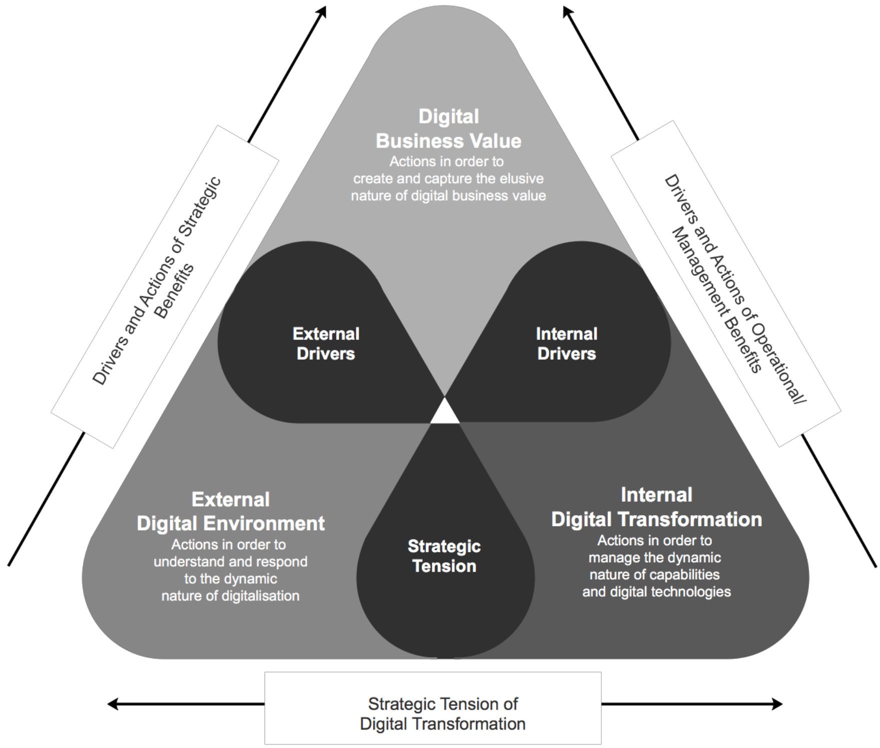

Figure 1: The nature and complexity of SME digital transformation, the SMEdit-framework.

Actions of digital transformation follow three categories: (1) actions of understanding and responding to the dynamic nature of digitalization (e.g., collaborating with other companies in order to promote change, applying for external government funding in order to conduct digital initiatives, adapting to digital technologies suggested by customers); (2) actions of managing the dynamic nature of capabilities and digital technologies (e.g., recruiting digitally skilled employees, re-structure work to suit employee levels of digital competence, develop, configure and adapt digital technologies); (3) actions of creating and capturing the elusive nature of digital business value (integrating digital technologies, people and company processes). Results indicate that SMEs need to be able to act within all three categories, sometimes simultaneously, in order to conduct their digital transformation successfully. Something that poses a challenge as most studied SMEs tended to lack clear strategies for digital initiatives and due to size related challenges (Wong & Aspinwall-Roberts, 2004).

Results further showed the presence of three strategic tensions that SMEs needed to pay attention to as they conducted their digital transformation. In practice, the first tension resembled the tension suggested by De Wit and Meyer (2010) the most: (1) balancing actions of adapting to external pressure of digitalisation versus holding on to internal capabilities and desires (e.g., turning physical store into an e-commerce business versus running in-store events and promoting physical customer interactions). The second tension is one of competencies: (2) balancing the nature and level of having in-house versus outsourcing digital competence (e.g., employing systems developers and having high degree of control versus paying external consults having less control). The third tension is one of: (3) balancing the role and level of digital versus physical in all aspects of the company (e.g., focus on being perceived as a high-tech, digital business versus focus on being perceived as a low-tech, physical nature and sports business). Identified tensions were on-going in their nature and emerged as SMEs had to make strategic choices. All tensions are understandable in light of faced challenges due to SMEs´ size (Zach et al., 2014).

In the end, a richer understanding of the complexity of SMEs digital transformation has been gained through identified drivers, categories of actions and strategic tensions. Used theoretical lens provided added support and a richer picture. Based on the results a framework SMEdit (SME digital transformation) is proposed and summed up in figure 1. The framework offers thoughts and structure for further research as well as a way for SMEs to discuss and approach the complexity of digital transformation.

The paper is not without limitations and should be understood based on its context. Interviews were made with the CEO of the company or the person responsible for its digitalisation/digital initiatives. Including a number of employees from each company could have provided added value to understanding the complexity of digital transformation.

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The impact of IT human capability and IT flexibility on IT-enabled dynamic capabilities

TINEKE KEMENA, ROGIER VAN DE WETERING & ROB KUSTERS

Abstract By conducting moderation mediation analyses, we investigate how IT human capability (ITHC) and IT flexibility—independently and jointly—influence the formation of IT-enabled dynamic capabilities (ITDC). In this paper, we also analyze the influence of different environmental conditions on the relationship between ITHC and ITDC. We do so by empirically testing the constructed model on a dataset of 97 international firms, using the PROCESS technique. We draw upon the dynamic capabilities view and modular system theory, which emphasize the need for a firm to develop ITDC to respond to changes. Currently, there is a gap in the literature concerning the role of ITHC on the formation of ITDC. Our results show that there is a positive effect of ITHC and IT flexibility on the formation of ITDC. Hence, organizations should invest in their ITHC and IT flexibility to address the rapidly changing business environment.

Keywords: • Dynamic capability view (DCV) • Modular systems theory (MST) • IT-enabled dynamic capabilities (ITDC) • IT human capability (ITHC) • IT flexibility • IT governance • Environmental dimensions •

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1 Introduction

In recent years, business environments have become more complex and turbulent, due to disruptive digital technologies such as big data, cloud computing, AI, and IoT. Hence, academics and practitioners need to recognize which IT-related capabilities are critical to an organization's survival and growth. The information systems (IS) literature broadly discusses the IT capabilities, the firm's ability to acquire, deploy, combine, and reconfigure IT resources to support business strategies and processes, in which organizations strategically must excel to add business value (Bhatt & Grover, 2005; Sambamurthy, Bharadwaj, & Grover, 2003). However, organizational capabilities, that enable organizations to coordinate and utilize their resources are also seen as critical success factors for success (Chen et al., 2014). Yet, the findings on whether the focus should be on the IT capabilities of the company to positively influence IT resources and IT competencies, or it is more strategic to focus on the organizational skills that IT initiatives should pursue, are not unambiguous (Kim, Shin, Kim, & Lee, 2011; Pavlou & El Sawy, 2011). Moreover, according to the dynamic capability view (DCV), the firm's capabilities should be dynamic to enable them to cope with a constantly changing competitive environment (Applegate, 2009; Eisenhardt & Martin, 2000; Sambamurthy & Zmud, 1999; Teece, 2007). In addition to dynamic capabilities, system modularity is another means proposed in the literature to manage turbulent environments (Langlois, 2002; Schilling, 2000).

Mikalef, Pateli, and Van de Wetering (2016) based their research upon the DCV and modular system theory. Their study emphasizes the need for *"strategically leveraging IT in core areas"* to gain business value. The IT-enabled dynamic capabilities (ITDC) of a firm refer to its capacity to deploy IT resources and IT competencies. The results demonstrate that IT architecture flexibility, positively influenced by IT governance decentralization, can contribute to the formation of ITDC. Although IS researchers acknowledge that ITDC has strategic value, they emphasize the role of IT human capabilities (ITHC) in this process (Fink, 2011; Kim et al., 2011; Sambamurthy et al., 2003). However, there is a literature gap concerning the role of ITHC in the formation of ITDC. Furthermore, several IS researchers have emphasized the role of environmental dimensions as an essential variable in developing dynamic capabilities, IT capability, and strategy-making behavior (Davis, Eisenhardt, & Bingham, 2009; Wilden & Gudergan, 2015; Zhou & Li, 2010). Given the considerable influence of the business environment, it is intriguing to analyze the role of ITHC and IT Flexibility in enhancing ITDC across different environmental conditions and states. Accordingly, our current research aims to address the gap above in the literature further. Concretely, the research questions in this paper are:

1. *How do ITHC and IT flexibility—independently and jointly—influence the formation of ITDC?*
2. *Does IT governance decentralization strengthen these influences?*
3. *What is the influence of different environmental conditions on the relationship between ITHC and ITDC?*

This paper comprises four sections. The first builds the theoretical foundation for the study. The second section describes the hypotheses formed. The third part describes the survey research (cross-sectional) and statistical analyses; the research methodology for data collection and analysis is also explained in detail. The final section presents the research conclusions, limitations of the study, as well as suggestions for future research.

2 Theoretical Background

2.1 The IT-enabled dynamic capability view

Strong IT capabilities enable organizations to leverage and utilize their existing IT assets, resources, and know-how effectively (Mikalef et al., 2016). Firm-specific IT resources are classified as IT infrastructure, human IT resources, and IT-enabled intangibles (Bharadwaj, 2000; Kim et al., 2011). To achieve a deeper understanding of the mechanisms through which flexible IT architecture adds value, and the key areas in which IT investments must be leveraged, Mikalef et al. (2016) developed a conceptual model on the formation of ITDC. They argue that it is more relevant to identify the organizational and dynamic capabilities that should be targeted by IT, rather than the aggregation of IT capabilities (IT resources and IT competencies). The focus in the DCV (Teece, 2007) is on the company's specific characteristics instead of the industry specifications as in traditional strategic management literature. Within the DCV the dynamic capabilities have been operationalized along the dimensions: sensing, seizing and reconfiguring, since an organization's capacity to sense and shape opportunities and threats, re-integrate, build, and reorganize external and internal competencies is foundational to dynamic capabilities. The dimensions that Mikalef et al. (2016) used to constitute ITDC are adapted measures of (1) sensing, (2) coordinating, (3) learning, (4) integrating, and (5) reconfiguring routines. These dimensions are used in other studies as well. Research results underline that the use of IT to support or enable various capabilities is very useful, particularly when it comes to coordinating and learning activities (Chen et al., 2014; Wilden & Gudergan, 2015).

2.2 Modular systems theory

The design structure of the modular system theory by Schilling (2000), decomposing systems, permits addition, modification, and removal of any software, hardware, or data components of the infrastructure with ease and with no major overall impact (Byrd & Turner, 2001; Langlois, 2002). The advantage of decomposition systems is that the formatted modules can be managed independently and efficiently, which improves system flexibility and responsiveness. It offers companies the opportunity to redesign existing processes rapidly, allowing them to respond quickly to market dynamics and customer demands (Chen et al., 2014). IS studies have measured IT infrastructure as technical modularity (Byrd & Turner, 2001; Mikalef et al., 2016; Tafti, Mithas, & Krishnan, 2013). Cloud computing, for example, makes it possible to scale application components independently. However, it is not only the flexibility of the IT architecture which is a factor in the ability of a firm to reshape business processes. Modularity can also be, besides a technical, an organizational characteristic. Already, since the 1980s and 1990s executives have been experimenting with solutions to decentralize decision making among departments/business units, so that decisions could be made faster through local control and ownership of resources (Applegate, 2009; Langlois, 2002; Schilling, 2000). A modular organization structure is one in which decision making is intentionally decentralized among departments, which, in IT context, is represented by IT governance decentralization (Mikalef et al., 2016; Tiwana & Konsynski, 2010).

3 Research Model

ITHC refer to skills required to manage resources related to IT. For instance, professional and relational skills and knowledge of technologies, technology management, and business functions are necessary for IT staff to undertake assigned tasks effectively (Denis, Trauth, & Farwell, 1995). Past studies identify ITHC through the presence of technical, behavioral, and business capabilities. IS studies reveal that organizations with competent IT staff are better at integrating IT and business planning, making investment decisions based on anticipated business needs, engaging in effective communication with business units, and executing systemic controls to achieve determined goals. In particular, the strategic sense-making ability of senior managers can help organizations deploy modular technology resources in ways that lead to new dynamic capabilities and advantages. Moreover, ITHC is of significant strategic value since they are not susceptible to rapid imitation (Fink, 2011; Kim et al., 2011; Sambamurthy & Zmud, 1999). Hence, the expectation is that ITHC has a positive impact on the enablement of ITDC (H1).

H1: *ITHC has a positive impact on ITDC*

Several studies emphasize the importance of a modular, flexible IT architecture to address rapidly changing business environments (Sambamurthy et al., 2003; van de Wetering, Versendaal, & Walraven, 2018; Zhu, Kraemer, Gurbaxani, & Xu, 2006). Mikalef et al. (2016) stated that the processes underlying ITDC are built on digital infrastructures. The ability to change these infrastructures fast, easy and relatively inexpensive helps an organization to develop ITDC. A valid, reliable instrument for measuring IT flexibility is through the four dimensions of loose coupling, standardization, transparency, and scalability (Byrd & Turner, 2001; Mikalef et al., 2016; Tafti et al., 2013; Tiwana & Konsynski, 2010; van de Wetering, Mikalef, & Pateli, 2018). The expectation is that IT flexibility has a positive influence on ITDC and moderates the effect of ITHC on ITDC. First, because with a loosely coupled IT architecture business processes can be reconfigured independently, which makes it easier to adjust. Loose coupling enables firms to decompose the IT architecture into units of functionality, referred to as software components, modules, objects, or services, which can be recombined easily with other modules in order to quickly construct a new process (Mikalef et al., 2016; Tafti et al., 2013). Next, standardization refers to the degree to which a firm establishes policies on how applications connect and interoperate (Mikalef et al., 2016; Zhu et al., 2006). Standardization increases modularity; by using open standards and off-the-shelf open source software (OSS), an organization can quickly adopt new technologies, with low cost and risks (Tiwana & Konsynski, 2010). Furthermore, transparency is associated with a greater likelihood of collaborative alliance formation, since the use of open standards for exchanging information, such as web services, increases transparency and visibility of capabilities across an organization. Transparency magnifies the possibility of merging or combining capabilities with other companies (Mikalef et al., 2016; Tafti et al., 2013). Ultimately, scalable IT architecture increases the agility of an organization. Based on continuously changing business needs, increased workload, transaction volume, or changed scope, a service or configuration can easily be increased or reduced (Byrd & Turner, 2001; Fink, 2011; Mikalef et al., 2016). In combination, these four dimensions allow an organization to change and innovate faster and enable ITDC (Mikalef et al., 2016). Based on the foregoing theoretical findings, and the previous hypothesis (H1), the following three hypotheses (H2, H3, and H4) are raised:

H2: *ITHC has a positive influence on IT Flexibility*
H3: *IT flexibility has a positive influence on ITDC*
H4: *IT flexibility positively mediates the effect of ITHC on ITDC*

In a modular organization structure, decision making is consciously decentralized among departments, which in the IT context is represented by IT governance decentralization. In past studies, IT specification (decisions about what business processes in the line functions IT must support) and IT implementation (decisions about the methods, programming languages, platforms, definition of IT standards and policies, and IT sourcing) have been defined as formative dimensions of IT governance decentralization (Mikalef et al., 2016; Tiwana & Konsynski, 2010). Mikalef et al. (2016) argue that even though IT governance decentralization is seen as a more efficient and effective response to emerging opportunities, the absence of a flexible IT infrastructure may weaken response. They claim that IT governance decentralization strengthens the effect of IT flexibility on the formation of ITDC. In light of the above discussion, it seems sensible to investigate if the effect of ITHC on the formation of ITDC, through IT flexibility, is strengthened by IT-governance decentralization. Therefore, we formulate the following moderation hypothesis (H5):

H5: *IT governance decentralization positively moderates the mediating effect of IT flexibility on the relationship between ITHC and ITDC*

Most IS researchers claim that dynamic capacities are needed to deal with rapidly changing environments. However, Eisenhardt and Martin (2000) suggested that in a moderately changing environment capabilities are detailed, analytical, stable processes with predictable results. Whereas in high-speed environments capabilities are simple, highly experiential, and fragile processes with unpredictable results. Three characteristics of a firm's external environment are discussed in the literature, namely: dynamism, hostility, and heterogeneity. Environmental dynamism is seen as an enabler unpredictable changes, which increases organizational uncertainty. Heterogeneity concerns the differences in competitive tactics, product lines, distribution channels, etc., across the firms' respective markets. Hostility is triggered by various economic, societal, and political factors, such as globalization and rapidly emerging new digital technologies, and can hinder firms in their effort to achieve process agility (Chen et al., 2014; Dale Stoel & Muhanna, 2009; Miller & Friesen, 1983; Newkirk & Lederer, 2006). Especially during periods of environmental change (threatening), the need for a developed ITDC, such as sensing and responding to shifts to remain competitive, is keenly felt (Mikalef et al., 2016). Following Teece (2007), environmental dynamism is an important driver of dynamic capabilities. Chen et al.'s (2014) research showed that environmental dynamism and environmental heterogeneity (complexity) positively moderate the relationship between IT capability and process agility. Based on the preceding discussion, it is clear that environmental factors affect organizations. It is, therefore, worthwhile examining the influence of different environments on the impact of ITHC on the formation of ITDC (H6).

H6: *Different environmental conditions (hostility, dynamism, and heterogeneity) influence the impact of ITHC on the formation of ITDC (through IT flexibility)*

4 Methodology

4.1 Data collection

To empirically test our research model and hypotheses, we developed a survey instrument and distributed it to key informants within international firms. A quantitative research approach was adopted to collect and analyze the data (Saunders, Lewis, & Thornhill, 2012), similar like Mikalef et al. (2016), Fink (2011), and Chen et al. (2014).

The data gathering process took only 1.5 months (October 2017 – November 2017). The key informants included Enterprise Architects (EAs), Chief Information Officers (CIOs), IT managers, Chief Technology Officers (CTOs), and Chief Executive Officers (CEOs). The study had a total dataset of 97 firms. The response rate grouped by firm size-class was 65% large (250+ employees), 16% medium (50-249 employees), 9% small (10-49 employees), and 9% micro (1-9 employees). The industries in which these firms operate are presented in the table 1.

Table 1. Characteristics of the sample

Industry	N
Basic Materials (Chemicals, paper, industrial metals & mining)	5
Industrials (Construction & industrial goods)	5
Consumer Goods	12
Health Care	13
Financials	15
Technology	11
Utilities	6
Consulting Services	10
Government	7
Other (Consumer Services, Telecommunications, Education, Oil & Gas)	13
Total	**97**

Furthermore, actions were taken to make sure that non-response bias would not become an issue. The respondents were aware that the survey would be strictly anonymous, and that the results of the study would only be reported at an abstract level. They were informed that the information would be coded and remain confidential. As a token of appreciation for their contribution, they could seek to receive a copy of this research. A maximum of two personal reminders were sent to non-responders.

4.2 Construct and items

The dimensions used to measure the constructs are based on earlier empirical and validated work from the areas of information systems, strategic management, and organizational science. ITHC was measured by adapting scales on the dimensions of *technical capability, behavioral capability,* and *business capability*, each dimension containing five indicators per construct on a 7-point Likert scale (Fink, 2011). We included the following dimensions for IT flexibility: (1) loose coupling, (2) standardization, (3) transparency, and (4) scalability, compromised of four constructs on a 7-point Likert scale (Byrd & Turner, 2001; Mikalef et al., 2016; Tafti et al., 2013; Tiwana & Konsynski, 2010; van de Wetering, Mikalef, et al., 2018). ITDC was measured through the five dimensions of *sensing, coordinating, learning, integrating,* and *reconfiguring*, with four indicators per construct, measured on a 7-point Likert scale (Mikalef et al., 2016; Teece, 2007). The continuum of centralization–decentralization IT governance was measured on a 5-point Likert scale (Chen et al., 2014; Mikalef et al., 2016). The environmental dimensions: *dynamism, heterogeneity*, and *hostility*, varied from three to five items on a 7-point Likert scale (Mikalef et al., 2016).

4.3 Data analysis

The quantitative gathered data was analyzed with IBM SPSS Statistics version 22. We conducted a moderated mediation analysis using a macro for SPSS called PROCESS to mathematically infer the existence and relationship of the latent variable. This technique relies on the inter-correlation between variables. A few standard statistical tests were carried out using SPSS, before running the PROCESS macro (Hayes, 2013). The dataset was screened for missing data, accuracy, and outliers. Based on the Cook's cutoff score, respondents marked as outliers were excluded so that the linearity assumption was satisfied and the heteroscedasticity assumption also was satisfied to run the fully specified predictive model.

A validity test was performed using principal component factor analysis to make sure that each item was measuring what it purported to measure (Pedhazur & Schmelkin, 1991). The Bartlett's test of sphericity value for all the scales is .000, meaning it is significant, and the Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) values for all the scales are above .6. Construct reliability (for quantitative analysis) was established by examining that all Cronbach's Alpha (CA) values were above the threshold of >0.70 (Saunders et al., 2012).

When analyzing the reliability of the 16 sub-scales, the CA of all the sub-scales was above 0.70, except the sub-scale dynamism (.446), which therefore was excluded from further research. If hostility item 1 is dropped, then the CA of the hostility variable becomes .717. The remaining 15 sub-scale item variables were merged to an average score per construct as mentioned in section 4.2. The relationship between the scale item variables was tested using the Pearson correlation. The matrix (table 2) shows that there is no significant correlation between the moderated variable IT-governance decentralization and the other variables.

Furthermore, there is practically no visible relationship between the variables ITHC and ITFL. The variance inflation variance (VIF) value from the predictors (i.e., independent variables) in the model variables is below 3, which is lower than the recommended maximum VIF value, meaning no multicollinearity is present. Table 2 also presents the mean, standard deviations, correlations, VIF, and the reliability coefficients (Cronbach's Alpha) of all the variables without the outliers as discussed above (N = 97).

Table 2: Assessment of the validity of the construct (sub-scales) variables

Constructs and sub-scales*	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
1. Dynamism																
2. Heterogeneity	.15															
3. Hostility	.36**	.47**														
4. Sensing	.46**	.24*	.13													
5. Integrating	.29**	.21*	.21*	.58**												
6. Coordinating	.38**	.41**	.41**	.62**	.74**											
7. Reconfiguring	26*	.27**	.28**	.62**	.69**	.72**										
8. Learning	.39**	.26**	.22*	.63**	.57**	.62**	.53**									
9. Loose Coupli	26*	.20*	.18	.64**	.63**	.68**	.71**	.72**								
10. Transparency	.22*	.13	.16	.46**	.49**	.51**	.59**	.49**	.64**							
11. Scalability	.12	.08	-.03	.45**	.45**	.46**	.46**	.47**	.61**	.62**						
12. Standardizatic	.17	-.02	.05	.48**	.52**	.50**	.48**	.52**	.55**	.56**	.63**					
13. IT Governanc	08	.00	.11	.01	-0.7	.07	.11	-.03	.05	.02	.03	.11				
14. Technical capability	.23*	.03	.30**	.12	.14	.31**	.15	.17	.11	.25*	.10	.13	.18			
15. Behavioral capability	27**	13	.28**	.31**	.24*	.26*	.25*	.19	.13	.19	.01	.10	-0.9	54**		
16. Business capability	.22*	.14	.20*	.27**	.19	.20	.18	.17	.14	.15	.05	.07	.00	.55**	.77**	
Mean	4.08	3.95	3.85	3.95	3.76	3.88	3.64	4.08	3.82	4.19	4.65	4.57	3.73	3.93	4.01	4.06
Standard Deviatio	.90	1.38	.96	1.30	1.25	1.31	1.27	1.35	1.38	1.41	1.39	1.18	0.97	1.37	1.43	1.38
VIF	-	-	-	-	-	-	-	-	2.15	2.18	2.35	1.95	-	1.80	2.91	2.75
Cronbach's Alph	.45	.79	.73	.87	.87	.90	.90	.89	.92	.88	.92	.85	.85	.83	.94	.92

*. Correlation is significant at the 0.05 level (2-tailed), **. Correlation is significant at the 0.01 level (2-tailed).

* Environmental dimensions 1-3, IT-enabled dynamic capabilities 4-8, IT flexibility 9-12, IT Governance decentralization 13, IT human capability 14-16

Based on theoretical findings (Hayes, 2013; Mikalef et al., 2016; Wang & Ahmed, 2007; Zhou & Li, 2010), we conducted a conditional process analysis. In this analysis, ITHC acted as a predictor (X), ITDC as a dependent variable (Y), IT flexibility (ITFL) as a mediator (M), and IT governance decentralization (GOV) as a moderator (V). The conditional indirect effect quantifies how differences in ITHC map onto differences in ITDC indirectly through ITFL, depending on the value of GOV. This is a conditional process analysis model containing a mediation process $(X \rightarrow M \rightarrow Y)$ combined with the moderation of the $M -> Y$ effect by V. The two equations representing this model, are: $M = i_1 + aX + e_M$ and $Y = i_2 + c'X + b_1M + b_2V + b_3MV + e_Y$. The direct effect of X on Y = c'. The conditional indirect effect is: $a\theta_{M \rightarrow Y} = a(b_1 + b_2V)$ (figure 1 and table 3).

A conceptual model (figure 1) was developed, based on the theoretical framework, reflecting the six hypotheses proposed in this research. A 95% confidence interval (CI) was calculated based on 5000 bootstrap samples for computing indirect effects at various values of the moderator (Hayes, 2013).

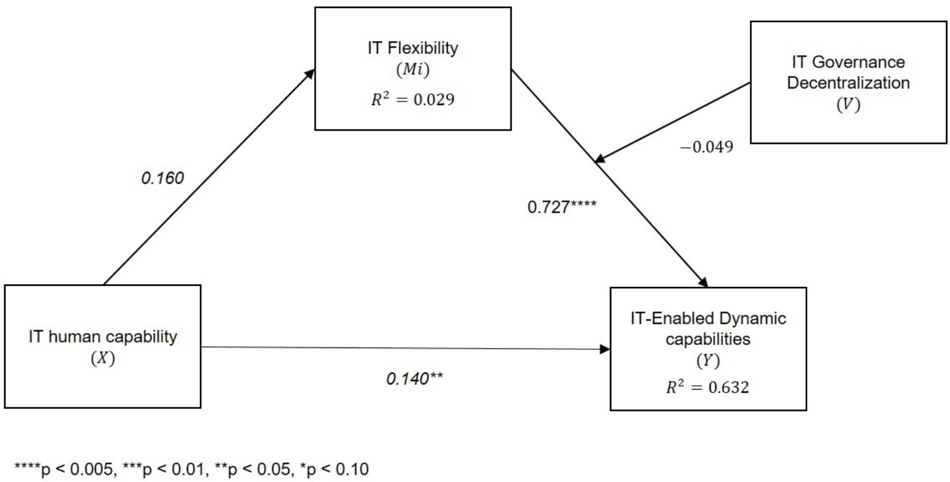

Figure 1: Moderated mediation model

Table 3: Coefficients for the moderated mediation model

		Consequent						
		M (ITFL)				Y (ITDC)		
Antecedent		Coeff.	*SE*	*p*		Coeff.	*SE*	*p*
X (ITHC)	a	0.160	0.128	0.216	c'	0.140	0.061	0.024
M (ITFL)		–	–	–	b_1	0.727	0.060	0.000
V (GOV)		–	–	–	b_2	-0.016	0.074	0.824
M x X		–	–	–	b_3	-0.049	0.063	0.440
Constant	i_1	-0.638	0.501	0.206	i_2	3.304	0.268	0.000
		$R^2 = 0.029$				$R^2 = 0.632$		
		$F(1.95) = 1.554), p > 0.1$				$F(4.92) = 47.099), p < 0.005$		

4.4 Results

Table 3 shows the resulting coefficients and model information summary. The model is significant $(F = (4.92) = 47.099, < 0.005)$, with a model prediction of 63.2% $(R^2 = 0.632)$ which indicates a strong positive relationship (Saunders et al., 2012). Looking at path c' in the model, ITHC has a direct, statistically significant positive effect on the formation of ITDC $(\beta\ 0.140\ t(92) = 2.295\ p < 0.05)$. The positive impact of ITHC on ITDC is hereby confirmed, and thus H1 is accepted. Furthermore, it appears that when ITHC is enhanced the IT flexibility increases, path $a = 0.160$; however, this relationship is not statistically significant $(\beta\ 0.160\ t(95) = 0.128, p = 0.216)$. Therefore, H2 is rejected. Also, the percentage of the explained variance is low, at 2.9% $(R^2 = 0.029)$, which means there is practically no correlation between the two variables. However, the relationship between IT flexibility and ITDC, path $b1$, is positive and significant $(\beta\ 0.727\ t(92) = 12.164, p =< 0.005)$, thus confirming H3. Since there is no significant relationship between ITHC and ITFL, there is no mediatory effect of $X \rightarrow M \rightarrow Y$. Given this result, there is no mediatory effect of ITFL between ITHC and ITDC, and thus H4 is rejected. Remarkably, the effect of IT flexibility on ITDC turns out to be not contingent on IT governance decentralization, path $b3\ (MiV)$, as evidenced by the statistically non-significant interaction between M and V in the model of

$Y\ (\beta = 0.049, p = 0.440)$. Following this result, H5 is rejected. This is in contrast to the earlier described theoretical findings, that future research should address.

This research also investigated the moderated influence of environmental factors on the enablement of ITDC, i.e., H6. The two constructs hostility and heterogeneity were measured on a 7-point Likert scale, which then, through dummy coding was divided into two different levels of groups: low <3.5 and high >3.5. Based on the findings (table 6), it is clear that environmental hostility, as well as environmental heterogeneity, do not influence the relation between ITHC and ITDC. Furthermore, the data shows that the effect of IT flexibility on ITDC is statistically significant $(p = 0.034, p = 0.000)$ for all the tested dimensions of environmental variables. Still, there is a slight change visible in the coefficients from the total effect $\beta\ .727\ (\beta = .649, \beta = .691, \beta = .589\ and\ \beta = .753)$. This indicates that environ-mental factors influence the intensity of the effect of IT flexibility on ITDC. Therefore, hypothesis 6 is partly rejected.

Table 6: Environmental factors

Environmental factors	*No. of companies*	*Direct effect X on Y*	*Effect M on Y*	*Model Summary*
Low environmental hostility	28	$\beta = .205$, $p = 0.176$	$\beta = .649$, $p = 0.034$	$(F = (4,23) = 19.065, < 0.005), R^2 = 0.787 = 78,7\%$
High environmental hostility	69	$\beta = .088$, $p = 0.170$	$\beta = .691$, $p = 0.000$	$(F = (1,67) = 0.844, < 0.005)$ $R^2 = 0.625 = 65,6\%$
Low environmental heterogeneity	37	$\beta = .139$ $p = 0.196$	$\beta = .589$, $p = 0.000$	$F=(4,32) = 13.632, < 0.005), R^2 = 0.605 = 60,6\%$
High environmental heterogeneity	60	$\beta = .109$, $p = 0.121$	$\beta = .753$, $p = 0.000$	$F=(4,55) = 30.381, < 0.005), R^2 = 0.656 = 65,6\%$
Total model	97	$\beta = .140$, $p = 0.024$	$\beta = .727$, $p = 0.000$	$(F=(4,92) = 47.099, < 0.005), R^2 = 0.632 = 63,2\%$

5 Conclusion and future work

Our research contributes to the IS literature through four important findings. First, the moderation mediation analysis shows a positive effect of ITHC and IT flexibility on the formation of ITDC. Based on these results, we claim that organizations that want to respond to rapid change should not only develop a higher degree of IT flexibility but also invest resources in the development of ITHC. ITHC is highly required to remain competitive, especially during periods of environmental change (threatening) (Miller & Friesen, 1983). Moreover, according to past IS research, ITHC is a resource-based competitive advantage which is hard for competitors to imitate in a short period (Eisenhardt & Martin, 2000; Fink, 2011; Sambamurthy et al., 2003; Teece, 2007). Hence, it is crucial for firms to invest in their ITHC to compete, survive and grow. Second, in a surprising outcome, the effect of IT flexibility on ITDC turns out to be not contingent on IT governance decentralization. This particular outcome contrasts the analyses in an earlier study conducted by Mikalef et al. (2016) and calls for further research. Third, since the results show that firms benefit from an IT flexible architecture in their response to technological changes, we assume that ITDC is a requirement, regardless of environmental factors. It should be mentioned, howerver, that firms which operate in a highly complex environment would benefit the most. Fourth, this paper supports the findings of earlier research, that IT flexibility is a strong enabler of ITDC. These results indicate that flexible IT architecture enables organizations to address the rapidly changing business environment.

Despite its contributions to the literature, this study contains several limitations, that future research should seek to address. First, a more extensive dataset can contribute to the generalizability of our findings. Second, although there is no significant indication of moderation, it is interesting to get a better understanding of the interaction between IT flexibility and IT governance decentralization. Additionally, researchers have also called for considering the *industry* as an essential contextual variable for environmental conditions (Dale Stoel & Muhanna, 2009). Hence, comparing results across industries and distinct groups can contribute to the generalizability of our current findings. Future research can, then, also identify various configurational and contingency patterns and antecedents of ITDCs and how they collectively contribute to organizations' competitive and innovative performance (Fiss, 2007; Mikalef, Pateli, Batenburg, & Wetering, 2015; van de Wetering, Mikalef, & Helms, 2017).

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From Enterprise Architecture Management to Organizational Agility: The Mediating Role of IT Capabilities

MAURICE PATTIJ, ROGIER VAN DE WETERING & ROB J. KUSTERS

Abstract Enterprise architecture (EA) has claimed to provide several benefits for organizations including improving organizational agility. Becoming more agile is an essential capability for organizations and a necessity to respond to the rapidly changing environment. The way these EA benefits are established is seen as complex and involves interconnections of multiple organizational facets. However, currently, there is a lack of empirical studies on EA and how it contributes to benefit realization. Moreover, empirically validated work on EA processes is even more scarce. This research addresses this gap and investigates the effect of an EA management approach on organizational agility. A conceptual model was developed proposing a mediation effect of IT capabilities on the relationship between enterprise architecture management and agility. A survey was performed among key EA stakeholders. Based on a sample of 110 responses, a partial least squares structural equation modeling analysis was performed to test the mediation model. The results indicate that the effect of enterprise architecture management on organizational agility is indeed mediated by IT capabilities. Finally, the present study discusses the implications of this research and provides suggestions for future research.

Keywords: • Enterprise Architecture • Enterprise Architecture Management • IT Capabilities • Organizational Agility • Mediating Role •

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1 Introduction

The environment in which organizations operate is becoming more complex and volatile. Organizations themselves are complex socio-technical systems. As such, interdependent people and information technology (IT) resources are required to interact with each other and with their environment to meet a common goal. At present, with the rapid technological and environmental changes, it is crucial to be proactive and agile in identifying and responding to threats and opportunities (Hoogervorst, 2004; Lu & Ramamurthy, 2011).

Enterprise architecture (EA) is a practice and an emerging field intended to improve the management of complex enterprises and their information systems. Extant literature argues that EA enhances an organization's IT capabilities and is regarded as an essential factor in improving organizational agility (Hoogervorst, 2004; Lapalme et al., 2016; Schmidt & Buxmann, 2011). Enterprise architecture management (EAM) aims to achieve optimal utilization of EA artifacts and concerns "the establishment and continuous development of EA" (Aier et al., 2011, p. 645). Although EA and EAM are widely accepted in the practical corporate context, scholars acknowledge the current lack of empirically validated research on EA and the way it contributes to the benefits for organizations (Foorthuis et al., 2016; Lapalme et al., 2016; Niemi & Pekkola, 2016; Van de Wetering, 2019). Research on EAM is even more scarce and seldom suggested as a source of benefits (Niemi & Pekkola, 2016). A possible explanation is that EA originated as a practice in an attempt to anticipated on the extension of scope and complexity of IT/IS systems (Zachman, 1987). Hence, the development of the EA field is mainly driven by input from domain experts within the practical context. Only recently, the number of academic publications related to EA is starting to increase (Gampfer et al., 2018; Lapalme et al., 2016). Nowadays, firms make significant investments to implement EA methodologies (e.g., TOGAF) to manage their IT/IS complexity within an organization (Tamm et al., 2011). Further theory development is required to get a better understanding of the mechanism behind EA benefit realization, so firms can take full advantage of EA and justify their EAM investments (Lange et al., 2016).

The goal of this research is to address this current gap and investigate the effect of EAM on the agility of an organization. Additionally, the role of IT capabilities in benefits realization is investigated. This research aims to answer the following research question:

> *How (i.e., through which path) can enterprise architecture management affect the agility of an organization?*

2 Theory and model development

In this section, we will review the core notions of EA and organizational agility and, subsequently, develop our model and the associated hypotheses that we test using empirical data. Figure 1 shows the conceptual research model and the conceptualization of the EAM, IT capabilities and organizational agility.

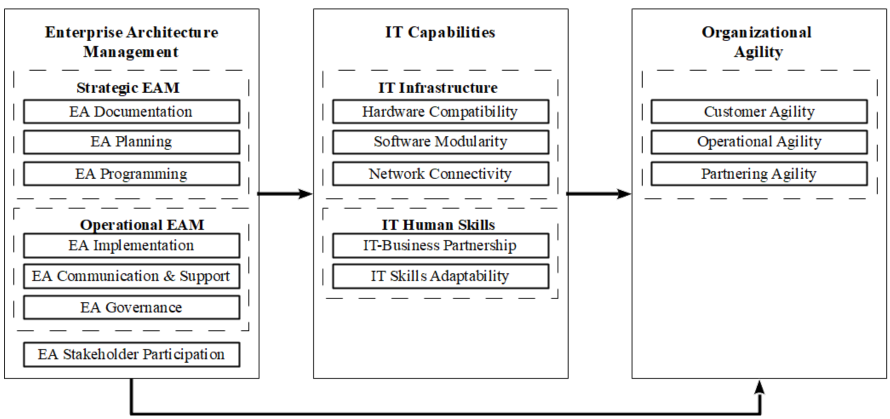

Figure 1: Conceptual research model

2.1 Enterprise architecture and organizational agility

EA provides a blueprint of the 'as-is' situation and supports its transformation to a 'to-be' situation by bridging the gap between IT and business. EAM includes a task to manage the continuous development and implementation tasks of EA and involves the planning of the migration to a future state (Aier et al., 2011). EAM activities cover both strategic- and operational issues. Strategic EAM is concerned with planning the transition from an as-is state to a to-be and providing the blueprint and rules and standards to achieve this. Operational EAM supports the implementation of EA and addresses compliance to rules and standards. Stakeholder participation is a continues activity to make sure that the requirements of the individual stakeholders are met on both a strategical- and operational level (Schmidt & Buxmann, 2011).

Organizational agility is the one of the main goals of EA (Hoogervorst, 2004) and is described as the "firm's ability to cope with rapid, relentless, and uncertain changes and thrive in a competitive environment of continually and unpredictably changing opportunities" (Lu & Ramamurthy, 2011, p. 932). Previous empirical research found a positive effect of EA on organizational agility. Evidence was found that architectural insight and EA-induced capabilities improve agility as a constituent of organizational performance (Foorthuis et al., 2016). Other researchers concluded that EA assimilation mediates a positive effect from EA strategic orientation on organizational agility (Hazen et al., 2017).

2.2 Enterprise architecture management and IT capabilities

The IT infrastructural capabilities often refer to the flexibility of the IT infrastructure and consists of measures to assess hardware compatibility, software modularity, and network connectivity (Schmidt & Buxmann, 2011). Architectural principles prescribe the requirements, design, and implementation of the IT in such a way that it supports the transformation to the desired state and potentially influences the ability to allocate and manage IT infrastructural resource, thus the flexibility of the IT infrastructure (Schmidt & Buxmann, 2011). However, EA itself is merely a set of artifacts that do not add value to an organization without a practice to utilize the benefits of EA (Foorthuis et al., 2016). EAM processes guide the transformation of an organization by managing the use and development of EA (Aier et al., 2011).

We now argue that EA contributes to IT human resource capabilities in two ways. First, standardization leads to a reduction of technologies. This reduction can lead to more effective and efficient allocation and utilization of human resources as a result of, e.g., reduced skill variation, simplified troubleshooting and focus on core competencies in resourcing (Tamm et al., 2011). Second, EAM helps to align stakeholders improving the overall acceptance of EA and supports stakeholders to plan and implement EA conformant projects and potentially guides CIOs and IT managers in the allocation and skills development of IT human resources (Iyamu & Mphahlele, 2014; Schmidt & Buxmann, 2011). Hence, we define the following:

> ***H1:*** *Enterprise architecture management has a positive effect on IT capabilities.*

2.3 IT capabilities as a mediator

Achieving organizational benefits from EA is not straightforward but highly complex and involves an interconnection between various organizational facets (Shanks et al., 2018; Van de Wetering & Bos, 2016). Although extant literature does not provide a unified theoretical foundation on EA benefit realization, previous researchers reach consensus on the distinction between benefits that are a direct result of EA processes (i.e., first level benefits) and higher-level benefits that are intermediated by first level benefits. First level EA benefit realization often targets to improve the ability to manage the complexity of the organization's IT infrastructure and business processes, to implement and establish EA in the organization and to have an insight in the complexity of the (IT/IS) organization for both business and IT stakeholders. (Foorthuis et al., 2016; Hazen et al., 2017; Niemi & Pekkola, 2016; Schmidt & Buxmann, 2011). This research aims to capture these aspects and proposes IT capabilities as a first level benefit of the EAM approach.

IT capabilities can be defined as "the ability to mobilize and deploy IT-based resources in combination with other organizational resources and capabilities (Chen et al., 2014, p. 327)". The resource-based view claims that specific combinations of firms' internal resources that are valuable, scarce and not easy to copy by others, lead to competitive advantages (Barney, 1991). IT capabilities demonstrating these properties are mentioned as an essential source to perform better than competitors (Chen et al., 2014).

A flexible IT infrastructure improves the ability to respond to changes by influencing an organization's ability to use IT or adjust the existing IT infrastructure to support business goals (Mikalef et al., 2016; Tallon, 2008; Tallon & Pinsonneault, 2011). Respond to changes in customer demands (i.e., customer agility) is improved by, e.g., the scale required resources like servers, storage, memory, CPUs or network bandwidth. Software modularity reduces software development time and simplifies combining and reconfiguring components to create new business processes. This modularity boosts process agility by decreasing response times to product launches of competitors, market expansion, product mix changes and the adoption of IT innovation (Tallon & Pinsonneault, 2011; Tallon et al., 2018). The adaptiveness of supplier networks (i.e., partnering agility) is improved if the IT infrastructure is simple to reconfigured to comply to the IT and standards of existing and new suppliers (Rai & Tang, 2010). Additionally, IT capabilities drive the synergetic effect of IT and organizational capabilities and enables innovation capabilities by, e.g., providing standardized and easily accessible real-time data that are important to provide accurate management information to decision makers (Chen et al., 2014; Mao et al., 2015; Van de Wetering et al., 2017). Organizations also use the insight and expertise of human resources to develop capabilities to increase the ability to move in different directions. From the perspective of IT skills, well-trained personnel is suggested to be easier to relocate within the organization (Tallon, 2008). Hence, we hypothesize that EAM contributes to organizational agility through a mediating effect of IT capabilities.

> ***H2:*** *IT capabilities mediates the positive effect of enterprise architecture management on organizational agility.*

3 Methodology

3.1 Data collection

A survey was developed to measure the constructs in the research model. Targeted respondents were expected to provide an insight into the coordination of an architecting effort and judgment on the EA practice, the IT and the agility of their organization. Previous research (Foorthuis et al., 2016) included the following professional positions: CIOs, enterprise architects, technical architects, IT analysts, IT/project managers, and business stakeholders. Our research targeted professionals working in similar positions.

Table 1: Sample characteristics

		Frequency	Percentage
Industry	Accountancy, banking and finance	23	20.9%
	Information technology	18	16.4%
	Energy and utilities	13	11.8%
	Healthcare	12	10.9%
	Transport and logistics	12	10.9%
	Others	32	29.1%
Position	IT Architect	41	37.3%
	Business Architect	11	10.0%
	IT Manager	17	15.5%
	Business / Management Consultant	24	21.8%
	IT / Software Consultant	15	13.6%
	Business Manager	2	1.8%
Size	Less than 100 employees	13	11.8%
	Between 100 and 1000 employees	22	20.0%
	More than 1000 employees	75	68.2%

Since no sampling frame for the targeted population (i.e., organizations that implemented the EA practice) was available, a quota sampling approach was used to improve generalizability. Industrial categories were derived from previous research (Aier et al., 2011; Foorthuis et al., 2016). In total, 481 professionals working for firms located in Belgium, the Netherlands and Luxemburg (Benelux), were personally invited online (e.g., e-mail or LinkedIn) to complete the online survey, leading to a total of 110 useful and complete responses and a response rate of 23%. Table 1 shows the sample characteristics for this research. During data collection, we kept track of which respondent from which organization completed the survey to ensure every organization completed the survey only once and assured them that the data collected would remain anonymous and only used for research purposes at an aggregate level. We performed Harman's single factor test using IBM SPSS Statistics□ v25 to control for common method bias (CMB). All relevant construct variables were loaded onto a single construct in an Exploratory Factor Analysis (EFA). The analysis showed that no single factor attributes to the majority of the variance, thus confirming our sample is not affected by CMB (Podsakoff et al., 2003).

3.2 Constructs and items

For all our measures, we use past empirical and validated work to increase the internal validity of the questions. The developed survey was, then, pre-tested and assessed by two practitioners and a panel of two academic experts to ensure face and content validity. We evaluated all survey items on a 7-point Likert scale.

Enterprise architecture management

Schmidt & Buxmann (2011) developed EAM as a type II second-order construct (first-order reflective and second-order formative). This second-order construct consists of 7 constructs:

- *EA documentation:* the process of capturing and describing the existing EA using architectural descriptions.
- *EA planning:* a goal-oriented process of developing descriptions of the target architecture based on global and long-term requirements.
- *EA programming:* the process of setting architecture rules and standards to be obeyed by change projects.
- *EA implementation:* the initiation and/or execution of system changes through the EAM function itself.
- *EA Communication & Support:* the extent of communication and support efforts undertaken by the EAM function.
- *EA Governance:* the degree to which EA-related decisions and guidelines bind to the organization and may be enacted based on formal processes.
- *EA Stakeholder Participation:* the extent to which stakeholders are involved in EAM decision making (Schmidt & Buxmann, 2011).

Table 2: Items and descriptive statistics of EAM

	Item	Loading	Mean	SD
	EA Documentation			
DOC1	Descriptions reveal the major dependencies	.751	4.83	1.560
DOC2	Descriptions are based on a common meta-model	.855	4.27	1.758
DOC3	Descriptions are stored in a repository tool	.872	4.06	1.998
DOC4	EA documentation is updated continuously	.848	4.09	1.740
	EA Planning			
PLN1	EA planning covers all relevant architectural domains	.860	4.78	1.692
PLN2	EA planning covers all segment of the IT landscape	.846	5.01	1.745
PLN3	EA planning covers systems engineering concepts	.860	4.92	1.602
PLN4	EA plans are frequently updated to remain up-to-date	.832	4.39	1.607
	EA Programming			
PRG1	Architecture principles are used in development	.847	5.00	1.629
PRG2	Standard catalogs restrict the usage of IT technologies	.779	4.62	1.624
PRG3	Reference architectures standardizes the design IS	.875	4.69	1.622
PRG4	Defined data is shared across business units	.790	4.46	1.682
	EA Implementation			
IMP1	Non-business-driven projects accelerate EA change	.759	4.47	1.661
IMP2	Common integration infrastructures are implemented	.858	4.99	1.665
IMP3	Shared technology services are created and operated	.861	5.32	1.433
IMP4	Reusable application services are implemented	.842	4.89	1.569
	EA Communication &Support			
COS1	EA plans are communicated to stakeholder groups	.865	4.61	1.668
COS2	EA documentation is easily accessible by stakeholders	.851	4.25	1.734
COS3	Stakeholders are provided with EA consulting services	.883	4.22	1.620
COS4	Architects work within projects	.820	4.85	1.798
	EA Governance			
GOV1	Conformance to EA plans is constantly assessed	.853	4.17	1.560
GOV2	Well-define review and approval processes are in place	.902	4.14	1.750
GOV3	Internal directives require the compliance EA	.870	4.32	1.737
GOV4	Violations of architecture are tracked and sanctioned	.870	3.23	1.571
	EA Stakeholder Participation			
PAR1	EA plans are approved by governance committee	.914	4.46	1.862
PAR2	Top-Management is actively involved in EA planning	.886	4.17	1.838
PAR3	Stakeholder participate in setting rules and standards Rules	.900	4.25	1.659
PAR4	and standards are set by governance committees	.923	3.99	1.750

IT Capabilities

A second-order reflective-reflective construct captured the latent variable IT capabilities including capabilities concerning IT human skills and IT infrastructure capabilities. IT-business partnership items measured the extent to which IT executives are involved in business concerns. IT skills adaptability measured to what extent IT personnel can adopt and bring into practice different programming methodologies and IT infrastructural skills (Tallon, 2008). IT infrastructure capabilities focus on the flexibility of the IT infrastructure. The first-order constructs and measures were adopted from previous research (Byrd & Turner, 2000; Tallon, 2008). These are presented in the Table 3.

Table 3: Items and descriptive statistics of IT Capabilities

	Item	Loading	Mean	SD
	Hardware Compatibility			
HAR1	Transport and use of IT/IS across multiple platforms	.751	3.74	1.611
HAR2	Transparent access to all platforms and applications	.846	4.12	1.559
HAR3	Multiple interfaces or entry points for external users	.884	4.76	1.595
HAR4	Extensive use of middleware to integrate key systems	.647	4.79	1.794
	Software Modularity			
SOF1	Usage of reusable software modules	.844	3.98	1.618
SOF2	Impact of legacy systems on new IT development	.792	3.55	1.735
SOF3	Adjustability of critical applications based	.880	4.05	1.580
SOF4	Ability to handle variations in data formats	.867	4.35	1.575
	Network Connectivity			
NET1	Degree of system inter-connectivity	.825	4.89	1.580
NET2	Flexibility to add electronic links to external parties	.848	4.65	1.632
NET3	Accessibility of centralized data by remote users	.833	4.69	1.628
NET4	Real time capturing and availability of data	.684	3.77	1.677
	IT-business partnership			
IBP1	Involvement IT executives in shaping business strategy	.805	4.78	1.563
IBP2	Promotion of IT among business executives	.869	5.19	1.385
IBP3	Help of IT executives to solve business problems	.777	4.88	1.432
IBP4	Usage of IT resources & skills in customer processes	.743	4.54	1.599
	IT skills adaptability			
ISA1	Encouragement to improve technical skills	.837	5.18	1.556
ISA2	Ability to develop IT solutions to business problems	.891	4.66	1.448
ISA3	Adaption to multi-tasking	.715	4.70	1.359
ISA4	Training in variety of programming methods and tools	.863	4.39	1.635

Organizational agility

We constructed organizational agility as a first-order construct measured by eight statements on the customer agility, operational agility, and partnering agility of an organization (Tallon & Pinsonneault, 2011) as shown in Table 4. Customer agility is the capability to gather market intelligence by co-opting customers. Operational agility refers to the ability to efficiently and effectively redesign business processes to exploit opportunities in a competitive environment. Partnering agility is the ability to rapidly respond to opportunities by forming alliances and partnerships with suppliers (Sambamurthy et al., 2003; Tallon & Pinsonneault, 2011).

Table 4: Items and descriptive statistics of Organizational Agility

	Item	Loading	Mean	SD
ORA1	Respond to changes in aggregate consumer demand	.832	4.14	1.587
ORA2	Customize a product for an individual customer	.745	4.04	1.684
ORA3	React to new product launches by competitors	.899	3.83	1.525
ORA4	Response to changes in competitors' prices	.793	4.34	1.680
ORA5	Expand into new regional or international markets	.766	3.82	1.759
ORA6	Change the variety of products available for sale	.839	3.89	1.648
ORA7	Adopt new technologies to improve production	.831	3.92	1.496
ORA8	Switch suppliers to improve costs, quality or delivery times	.748	3.70	1.643

Firm size was included as a control variable and was measured as the overall number of full-time employees (FTE) in the organization. FTE is a potential influencer of organizational agility (Lu & Ramamurthy, 2011). Categorical variable (i.e., dummy variables) were included as a formative latent variable (Henseler et al., 2016). Firms counting less than 100 employees were defined as small firms, between 100 employees and 1000 employees as medium-sized, and 1000 employees or more as large (Chen et al., 2014).

4 Analysis

This study uses partial least squares structural equation modeling (PLS-SEM) to assess our research model. PLS-SEM is a mature variance-based regression approach undergoing severe methodological and theoretical examinations (Henseler et al., 2016). We estimate our model's parameters using SmartPLS version 3.2.7. (Ringle et al., 2015) and used 5000 replications within the bootstrapping procedure to obtain stable results. As for sample size requirements, the included data exceeds all minimum requirements.

4.1 Analysis of the measurement model

Construct reliability was assessed on an item level and a first-order factor level. For the former, all Cronbach α values were greater than the 0.7 threshold (Henseler et al., 2016). Table 5 shows that both the α and composite reliability (CR) values exceed 0.7 for first-order factors. Convergent validity assessment showed average variance extracted (AVE) values greater than 0.5 for all constructs. The square roots of the constructs' AVE were higher than the inter-construct correlations, proofing discriminant validity (Fornell & Larcker, 1981).

Table 5: Reliability, convergent, and discriminant validity of first-order factors

	1	2	3	4	5	6	7	8	9	10	11	12	13
EA Management													
1. Planning	**.85**												
2. Communication & Support	.70	**.86**											
3. Documentation	.67	.76	**.83**										
4. Governance	.61	.80	.70	**.87**									
5. Implementation	.58	.69	.66	.70	**.83**								
6. Stakeholder Participation	.58	.78	.66	.79	.65	**.91**							
7. Programming	.69	.78	.75	.78	.78	.70	**.82**						
IT Capabilities													
8. Hardware Compatibility	.32	.47	.39	.53	.57	.38	.46	**.79**					
9. Software Modularity	.35	.51	.43	.46	.57	.39	.47	.76	**.85**				
10. Network Connectivity	.36	.48	.42	.45	.57	.36	.48	.70	.76	**.80**			
11. IT Business Partnership	.39	.49	.37	.51	.56	.55	.49	.46	.55	.52	**.80**		
12. Skills Adaptability	.38	.44	.41	.50	.52	.46	.43	.69	.73	.63	.65	**.83**	
Dependent Variable													
13. Organizational Agility	.32	.38	.33	.37	.33	.28	.32	.55	.68	.52	.49	.62	**.81**
AVE	.72	.73	.69	.76	.69	.82	.68	.62	.72	.64	.64	.69	.65
CR	.91	.92	.90	.93	.90	.95	.89	.88	.91	.88	.88	.90	.94
Cronbach α	.87	.88	.85	.90	.85	.93	.84	.79	.87	.81	.81	.85	.92
VIF	2.3	4.6	2.9	4.0	2.8	3.3	4.3	-	-	-	-	-	-

The variance inflation factors (VIF) for the formative first-order constructs were less than 5 as indicated in Table 5, thus multicollinear is not an issue (Hair et al., 2012). These measurement model outcomes support the appropriateness of the first-order reflective measures and suggest that all the included measures are good indicators for their respective latent constructs.

4.2 Analysis of the structural model

We estimated and validated the structural model and the relationship among its constructs to analyze our model's hypotheses. Our analyses of the structural model are summarized in Figure 3, where the explained variance of endogenous variables (*R^2*) and the standardized path coefficients (*β*) are depicted. We evaluated the structural model by assessing the coefficients of determination (*R^2*) values, Stone-Geisser's predictive relevance (Q^2), Cohen's effect size (f^2) and path coefficients (Henseler et al., 2016). Mediation was assessed in two ways. First, the Kenny approach (Baron & Kenny, 1986) was applied. Second, we analyzed mediation in PLS-SEM using Zhao et al.'s (2010) approach. Figure 2 indicates that the overall direct effect of EAM on organizational agility is both positive and significant ($\beta = .467$, $\varrho \leq 0.001$), fulfilling the first condition of Kenny approach. Evaluating the Cohen's effect size shows a moderate effect ($f^2 = .245$) of EAM on organizational agility in the direct model.

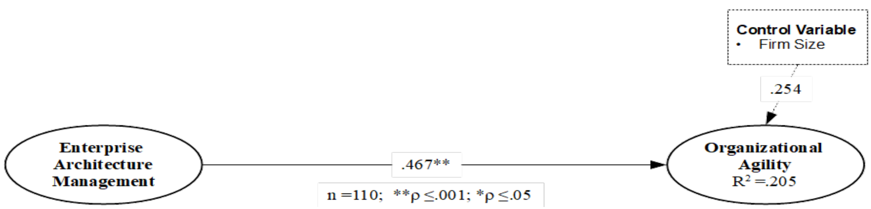

Figure 2: Direct model

The mediation model presented in Figure 3 confirms a positive, significant and strong effect ($\beta = .623$, $\varrho \leq 0.001$, $f^2 = .633$) of EAM on IT capabilities with an explained variance of 38.8% ($R^2 = .388$). Hence, H1 is accepted. Cohen's effect size reveals that IT capabilities have a strong effect ($f^2 = .555$) on organizational agility. This effect is both positive and significant ($\beta = .689$, $\varrho \leq 0.001$). The direct effect of EAM on organizational agility is minimal and insignificant ($\beta = .012$, ϱ

= .903, $f^2 < .001$). The model estimates organizational agility with an explained variance of 48.7% ($R^2 = .487$). These results imply full mediation according to the Kenny approach.

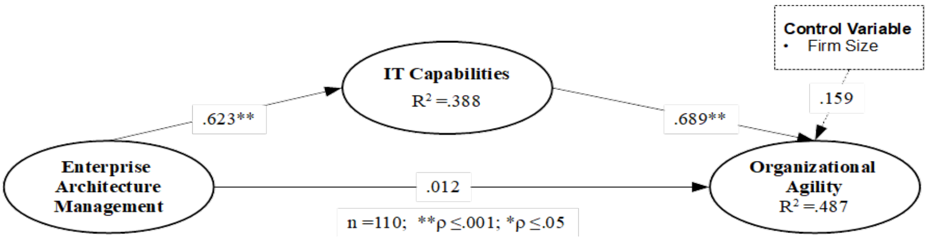

Figure 3: Mediation model

According to Zhao et al.'s (2010) approach we confirmed that the indirect effect of EAM on organizational agility is positive and significant (β =.429, $\varrho \leq 0.001$). The direct effect was not significant, leading to the identification of a mediator "consistent with the hypothesized theoretical framework" (Zhao et al., 2010, p. 201). Hence, H2 is accepted. The control variable (i.e., firm size) doesn't have a significant effect (β = .159, ϱ = .083) on organizational agility.

Predictive relevance was evaluated by assessing Stone-Geisser's Q^2 value. We used a sample reuse technique called blindfolding to calculate Q^2 values for the latent variables (Hair et al., 2016). A Q^2 value greater than zero indicates predictive relevance for endogenous latent variables in a PLS path model. The procedure demonstrated predictive relevance for both IT capabilities ($Q^2 = .167$) and organizational agility ($Q^2 = .278$).

5 Discussion and conclusions

This research builds upon earlier work of Schmidt & Buxmann (2011) who developed the construct EAM approach. While their research found evidence that the EAM approach has a positive effect on IT infrastructural capabilities (i.e., IT flexibility), we focused on benefits realization on a broader conceptualized construct IT capability, including IT human capabilities. We extended previous EAM studies by looking further than first level benefits and included benefits on an organizational level, i.e., organizational agility. From a theoretical point of view, our results are relevant. We now show that EAM, mediated by IT capabilities does enhance business benefits, i.e., organizational agility. Thereby, we contribute to a much-needed empirical knowledge base on EA.

Our results are practically relevant. We show that business benefits are not a simple result of EA artifacts. Decision-makers can consider an EAM approach to enhance the organization's IT-business partnerships, IT skills adaptability and flexibility of the IT infrastructure. The EAM approach should cover the various strategic and operational tasks. Furthermore, stakeholders from both the business and IT departments must be involved as their engagement is essential for successful EA utilization and EAM acceptance. Stakeholders should also actively participate in setting architecture rules and standards (Schmidt & Buxmann, 2011). It is important to emphasize that implementing existing EA methodologies like TOGAF, is not a guarantee for successful EA benefit realization. Empirical research on the usefulness of such methods is lacking (Lapalme et al., 2016). Moreover, recent literature questions the practical use of TOGAF (Kotusev, 2018). Hence, investigating the practical use of EA methodologies and draw parallels with the theoretical foundation of EA and EAM is a valuable avenue for future research (Van de Wetering, 2019).

We also discuss some study limitations. First, a quota sampling approach was used to improve the representativeness of the dataset in non-probability sampling. Although this improves the external validity, future research should focus on identifying the population and develop a sample frame to support probability sampling.

Second, the survey was limited to the Benelux area. Extending the geographical area to collect data, might contribute to the generalizability of the findings.

Third, the survey was filled in by a single person. Several forms of self-reported bias can occur when a single source completes the survey items for all constructs (Podsakoff et al., 2003). A matched-pair survey, where the survey items for a single survey are distributed among different respondents (e.g., IT and business executives) with specific domain knowledge, is suggested in prior related research (Mao et al., 2015).

Finally, we did not analyze the combinations of causal conditions that lead to organizational benefits. To get a better understanding of the complex nature of EA benefit realization, researchers could employ set-theoretic methods like fuzzy set qualitative comparative analysis. This approach provides valuable insights into different configurations of EA-related attributes that lead to benefits like organizational agility and innovation (Fiss, 2007). Future work could also include external factors; e.g., environmental turbulence, as they can have a substantial impact on organizational capabilities including organizational agility (Chen et al., 2014; Tallon & Pinsonneault, 2011).

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Traditional Businesses in the Sharing Economy: Critical Success Factors and Prerequisites

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Abstract The sharing economy emerged as an alternative way to earn or save money during the financial crisis. Customers started to share underused products for a small fee. This trend is projected to grow over the next years. Not only is the market volume rising, but also the customers' willingness to use it. Projections indicate that traditional businesses will lose customers as well as market share. Hence, this paper tries to understand why traditional businesses should consider the sharing economy and intends to find critical success factors, prerequisites, potentials and risks. To achieve these goals, a comprehensive qualitative research approach involving six experts was applied. The results show that being customer-centric and adopting a sharing mindset are examples of CSFs, while an important prerequisite is to understand the customers' needs and wants. These findings can guide traditional businesses with a B2C business model in the sharing economy as a provider of their products and services.

Keywords: • Sharing Economy • Traditional businesses • Critical Success Factors • Prerequisites • Potentials • Risks • B2C Business Model •

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1 Introduction

The sharing economy is not a new idea per se. People have always shared goods among their family, neighbours and close friends, mainly in order to survive. This new phenomenon gained momentum through the financial crisis of 2007/2008, when people started being more price conscious and looking for alternative ways to gain money. Sharing platforms offer respective options, because they enable private individuals to rent out their spare rooms or private cars to other people for a limited period. Because such peer-to-peer or consumer-to-consumer (C2C) transactions require almost no specific investments and cause only very little variable costs, they can be offered less pricey than professional rental services. Furthermore, the internet made global presence and distribution handy and thus, sharing platforms became commonly available (Schor, 2014).

The rise of the sharing economy causes a growing overall market volume in the rental business (Zervas, Proserpio, & Byers, 2017). However, growth takes place among the sharing businesses whereas growth of the traditional rental businesses is projected to be close to zero (Le Jeune, 2016). In addition to this, traditional businesses experience a disruptive change because of new sharing start-up companies. Well-known examples for the disruptive potential of sharing platforms are Uber and Airbnb. Analyses undermine the continuous growth of the sharing economy: 32% of the participants of a survey answered that they will increase their participation in the sharing economy in the next twelve months and 40 % said it will stay the same (Bright & McKenzie-Minifie, 2015). The latest figures from eMarketer (2017) predict that the sharing economy users will grow from 26 % of all internet users in 2017 to 38 % in 2021. This development poses a risk to established businesses (Le Jeune, 2016). As a consequence, the sharing economy has meanwhile attracted the attention of traditional businesses (Ciulli & Kolk, 2019).

Instead of considering the new thinking, affected established businesses try to protect their business models (BM) by emphasizing the regulatory aspects. However, regulations only help in situations of market failures. Other options are available for companies, but only a few have started to adapt them so far (Le Jeune, 2016). For example, companies could enhance their existing BM by sharing their own asset base (Belk, 2014).

The focus of this paper lies on traditional businesses that could expand their existing B2C BM by offering their consumer products and services on a pre-existing sharing platform. Hence, this paper concentrates on business model innovations (BMI). It analyses neither the creation of a new sharing economy platform nor the introduction of a new sharing economy BM.

Due to the situation described above, the main research question of this paper is whether and how it makes sense for businesses with a traditional BM to provide their products and services in the sharing economy. The goal is to identify critical success factors (CSF) and prerequisites for prosperous activities in the sharing economy as well as to identify the potentials and risks for B2C businesses. The three research questions (RQ) below guide the analysis:

- RQ1: Why should traditional businesses consider activities in the sharing economy as an extension of their BM?
- RQ2: What are the CSFs of the sharing economy and – according to them – what prerequisites do traditional businesses have to meet if they want to offer their products and services on sharing platforms?
- RQ3: Which potentials and risks result from activities in the sharing economy specifically for B2C businesses?

The paper is structured as follows: In chapter 2, literature is reviewed to give an understanding of the term sharing economy and to analyse related work. Chapter 3 describes the frameworks used and the research methodology applied. The interpretation of the survey results follows in chapter 4. Chapter 5 provides a summary and draws conclusions.

2 Literature Review

A number of initiatives fall under the umbrella term of the sharing economy and a debate is ongoing how to define, structure and categorize them (Netter, Pedersen, & Lüdeke-Freund, 2019). The definition used in this paper, includes the five aspects below:

- Sharing processes or transactions are handled through an online platform (Botsman & Rogers, 2011; Hamari, Sjöklint, & Ukkonen, 2016)

- Sharing is compensated by a fee or other compensation (Frenken & Schor, 2017; Plewnia & Guenther, 2018)
- Sharing subjects are underused products or services (Botsman & Rogers, 2011; Frenken & Schor, 2017; Hamari et al., 2016)
- Sharing allows temporary access-based consumption (Bardhi & Eckhardt, 2012; Botsman & Rogers, 2011; Frenken & Schor, 2017)
- Sharing takes place in C2C or B2C contexts (Hamari et al., 2016; Plewnia & Guenther, 2018)

Sharing has a long-standing tradition (Schor & Fitzmaurice, 2015). The financial crisis of 2007/2008 boosted the sharing economy as people looked for cheaper products and services (The Economist, 2013). Sharing is more cost effective for all participants, e.g. because of a higher degree of use and the absence of additional intermediaries like merchants. Hence, products and services which were previously too expensive became accessible for people with lower incomes (Schor, 2014).

The main idea of the sharing economy is that sharing a product is more efficient than owning it. This concept is not new (e.g. second-hand books, second-hand clothes), but the sharing economy differs often in two points (Winterhalter, Wecht, & Krieg, 2015):

1. global scale and
2. products are shared much earlier in the product lifecycle compared to conventional second-hand markets.

Another difference between sharing economy and traditional businesses is that the "... sharing economy facilitates parallel sharing (i.e. while the original owner still owns and uses the resource) and sequential sharing (i.e. reselling/lending used products to new users) ..." (Winterhalter et al., 2015). Thus, sharing companies have increased efficiency in the use of resources. Furthermore, start-ups in the sharing economy have low operational costs which are in contrast with the high operational costs (e.g. real estate rental and acquisition of machines) of traditional businesses (Hasan & Birgach, 2016).

Many strategies for how traditional businesses can approach the sharing economy have been studied. According to Belk (2014), there are three viable solutions:

- Flight: Diversifying out of the industry
- Fight: Regulations to stave off the sharing economy. Although, fights have been poor and prevent the industry from adopting new technologies and profiting from them.
- Destruction of old BMs and adoption of creative new ways: e.g. provide content for free and find other revenue (e.g. Google), or buy up a leading company offering the disruptive technology (e.g. Avis buying Zipcar), or expand into the new market.

BM research is soaring and many different definitions are used. Often BM is described with "value creation" and "value capture" (Massa, Tucci, & Afuah, 2017). According to Osterwalder & Pigneur (2010) a BM "describes the rational of how an organisation creates, delivers and captures value". Whereas, BMI is the development or modification of components of the existing BM (Osterwalder, Pigneur, & Tucci, 2005). BMI is key for a company's future (DaSilva, 2018).

According to Massa, Tucci & Afua (2017), organisations have started to experiment new ways to achieve their goals due to technological and other trends. To do so, a company must adapt and therefore it is important to understand the implications. Some information about the CSFs, prerequisites, potentials and risks can already be found in the literature as part of the description of the sharing economy. However, there is a lack of a systematic approach to identify what the CSFs and prerequisites for traditional businesses are to participate in the sharing economy in the sense of BMI.

3 Methodology

This chapter consists of the research design, including the approach for the data gathering and data analysis. The second subsection introduces the chosen models.

3.1 Research Design and Data Analysis

The research method for this paper has been selected based on the research onion by Saunders, Lewis and Thornhill (2016). The applied research design for this paper is grouped into three phases: analysis, development and evaluation. In the *analysis phase*, current literature was studied to understand the underlying problem as suggested by the interpretivist philosophy. This fits the goal of this paper, which is to understand the CSFs of the sharing markets and the prerequisites for traditional businesses that want to participate in that market. In this phase, the answers were found for the first research question.

In the *development phase*, the questions for the qualitative interviews were created and the interviews held. The questions were created based on the Organisational Fit model, which gave the perspectives of the questions, and the BOAT model for the more detailed structure. The idea was to begin with specific observations in the interviews, which would then be summarised in general conclusions as per the inductive approach. Qualitative interviews were used because of the explorative character of the study. The interviews themselves were semi-structured. Open questions were chosen in order to allow participants to describe a situation and to be encouraged to provide an extensive answer. Probing questions were added to further explore the responses as needed (Saunders et al., 2016). The following questions were developed to find responses to the research questions:

Table 1: Interview questions

Area	Questions
Critical Success Factors of the markets of the sharing economy	#1: Which points do you see critical for success for a traditional business in the sharing economy? #2: Why are some traditional businesses which already operate in the sharing economy successful?
Prerequisites for traditional businesses	#3: What would traditional businesses need to do in order to be ready to use the sharing economy for their own advantage and business? #4: What are the prerequisites for the products and services by a traditional business to be offered on sharing economy platforms?
Results of Organisational Fit	#5: What are the benefits resulting from a participation of traditional businesses in the sharing economy? #6: What are the risks for traditional businesses participating in the sharing economy?

The interviews took place face-to-face with six identified experts and stakeholders in October 2017. There are three stakeholder groups in the sharing economy: the supplier, the platform provider and the end-user. The idea was to interview from each group at least one expert in order to have a good mixture of different perspectives and experiences. The following six experts were chosen:

Table 2: Interviewed experts

#	Function	Description
[A]	Expert, End-user	He is the co-founder and board president of the Swiss non-profit association for sharing economy. He holds a Master's degree in executive management.
[B]	Expert, End-user	She founded her own consulting company where she supports traditional businesses. She holds a bachelor's degree in mathematics and a master's degree in computer science. She has published papers in international journals and got accepted for a PhD program with the focus on business models in the rail freight industry.
[C]	Platform provider, End-user	He gained over ten years' experience in the banking industry before founding a sharing platform where workspaces are shared. He has a bachelor degree in business administration and banking and finance.
[D]	Platform provider, End-user	He is an entrepreneur and the CEO of a sharing economy platform where the user can exchange books and DVDs. He holds a bachelor degree in Business and Economics.
[E]	Platform provider, End-user	He is the founder and CEO of a sharing platform which focuses on sharing everyday objects. He has a master's degree in Business Administration, Marketing, Services and Communication.
[F]	Supplier, End-user	He is the owner of a loft. He offers this apartment on sharing platforms. His educational background is in marketing and business management.

The interviews were audio-recorded and summarizing transcripts were generated based on the audio recordings. The transcripts were sent to the interviewed persons for verification. Based on the verified transcripts, the data analysis started. First, the main points mentioned were categorized into CSFs, prerequisites, potentials and risks. From these four categories, the points were structured into the BOAT layers. Then, similar points were grouped by topic. The literature was screened in the same way and the identified points were added to the ones from the interviews. After that, for each group of topics an overall naming was given which summarized the findings from the interviews and the literature. This was done for all four categories.

In the evaluation phase, the goal was to create the artefact as per the design science research. The artefact is a comprehensive list of CSFs, prerequisites, potentials and risks. Afterwards, the interviewed experts verified these lists. They were requested to provide feedback on the collected findings. At the end, the findings were adjusted and finalised.

3.2 Models

The model of Organisational Fit and the views of the BOAT approach were used for the structuring of the interview questions, analysis and interpretation. The Organisational Fit provides the fundamental perspective and the BOAT approach contributes the next level of the structure. As the paper has an e-business approach, these models are better suited than others like the Business Model Canvas from Osterwalder & Pigneur (2010) or the STOF model from Bouwman, Faber, Haaker, Kijl, & De Reuver (2008). The latter look at every aspect of a BM including financials. They are usually used to conceptualize BMs, thus do not suit this analysis (Marolt, Maletič, Borštnar, Lenart, & Pucihar, 2016).

The Organisational Fit is used to derive the relationship between the CSFs of a market and the prerequisites that a business needs to deploy in order to be successful in the selected market. A company develops prerequisites, which consist e.g. of capabilities and resources (Amit & Schoemaker, 1993). These prerequisites for traditional businesses must then fit the CSFs of the markets and need to be adapted in cases of change. A fit between these two results is a potential, a misfit poses risks (Leimstoll, 2001).

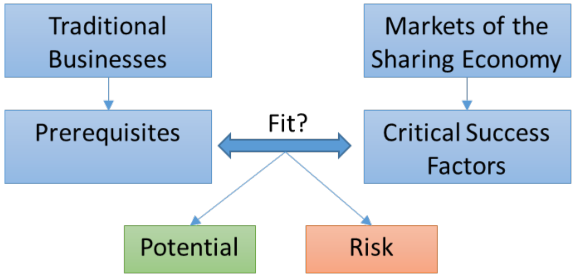

Figure 1: Organisational Fit (adapted from (Leimstoll, 2001))

The BOAT approach was chosen as it gives the interview and outcome an additional structure. BOAT stands for Business, Organisation and processes, Application and Technology (Grefen, 2010). The four layers can be described as follows, from top to bottom (Schubert & Wölfle, 2007):

- The Business view describes mainly the involved business partners and their roles. This also includes the business processes, objectives and business concept.
- The Organisation and process view covers the business processes in detail, the process sequences and links between involved parties.
- The Application view is about the involved information systems and their distribution within the roles of the business processes. Examples are data management, business logic and user-interface.
- In the Technical view, the involved system component and the network environment are considered. (However, this view is not in scope, as this paper has a stronger business focus.)

4 Results and Interpretation

The following sub-chapters summarize the findings of the qualitative interviews. To sum up, every chapter shows a table with the different clustered topics.

4.1 Critical Success Factors of the Markets of the Sharing Economy

In order to be successful, the mind-shift of the traditional business must take place. Important is that this shift takes place on all levels of the company, said [A] and [D]. The most important aspect, confirmed by all interview candidates, is the customer-centric perspective of a traditional business. According to [B], companies that are successful in the sharing economy are not traditional per se anymore. They performed the mindset change. A product on a sharing platform can only be a success if the product is actually shareable and people want to share it. This was confirmed by [A], [E] and [F]. Successful companies must have a high demand for their product or service and have a unique offer [F]. Hence, they did the mind-shift, and are now concentrating on the customers' needs and provide a better offer [C].

Another CSF is the platform itself, said [B]. Here, it is important how the platform is organised, how many customers it has, how the prices are calculated and how the supply and demand are balanced. The latter was also found essential by [C] and [D].

To take away the fear of many traditional businesses, a CSF is to provide low entrance barriers, so they can try it and feel that they do not lose too much in case it does not work [C]. [B] added that the standardization is key. This does not only include the standardization of the production chain in the core and support processes, but also the products on a platform that must adhere to a certain standard. The customer expects certain service standards like delivery, response time, tracking, wrapping, appearance, etc.

With regard to technology, the following CSFs were mentioned by [A]: scalability, ability to evolve and agility. [B] added that technology itself is an important factor, and data must be well protected. In addition, media disruptions in the application layer are no longer tolerated by users.

Table 3: Findings regarding CSFs

Findings
Business view
Be customer-centric
Adopt sharing mindset
Establish trust
Promote low entrance barriers
Provide a well-balanced demand and supply
Offer a variety of shareable products and services
Have unique offerings
Organisation and Process view
Provide standardised processes
Application view
Provide scalable and agile applications
Provide seamless integration
Ensure state-of-the-art security

4.2 Prerequisites for Traditional Businesses

In order to be ready to use the sharing economy, the first two steps which [A] underlined were to recognise the problem and the digital mind-shift. A radical perspective change and mind-shift are needed and the customer must be put in the centre of attention. A company must understand what the customer wants and needs. All interviewees confirmed this latter point.

A traditional company must rethink everything whereas new start-up companies can more easily set their strategies up as needed [C]. It is essential that a strategy is developed and a plan is created, before entering a platform [B].

Partnerships become increasingly important for professional suppliers on sharing platforms, stated [B]. They do no longer only have a few selected corporations but suddenly many more potential partners. [E] added that a company must be aware of having less contact with intermediaries but more direct interactions with the end-users. This makes it even more important to have a unique selling proposition [F].

Furthermore, [C] and [D] agreed that the offer must be a lot better than what the customer can already get today. It must be unique and cool and preferably with no emotional attachment, although this differs from person to person. In addition, expensive products are more appropriate for sharing than cheap products, which was confirmed by [C] and [E]. You have to be a bit creative since often more products and services are shareable than first thought of [E].

[C] and [D] agreed that it is important to start small and develop the business on sharing economy platforms over time, and that this change should grow organically from within the company. With regard to the employees, [E] mentioned that training and re-education must be considered before starting to offer services on sharing platforms. Sales capability is no longer paramount – it is all about repairing, maintaining and building a solid relationship with one's customers [E].

More on the process side, [B] emphasized standardisation is key on sharing platforms. It creates efficiency in the business processes and is necessary to provide standardized products. If a certain standardization is possible, it is easier to offer a big range of products at a competitive price.

In order to be ready to offer products on a sharing platform, the platform itself must be examined. It must have a balanced demand and supply [C]. Furthermore, a company must consider the processes. Often platforms already provide a certain level of standardized digital processes, which a supplier can simply take over. However, the background processes of the supplier must be adapted and organisational capabilities are key. The latter must match the new process requirements. Here, it can be added that digitalization is key [B].

Table 4: Findings regarding prerequisites

Findings
Business view
Understand customers' needs and wants
Establish mind-shift
Have a clear strategy and vision
Create combinable business model
Offer suitable products or services
Analyse suitable platforms
Organisation and Process view
Implement standardised processes
Train employees
Establish strong partnerships
Application view
Ensure digitalised processes
Support scalable and flexible infrastructure
Provide suitable applications

4.3 Potentials

Half of the interviewed experts, namely [A], [B] and [F] described reaching customers around the world as one of the first potentials. This is a new situation for most traditional businesses. Additionally, [A], [B] and [E] pointed out access to a larger market and a new customer segment. A traditional business, which offers on sharing platforms, could have more customers than before [E]. [D] mentioned that the traditional business probably makes "the job to be done" better than before. The consequence is meeting the customer's needs better und thus, attracting more customers.

[B] pointed out that a company must have standardized processes otherwise they would not be able to offer the products and services on a sharing platform. According to [F], a traditional business can profit in many ways from standardized processes offered by reputable platforms: They usually offer various processes (e.g. invoicing, customer support) and services (e.g. mobile app) to their users. Furthermore, a platform brings interested customers to the suppliers [F] and the suppliers are in direct contact with the end-users. [B] explained it like this: suppiers learn immediately what works and what does not. In return, this allows a company to react quickly to customer feedback.

As soon as a company is represented on a platform, it can profit from data collection. Hence, it can analyse data and learn more about its customer base [B]. This information can then be reused for further developments to cater to customer needs. Another potential for traditional businesses is a disruption. They can make other BMs obsolete. Hence, if traditional businesses adapt, they have the chance to disrupt the industry [D].

To sum up, [C] added that it makes sense to share, because it is ecological and more efficient as a whole. [E] commented that sharing can optimize your image as sharing is directly associated with trendiness and innovation.

Table 5: Findings regarding potentials

Findings
Business view
Gain new customers & increase sales
Gain international presence
Understand customers' needs better
Improve the company's image
Increase profitability
Contribute to an ecological environment
Increase diversification
Organisation and process view
Optimise flexibility and agility
Application view
Increase digitalisation

4.4 Risks

The necessary mind-shift of the company was mentioned twice as a risk [A and B]. Due to this change in a company, the motivation of the employees can suffer [B]. When a company extends its BM in order to offer products on a sharing platform, the old and the new part of the BM can compete with each other and lead to cannibalistic effects [B and E]. Extending the BM poses the risk of investment. Change is time and cost-intensive per se, agreed [A], [B] and [C].

Turning to the duration and trendiness of sharing platforms, four experts [A, B, D and F] agreed that such a venture might be of short duration, as nobody knows what will be trendy in the future. Besides, [D] mentioned that sharing economy is a buzz word and the problems with buzz words are that it is not good per se. Offering products and services on a sharing platform must create a certain benefit for the end-users.

In order to compete with the rivals, there is a certain price pressure, which is absorbed by standardizing the processes. However, a company has a risk of low margins due to the high price pressure [B]. In this regard, [C] commented that the suppliers are constantly compared with each other due to the direct competition with opponents. Furthermore, the market environment, financial crises, the country's economy, the country's specialities, languages, regulations and natural disasters are further possible risks for a company in general [B].

New technologies are constantly arising and posing a threat [B]. [D] confirmed this and added that artificial intelligence and robotics are two other big new technology trends, which an enterprise must consider. With these new technologies, there is the danger of being disrupted, as [D] had to experience. This usually happens when the use case becomes obsolete and the customer needs are catered to differently.

Another aspect is trust in the platform. [A] and [B] agree with each other that privacy and security are risks. Customers must have confidence in the platform. A further aspect which [B] added, is the data security and the threat of data being stolen.

Table 6: Findings regarding risks

Findings
Business view
Lose customers' trust and attention
Fail mind-shift of the company
Cannibalise traditional business model
Decrease employee motivation
Have risk of investment
Be compared directly with competitors
Change in environment
Be the target of the next disruption
Organisation and process view
Increase risk of process failures
Application view
Fail to follow state-of-the-art technologies
Increase security risks

5 Conclusion

The problem of traditional businesses is that they experience a disruptive change caused by the sharing economy. The sharing economy BMs are different from the previously known traditional BMs and thus pose risks for traditional businesses. Furthermore, the growth rates of sharing economy models are partly skyrocketing compared to the figures of traditional BMs. These are all indications why traditional businesses must consider sharing economy platforms for their products and services. This answers RQ 1.

The findings from the literature review and the points raised during the six expert interviews answer the second and third research question. The contribution of this paper to research and practice are the comprehensive lists of CSFs, prerequisites, potentials and risks. Nearly half of the listed findings were not mentioned in the literature before in this context. The other findings confirm previous results of other authors. Overall, the lists of identified aspects can serve as a guide for traditional businesses planning to offer their products and services on sharing platforms.

If traditional businesses want to keep the reins of the sharing economy, the CSFs are important to understand. The interviews stated clearly that a company should be customer-centric, adopt a sharing mind-set and offer unique products or services. Important is that low entrance barriers are promoted. Schor (2014) added that to earn money there should be low entrance costs. Furthermore, establishing trust is key. Tollefson (2013) mentioned that trust will attract customers, and building trust Belk (2014) said can be done by providing a place to give feedback in order to overcome the customers' fear of using a platform. A further CSF is that the demand and supply side is well balanced and that a variety of products and services are offered on the platform. Offers on the platform should be unique and it is important that "everybody wins" (Hasan & Birgach, 2016). Providing standardized processes is essential and can be achieved by providing scalable and agile applications and seamless integration. In this regard, Schor (2014) mentioned that new innovative technology is key to success and Accenture (2016) underlined that the different layers should be integrated. The final CSF is about security. Based on the interviews it became clear that it is important to ensure state-of-the-art security which Tollefson (2013) confirmed.

Moreover, there are several prerequisites for traditional business as suppliers on sharing economy platforms. For example, the interviewees said that it is important to understand customers' needs and wants and to have established a mind-shift. Belk (2014) mentioned that traditional companies must consider the trend from "you are what you own" to "you are what you share". Deloitte (2015) threatened that companies which do not participate in the sharing economy, will not make this mind-shift, and thus will lose market share. Another significant point is to have a clear strategy and vision. With regard to this point, Zekanović-Korona & Grzunov (2014) argued that modern ICT helps to pursue the strategy and goals. Furthermore, a company should create an autonomous BM, which is combinable with the previous one. Offering suitable products and services is a further prerequisite. To consider here is that the appetite for higher quality and more durable goods is growing, products are cheaper and usually underused (Botsman, 2015; PwC, 2015; Schor, 2014). It is important to analyse suitable platforms and Accenture (2016) found that the platforms must enable the BMs. A point only mentioned by the interviewees was the aspect of understanding the influence of legal and compliance in the markets. Implementing standardized processes, establishing strong partnerships and having trained employees is key. The focus should be on having digitalized processes, scalable and flexible infrastructure and suitable applications.

Furthermore, potentials and risks can arise, depending on the fit between the CSFs and the prerequisites. On the one hand, potentials are that a traditional company could gain new customers, increase sales and gain international presence. Different literature references confirmed that the market is growing, more products are shared on a global scale and that one can gain extra money (Hasan & Birgach, 2016; Le Jeune, 2016; Sauer-Gründel, 2017; Schor, 2014; Winterhalter et al., 2015; Zervas et al., 2017). In addition, it can improve the company's image and increase its profitablity. The latter can be achieved as technologies reduce transaction costs (Schor, 2014), high population density leads to economies of scale (Yaraghi & Shamika, 2016) and increased resource-use efficiency to lower costs (Winterhalter et al., 2015). Bertand, Chalon & Yin (2016) underlined that it is possible to collect huge amounts of data through digitalization and McLean (2015) added that through diversification a "multi-option society" can be catered.

On the other hand, the risk is losing customers' trust and attention. The literature mentioned in this regard that the fear of sharing with strangers can affect trust (Belk, 2014) or that the concerns are only gone after using the offers of the sharing platforms for the first time (Tollefson, 2013). Failing in the mind-shift of the company, cannibalising the traditional BM, being directly compared with competitors, being the target of the next disruption and decreasing employee motivation count also as risks based on responses of the interviewees. Points which arose in the interviews and the literature are the risk of investment and the changing environment. In that respect Hasan & Birgach (2016) wrote that margins are lower in the sharing economy which is difficult for traditional businesses to compete with. Le Jeune (2016) specified that sharing models are expected to appear in a wider range of markets than has been seen to date with commensurate impacts on traditional industries. Further risks are security issues and process failures.

When using the results, it has to be considered that the study is explorative and based on six qualitative interviews. Another limitation is the focus on traditional B2C businesses that intend to become active on already existing sharing platforms. Further research could analyse industry-specific differences, elaborate concrete guidelines and establish a maturity model or a value benefit analysis. This could be of great benefit for traditional businesses.

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Digital Coaching to Support University Students' Physical Activity

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Abstract In this paper, we aim to find out if digital coaching could support students to become physically more active. Studies show a worldwide trend of declining physical activity, and students are no exception. The search for means to keep the younger population physically active is not an easy task but technology will for sure play an important role in alleviating this trend. If a digital coach is one of the possible solutions it needs to offer support and feedback that are relevant to the students in their everyday activities. We carried out a survey with 138 undergraduate students to find out if features expected of a professional trainer who coaches athletes would be important also for a digital coach for it to be attractive and useful for students.

Keywords: • Digital coach • Everyday activities • Training technology • Physical activity • University Students •

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1 Introduction

Physical activity is in decline all over the globe, and the young are no exception. Many technologies are available which claim to enable behaviour change and encourage to physical activity; e.g. activity trackers, smart watches and sports watches. In this paper we focus on training technology in its most advanced form – Digital Coaching – and raise discussion on the role this technology could play in students' lives.

Training technologies typically enable the user to track and monitor data e.g. on movement, sleep and heartrate. Digital coaching systems also include analysis and suggestions based on the data. A digital coaching system can help the user to set and achieve goals, give suggestions for structuring a training session, and offer possibilities to connect with others. A digital coaching system adapts according to the user's actions and progress.

Despite the prevalence of training technologies, there is a lack of tools to study them. In this paper we use physical/«real-life« coaching as our starting point. We adapt a validated tool to study physical coaching behaviors to the context of digital coaching. We also explore students' attitudes towards possible functions in a digital coaching tool, to see whether they meet the exercise support needs of the students.

The aim of the paper is thus twofold: (i) to apply a coaching behavior scale to a digital context, and (ii) to find out students' attitudes towards digital coaching.

The rest of the paper is organized as follows; in section 2 we will give an overview of students' physical activity and introduce coaching and digital coaching; in section 3 we introduce the Coaching Behavior Scale for Sport (CBS-S) and work out how it will serve our purposes, in section 4 we introduce the survey we carried out with 138 students, and carry out an analysis of the students' responses. Section 5 is a discussion of our results and we present some conclusions.

2 Literature Review

2.1 Students' physical activity

Being physically activitive is beneficial for all age groups. Physical activity is associated with increasing helth benefits whereas physical inactivity has been observed as one of the leading risk factors in many diseases as well as mortality (Goje et al. 2014). Thus regular physical activity is essential for maintaining as well as increasing health benefits. Recent findings show alarming physical inactivity trends among young people.

Fagarasa et al. (2015) carried out a study with 334 students to assess the level of physical activity of university students. The students first went through a (voluntary) anthropometrics test to decide their body mass index (BMI) after which they filled in the short form of the International Physical Activity Questionnaire (IPAQ) to report on their physical activities during a fortnight. The students reported on their vigorous, moderate and/or walking activities and their activities scored MET-minutes per week according to the IPAQ formula. The authors conclude that the findings show reasonable basis for health and active lifestyle among students.

Clemente et al. (2016) recruited 126 Portuguese university students (73 female) to find out if they meet the public health recommendations for physical activity. The students wore an ActiGraph wGT3X-BT accelerometer for 7 days to record the number of steps taken, time spent sedentary and time spent in light, moderate and vigorous physical activity. Clement et al (2016) found that gender and day of the week had significant effects on physical activity. Male students reached the recommended 10 000 steps/day during the workweek but female students did not reach the target. Weekends increased sedentary time for both groups. The study was too short to show anything about health effects.

In a study by Haase et al. (2004) the link between physical activity and chronic disease and obesity is explicit. Haase et al. (2004) collected data on leisure-time physical activity, health beliefs, and health knowledge from a cross-sectional study of 19289 university students from 23 countries. They found that leisure-time physical activity is below recommended levels for a substantial proportion of the students, and connected this to cultural factors and the stage of national economic development in the countries involved in the study. They also noted that inactivity during leisure time had an average between 23% (North Western Europe) and 44% (developing countries) but found that the likelihood of leisure-time physical activity correlated positively with the strength of beliefs in the health benefits of physical activity. Nevertheless, knowledge about activity and health was low, only 40-60% knew that physical activity is relevant to the risk of heart disease.

Hallal et al. (2012) report on data collected on physical activity levels from 122 countries for adults [15+ years] and adolescents [13-15 years]. They found that 31.1% of adults are physically inactive but with variations between regions: 17.0% (Southeast Asia) to 43% (Americas, Eastern Mediterranean). They found that inactivity increases with age, is higher for women than for men and increases in high-income countries. The 13-15 year olds who do less than 60 min per day of physical activity of moderate to vigorous intensity is 80.3%, which they found alarming; boys are more active than girls. They proposed that programs should be worked out to seriously increase the levels of physical activities for adolescents (and to monitor that they are actually implemented). This will be a long-term strategy to reduce the probability for increase in non-communicable diseases.

In Finland, most of the young men (about 75%) serve in the Finnish Defense Forces (FDF) for 6-11 months. In 1975, the FDF started testing the physical activity levels of all recruits and has continued the tests since then without interruptions or changes. This has created a unique database. This test called Cooper's test builds on a 12 min run with an ideal result of 3000 m or more. In the first years, the average results were close to the ideal, with an average of 2750 m in 1979. After that, the results gradually decrease during 20 years and reached on average 2600 m; then in 1999-2002, the results jumped down to 2450 m and then stabilized around 2400 m; they were on average 2418 m in 2015. The proportion of recruits reaching the ideal 3000 m was 25.1 % in 1979 but only 6.1% in 2015; the proportion of weak results (2200 m or less) was 6.1% in 1979 and increased to 25,9% in 2015. The trend is clear and alarming; the physical endurance of Finnish males declines. A newly released Finnish physical activity monitoring study for children and adolescents (Liitu-2018) shows that only 38% of children and youth in Finland aged 9 to 15 fulfill the minimum recommendations for physical activities i.e. 60 minutes moderate-to-vigorous intensity physical activities per day. The older the children the less physical activities were reported, for example of those aged 15 only 19% fulfilled the recommendations. These results are of major concern for the society and indicate increasing possibilities for serious illness at later age. According to Janssen and LeBlanc (2010) "there is undisputed evidence that living a physically active lifestyle can be beneficial to the physical, social, and mental health. Thus, effective improvements are necessary and students represent a good target group for innovations and experiments.

2.2 Coaching and Digital Coaching

We will assume that it is possible to develop a digital coach but in order to do so we need to understand the main differences between an athletics coach and a digital coach. A personal trainer (PT) offers the kinds of services we expect from a professional coach (Passmore 2014). The PT, as a rule, is a certified professional working on a one-to-one basis with a client. The coach works out individualized exercise programs for the athlete, monitors and measures his/her progress, provides feedback, and gives advice on physical fitness, health and nutrition. The probably most important role for a PT is to motivate the athlete in achieving jointly agreed goals (Doğan 2017), in other words the PT has a unique opportunity to make significant changes in the everyday life of a client (Côté 1999).

Coaching typically is a series of activities that is the domain of personal trainers (as they developed the programs) but which now changes to support offered by digital coaches. Digital coaches are part of monitoring software for smart watches, activity bracelets, movement sensors, etc.

Coaching intends to change people's behavior, in our case to work out effective physical activities that could form wellness interventions in their daily routines. The interventions should be personalized, ubiquitous, seamless and (mostly) in real time (Fukuoka et al. 2010, Kranz et al. 2012, Kulyk et al. 2014, op den Akker et al. 2015, Schmidt et al. 2015, Warraich 2016) in order to be effective. However the reliability of the sensors and the network required for "real-time" and adequate coaching instructions are according to Klaassen et al. (2016) major challenges.

Literature shows the design and use of digital coaches that build on smart technologies that make use of data collected with activity sensors (Klaassen et al. 2016). The sensors represent a decisive development step as they offer inexpensive, accurate, reliable and objective assessments of physical activity that become numerical feedback on step counts, sleep hours and use of energy.

This data has become the first level of motivational feedback for users of smartphones, activity bracelets, smart watches, pulse monitors, activity trackers, etc. Data gets processed with smartphone apps, with algorithms on websites or through cloud services. There are efforts to develop advanced methods for processing activity sensor data using machine learning, computational intelligence, OWL 2 ontology, etc. in the belief that the feedback presented to users will be more instructive and offer deeper insight (Villalonga et al. 2017).

Klaassen et al. (2013) and Kulyk et al. (2014) implement most of these principles in the *Kristina* coaching system that will motivate and support users to change their lifestyle. The system supports self-monitoring of current behavior towards personal goals and offers tips on how to reach the goals, which now is a typical action plan for digital coaching. The *Kristina* is a multi-device coaching system that combines the advantages of single device feedback systems in one integrated service platform. It offers the user multiple contact points and can collect context information, which offers more effective feedback and guidance. An additional benefit is that a multi-device coaching system offers inter-usability across devices, platforms and contexts, which reduces possibilities to be frustrated or fed-up with the system.

Kranz et al. (2012) developed *GymSkill*, a smartphone system for comprehensive physical exercising support, which is a typical coaching tool. The system uses sensor data logging and activity recognition to make skill assessments using the smartphone's built-in sensors. The feedback produced is individualized, personalized and automatic. The *GymSkill* tracks training quality and success and gives continuous feedback to the user to motivate regular exercising. Schmidt et al. (2017) show that the use of activity tracking systems promotes improved self-awareness as the user follows his/her own fitness data and – in some coaching systems – compares performance with other users. The digital coach should identify use strengths and weaknesses, it should generate a physical activity plan and motivate and support like a personal trainer. Coaching contributes to learning, personal development and performance (Passmore 2014), which when offered as digital coaching is available where ever and whenever needed.

Klaassen et al. (2013, 2016) and Kulyk et al. (2014) demonstrate with *Smarcos* that a digital coach could work through a range of interconnected devices and inter-usable user interfaces. They found, when working with groups of users, that there are clear preferences for different types of messages on different devices. This shows that we should consider using multiple versions of a digital coach for different user contexts. Kulyk et al. (2014) found that a virtual conversational agent could have a positive effect on the perceived relationship between a patient and an eHealth system. The tailoring of software and the building of personalized service will motivate people as they can get personal information and feedback that follows their own physical activities, not comparisons with some standard averages of data collected from some other, unknown context. Zhou et al. (2018) tried out a more advanced coaching tool to test if assigning adaptively personalized goals would be more effective than assigned goals as goals change over time as individual behavior changes, which now is an important improvement. They use an automated iOS application called *CalFit*, which helps set personalized, adaptive step goals that are worked out with a behavioral analytics algorithm. The algorithm applies machine learning to individual goal and performance data to develop a predictive quantitative model for the progress of each *CalFit* user. The estimated model gives challenging (but realistic) step goal ways to maximize future physical activity.

Klaassen et al. (2013, 2016) and Kulyk et al. (2014) develop platforms that monitor physical activity with data collected with wearable sensors and produce personalized feedback. They found that tailoring and context awareness, when used as a basis for feedback and interaction, are key features for effective coaching. They tested different presentations forms – text, graphics and an anthropomorphic talking character – and found (to their surprise) that the talking character did not have any positive effect, but that personal motivation is of key importance for the effectiveness of the system. Op den Akker et al. (2015) found that tailoring – the process of adjusting system behavior to individuals in a specific context – is a prime design requirement. They noted that for physical activity monitoring systems standard requirements on usability, acceptance and compliance apply that typically are found for information systems that should be used continuously for long periods.

The healthcare sector shows a growing interest in using digital coaching technology to build good interfaces between patients, medical doctors and nurses. Carrino et al. (2014) developed a health companion for healthier lifestyles. The companion has an advanced interface, which assists and entertains the user but also gives adequate knowledge on alimentary education and physical activity. The companion offers assistance for life and works with a knowledge model of the user and his/her behavior. Kari et al. (2016, 2017) move beyond physical activity and show that nutrition and sleep can be monitored with similar self-tracking technology as physical activity. This offers the possibility for more holistic wellness solutions as physical exercise needs supporting diet and sufficient sleep in order to be effective. They also found in their experiments that the perceived wellbeing is rather minor and that the actual health effects are more long-term than first expected; there were no immediate health effects of self-tracking technology.

In summary, there are a few features that emerge as important for digital coaching design: digital coaches should be tailored to the context and the needs of the users, the coaching should be adaptive to the changing activity levels of the users, digital coaches should retrieve knowledge from the users and physical activity should get support from coaching on effective dietary choices and sufficient sleep and rest time.

3 Methods

In our study we started with the Coaching Behavior Scale for Sport (CBS-S) developed by Côté and colleagues, which we adapted to the context of digital coaching. As pointed out by Jain et al. (2018) CBS-S has been used in many empirical studies (for example in Koh et al. 2014) and recommended as a useful instrument for measuring effective coaching. The CBS-S is grounded in coaches' and athletes' experiences and it has originally been developed for assessing coaching behaviors from athletes' perspective and was co-created with coaches and athletes (Côté et al. 1999, Baker et al.2006). According to Côté et al. (1999) the scale presents a grounded instrument that may better examine coaching behaviors than other available scales. CBS-S is developed based on the Coaching Model framework (Côté et al. 1995). With the scale we are able to describe and treat digital coaching in terms of several measurable components.

The original CBS-S includes variables on seven dimensions: physical training and planning, technical skills, mental preparation, goal setting, competition strategies, personal rapport and negative personal rapport. We adapted the variables and dimensions to fit the digital coaching setting, in some cases only swapping the word 'coach' to 'digital coach' (*e.g. The coach provides me with immediate feedback*). Some items were excluded, most notably all items on the negative personal rapport dimension, as this dimension is not relevant in the digital context, as well as the items on the competition strategies dimension, as this dimension is only relevant when studying competitive athletes. We added items describing possibilities to connect with other users, e.g. *"allows you to compare your performance to others"*. Social support has been found to be a predictor for engaging in physical activities (Trost et al. 2002). In a previous study we found that social dimension is indeed perceived to be an enabler for participating in physical activities (Sell et al. 2017). We also added items on the handling and security of data in the system as data handling and capture have been found to be important factors in previous studies on wearable use (Fritz et al. 2014, Harrison et al. 2015, Walden and Sell 2017). We also added items inspired by the review of existing coaching systems for example on the adaptiveness of the digital coach. We cannot assume that the original seven dimensions are present in the first version of the Digital CBS-S, as variables have been adapted, added and removed, and the context is new; we perform factor analysis to examine dimensions in the adapted scale.

The empirical data was collected through a self-administered questionnaire in 2018. The questionnaire was available on-line for all first-year business students at the Åbo Akademi University in Turku, Finland and to participants in some courses at the School of Business and Economics at Linnaeus University in Kalmar, Sweden. We did not have access to contact information for the whole student populations and used convenience sampling. The number of completed, valid responses was 138.

4 Analysis and Results

We will start with an overview of the data we collected. The mean age of the sample is 28 and the sample lies between 19 years and 56 years, the median value being 24. Of our respondents, 53% were female and 46% were male. The highest degree that most of the students had finished by the time of the study was matriculation exam (61%), second highest was an undergraduate degree (22%).

Most of them used their smartphones in support of daily exercise (34%) or weekly exercise (34%); much fewer used a smart watch (daily 4%, weekly 1%), sports watch (daily 3%, weekly 2%) or activity bracelet (daily 5%, weekly 3%); still fewer were using heart rate monitors, smart rings, smart scales, etc. Of the respondents 53% report using supporting apps on their smartphones to monitor their exercise and progress; the most typical apps are Runkeeper, Apple Health and Samsung Health. Mindfulness apps (for a relaxed and healthier state of mind) and Polar Flow were also mentioned by some students.

The students were asked how much time they spend during a normal week on "moderate physical activity" and on "vigorous physical activity". The concepts moderate and vigorous physical activity are according to WHO (2019) about "…the rate at which the activity is being performed or the magnitude of the effort required to perform an activity or exercise". It can be thought of "*How hard a person works to do the activity*". It is suggested that 75 minutes of vigorous activity matches the health benefits of 150 minutes moderate activity (National Health Service, 2019)

We gave the students examples of moderate and vigorous physical activities, the former being walking, cycling and fishing and the latter being running, hill climbing, ballgames and fitness swimming. The descriptive results for moderate, vigorous and muscular and/or balance training are presented in Table 1 and Figure 1.

Table 1: Moderate, Vigorous and Muscular and/or Balance Training in Minutes per Week

Time in minutes per week	Moderate physical activity n=137	Vigorous physical activity n=137	Muscular and/or balance training n=136
0 min / not at all	2 / 1%	13 / 9%	15 / 11%
< 30 min	4 / 3%	18 / 13%	26 / 19%
30-60 min	19 / 14%	27 / 20%	25 / 18%
60-90 min	24 / 18%	21 / 15%	18 / 13%
90-120 min	22 / 16%	12 / 9%	12 / 9%
120-150 min	18 / 13%	11 / 8%	7 / 5%
> 150 min	48 / 35%	35 / 26%	33 / 24%

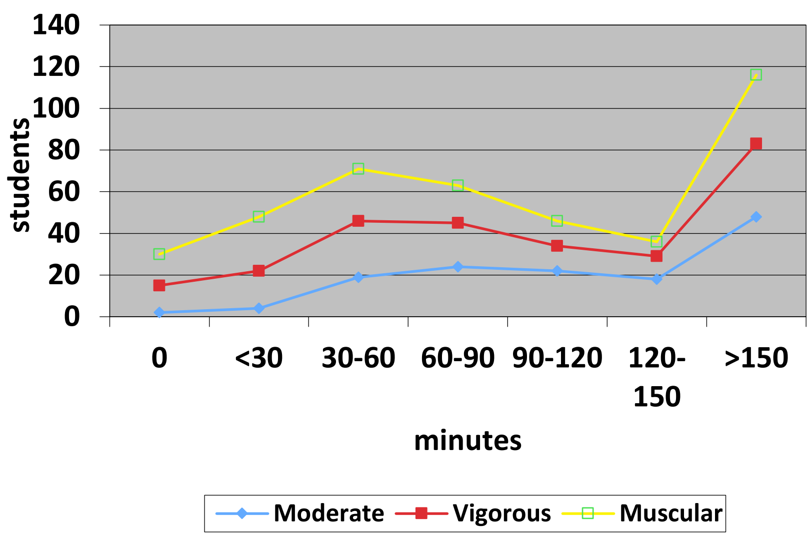

Figure 1: Time spent per week on different training activities

Students spend more time per week on vigorous physical activities than on moderate training and even more time on muscular and/or balance training than on vigorous training. From Figure 1 we can see that the three curves show similar patterns, those students who do more than 150 minutes training per week form the biggest group in all three training categories. Most of the students are active in all three categories, moderate, vigorous and muscular and/or balance training.

In order to better understand the students' exercise behaviors, we asked them to describe in free text the types of physical activities they are regularly involved in. The students show quite some variety in what they mentioned as their activities (number of respondents 124). We run a word cloud analysis on the activities mentioned by the students.

Figure 2: Physical activities that the students are regularly involved in

As can be seen (Fig. 2) gym training was the most frequently mentioned activity by the students (51 students). This is in line with Doğan (2017) who points out that training at the gym has become one of the most popular activities. Running (35 students), walking (25 students) and biking (15) were next among the popular activities. Also football, yoga, soccer, floorball and swimming were mentioned by several students. Most of the respondents volunteered in several activities, among them also more unusual activities such as kiteboarding and rope skipping.

In the first stage of the analysis, we conducted exploratory factor analysis with Direct Oblimin rotation, on the set of items describing the respondents' attitudes towards digital coaching. We found the best results with a five-factor solution, explaining about 75% of the total variance. Variable loadings above 0.7 were seen to contribute to the factors. Cronbach's Alpha is above 0.8 on all five factors (see Table 2). Each factor exhibited eigenvalues exceeding 1.0 and accounted for significant variance beyond that of the other factors. See Table 3 for details.

The factors are described as (1) *Exercise program*, (2) *Goal orientation*, (3) *Data handling*, (4) *Social functionality* and (5) *Mental support*. The dimensions of Social functionality and Data handling are distinct for the modified version of the CBS-S, not present in the original version of the scale. The other three dimensions have counterparts in the original CBS-S.

The items were measured on a five-point scale. Mean values, standard deviations and alpha values for the five dimensions are shown in Table 2. The Data handling dimension shows the highest mean value, above 4 on a 5-point Likert scale ranging from Not important (1) to Very important (5).

Table 2: Mean values, standard deviations and reliabilities

Dimension	**M**	**SD**	**Alpha**
1. Exercise program	3.48	.93	.87
2. Goal orientation	3.83	1.06	.87
3. Data handling	4.26	.89	.90
4. Social functionality	2.51	.96	.90
5. Mental support	3.74	1.10	.90

Table 3: Factor loadings

Item ("The digital coach....")	Goal orientation	Social function ality	Exercise program	Data handling	Mental support
Designs a detailed exercise program for you			.881		
Gives you advice for proper warm-up before exercise			.785		
Designs an exercise program that is suitably physically challenging for you			.838		
Designs an exercise program for a time period specified by you (e.g. two weeks, one month, three months)			.774		
Gives you advice on how to structure your training sessions			.783		
Gives you hints how to improve your training performance	.809				
Asks for input from you in order to tailor your program	.836				
Helps you set specific goals	.787				
Helps you identify training strategies to achieve your goals	.838				
Monitors your progress towards goals	.775				
You have control over how, where and which data is shared				.941	
You trust the system to keep your data safe				.893	
Allows you to observe other users' training behavior (e.g. you can see how similar users are training and reaching their goals)		.834			
Allows you to compare your performance to other users' performance		.879			
Allows you to communicate with other users		.853			
Allows you to compete with other users		.889			
Gives you access to success stories of people who have reached their goals		.804			
Allows you to team up with other users to together reach your goals		.767			
Helps you stay positive about yourself					.916
Helps you stay focused on your goals					.860
Helps you stay confident about yourself					.898
Eigenvalue	7.65	3.90	1.64	1.46	1.14
% of total variance	36.2%	18.6%	7.8%	6.9%	5.4%

In order to investigate our student sample through the lens of physical activity we utilized K-means cluster analysis with Ward's method to group our respondents. As input we utilized two variables where the respondents rated their weekly participation in (a) vigorous training and (b) muscular and/or balance training. Three distinct clusters emerged, see Table 4. The first cluster (41 respondents) is characterized by very frequent involvement in both types of training. The third cluster (44 respondents) is at the opposite end of the spectrum, characterized by low involvement in both types of training. The second cluster (45 respondents) falls in between these. Cluster membership is rather evenly divided in the sample. Cluster 1 has more male respondents (27, 66%, n=41), whereas cluster 2 and 3 include more female respondents (27 females, 63%, n=43 and 25 females, 48%, n=43).

Table 4: Final cluster centers and cluster membership (n=130)

	Cluster 1 (n=41)	Cluster 2 (n=45)	Cluster 3 (n=44)
How much time do you spend during a normal week on vigorous physical activity, e.g. running, ball games, hill climbing, fitness swimming?	6.00	4.80	2.11
How much time do you spend a normal week on muscular and/or balance training?	6.68	3.33	2.45

We analyzed the clusters for differences in their response to the attitude statements on digital coaching. Significant differences arose, especially between the most and least active clusters. Overall, the more active students rate functions more highly. See Table 5 for significant differences found through two-way ANOVA and post hoc tests (Bonferroni, or Games-Howell when equal variances could not be assumed).

Table 5: ANOVA summary table

Attitude statement (How important do you think the following features are in a digital coach for physical training?:)	*df*	*SS*	*MS*	*F*	*p*	Cluster 1	Cluster 3
Designs an exercise program that is suitably physically challenging for you	2, 125	10.38, 139.5	5.19, 1.12	4.65	0.011	M=4.06, SD=1.02	M=3.4, SD=1.18
Gives you advice on how to structure your training sessions	2, 125	12.98, 149.02	6.49, 1.19	5.44	0.005	M=3.93, SD=0.98	M=3.19, SD=1.18
Gives you feedback on your technique	2, 127	13.15, 151.65	6.57, 1.19	5.5	0.005	M=4.2, SD=0.98	M=3.4, SD=1.15
The digital coach is easily accessible to you	2, 127	10.1, 139.9	5.09, 1.1	4.58	0.012	M=4.24, SD=0.99	M=3.6, SD=1.2
The digital coach helps you set specific goals	2, 126	10.55, 131.93	5.27, 1.05	5.04	0.008	M=4.12, SD=0.87	M=3.49, SD=1.1
The digital coach helps you identify training strategies to achieve your goals	2, 125	13.86, 110.6	6.93, 0.89	7.83	0.001	M=4.22, SD=0.73	M=3.44, SD=1.16
The digital coach guides you to reach your goals through concrete training tasks	2, 125	10.19, 147.74	5.1, 1.18	4.3	0.015	M=3.63, SD=1.19	M=3.14, SD=1.1
The digital coach allows you to compare your performance to other users' performance	2, 125	11.07, 182.3	5.53, 1.46	3.79	0.025	M=2.8, SD=1.32	M=2.07, SD=1.22
The digital coach allows you to compete with other users	2, 123	11.05, 183.67	5.53, 1.49	3.7	0.028	M=2.8, SD=1.27	M=2.07, SD=1.14
The digital coach gives you access to success stories of people who have reached their goals	2, 123	12.53, 196.9	6.26, 1.6	3.9	0.022	M=2.85, SD=1.35	M=2.07, SD=1.18

5 Discussion and Conclusions

We have applied and adapted a scale for coaching behaviors to the digital context. We have found the adapted scale to have a factor structure, which seems to capture dimensions that are relevant in the digital coaching context. The addition of items on social functionality and data handling resulted in two novel factors necessary in the digital context. Further studies should seek to confirm the suitability of the scale for the digital coaching context, and identify possible other dimensions not identified in this study. The data handling dimension reflects the current interest towards 'quantified self', as well as the importance of data security and privacy.

When examining the respondents' attitudes towards digital coaching, it was interesting, but perhaps not surprising to see that those respondents who are more physically active also show more interest in many of the suggested features of digital coaching. It is possible that they are overall more interested in developing their physical performance, but this we cannot confirm based on the current study. Interestingly, there are no significant differences between the frequency that the most and least active respondents use technologies to support their training (e.g. smart phones and smart watches). In other words, the difference in attitudes is not explained by their differing current use of training technologies.

The modified CBS-S for digital coaching seems to capture a range of features relevant in digital coaching. In subsequent development of the scale, it is of interest to test additional features based on emerging research. Firstly, features using gamification would be a possible value-adding addition, which was verified in studies carried out by Kari et al. (2016, 2017). Secondly, as the sedentary students were the least interested in any of the functionalities offered, it would make sense to further investigate functionalities designed to raise exercise motivation and promote behavior change. The active students appreciated the offered functionalities the most – which makes sense, as they are already following an active lifestyle and the digital coach would simply support or enhance that lifestyle. The sedentary students are in a different position; they would require support to introduce new behaviors and routines – a behavior change support system. The features we describe in the "digital CBS-S" might be too far removed from their current everyday routines. In order to achieve a behavior change from a sedentary lifestyle to an at least comfortable – or even better – active lifestyle, they would need either an adaptive digital coach designed to introduce incremental changes, or a tailor-made program with an actual personal trainer. Finally, as previous research has shown that hedonic value is important in practically every information system, the digital coach is likely no exception. The role of hedonic value in a digital coaching solution should be considered in a future version of the scale.

The social functionalities of a digital coach garnered less interest from the students than other features. This is an important finding, considering that previous studies have identified the social dimension to be important in the context of physical activity, e.g. Trost et al. (2002) found social support to be a predictor for physical activities. The social functions thus warrant further research attention to capture social functionalities, which would fulfill the need of social support in a way that is acceptable to the users of the digital coaching system. In previous research we could find that social functionality was value-adding and appreciated by a group of adults, who participated in a fitness bracelet trial (Sell et al 2017) and our assumption was that the students would also find these features desirable. It is possible that we did not identify the *right* types of social functionality for this target group and future research should investigate other implementations of social functionality to see which social functions fulfill their need of social support. It is also conceivable that in actual use, students might find the value of social connectivity, but at this point fears of privacy overrode any interest in it. The students also showed a marked concern for how their data is handled and the privacy and integrity of their data. This is somewhat surprising, given the overall prevalence of social media use and the consequential data sharing. It is possible that exercise data is perceived to be rather sensitive. This warrants future attention.

Entering higher education is an important transition phase in life, comparable to retirement later in life. Previous routines and structures are left behind, and new ones are created. Our results offer indications on how technology can be harnessed to aid students in their physical activities.

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Willingness to Share Supply Chain Data in an Ecosystem Governed Platform – An Interview Study

TOMI DAHLBERG & TIINA NOKKALA

Abstract The exchange of business documents and technical product data between the partners of industrial ecosystems can be automated and integrated through digital supply chain (DSC) platforms. The advocates, managers and developers of DSC platforms need to solve several technical and social challenges during the implementation of such platforms. Operative level officers' willingness to share business and technical product data with partner organisations' officers is one of them. This article presents findings from the interviews of 25 sourcing and accounting experts in two industrial ecosystems jointly developing a DSC platform to be governed by industrial ecosystems. The interviewees considered schedule data shareable and detailed design drawings non-shareable. We discovered 12 factors increasing and 9 factors decreasing the willingness to share data. Our study contributes to platform and ecosystem research and offers practical advice to the developers and other stakeholders of the investigated DSC platform.

Keywords: • Governance of data • Digital business ecosystems • Platforms • Data Sharing • Blockchain •

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1 Introduction

With the exception of e-invoices, business documents are exchanged manually between the partners of industrial ecosystems., e.g. an order with related technical product data documents, such as an electric motor specification for a functional location, Ecosystems consist of buyers, suppliers, engineering companies, financiers and other partners. In 2017, the Swiss market research company Billentis (Koch, 2017) disclosed that even for e-invoices the global penetration rate was below 10 % from the global volume of 200 billion B2B invoices. Thus, business documents produced with ERP and other information systems are typically exchanged as excel or pdf files via e-mail, or on paper. The receivers and senders may compare and validate documents manually several times during supply chain processes, e.g. an order against an order confirmation, then transportation documents, an arrival note, and finally an invoice.

Digital supply chain (DSC) platforms are considered as means to automate and integrate the exchange of business and technical product data (Korpela, Hallikas, & Dahlberg, 2017). By doing so DSC platforms are seen to first deliver cost savings (Mikkonen, 2011) and then other benefits, such as agility or new trade finance services, to each member of an ecosystem and to entire ecosystems (Korpela et al., 2017). An earlier study (Korpela, 2014) reported that a 40-company biorefinery industry ecosystem, with 8,5 million business documents and 2,5 million invoices annually, has cost savings potential of 580 million € per year, should 100 % automation rate be achieved.

The development and implementation of a DSC platform with the name DBE Core is the background of the present study. For the DBE concept see e.g. Nachira (2002). Three collaborating industrial ecosystems mandated the establishment of the DBE Core Ltd in 2018 with the objective to develop and implement the DBE Core platform. Individuals representing the focal companies of participating industry ecosystems govern the platform together with the DBE Core Ltd. The use of the platform is offered as a service to the members of these ecosystems and to any other interested enterprise with a pay-as-you go business model. A fourth industry ecosystem joined the platform development in 2019.

The developers of the DBE Core platform have to solve several technical and social challenges during the development and roll-out of the platform. Typically engineering, procurement, logistics and/or accounting executives of the ecosystem companies participate to the governance of the DBE Core platform and guide its development. For example, they agree what data attributes each document (e.g. an order) includes. The agreed contents of documents define data shared between ecosystem partners including data protection and privacy considerations. Executives also act as internal advocates within their enterprises but are seldom operative level users of the platform. Consequently, one of the key social challenges is: are the operative-level officers really willing to share business and technical product data with their peers in other ecosystem enterprises via a DSC platform provided as a service without any platform ownership? We interviewed 25 operative level sourcing and accounting specialists to find the answer. The purpose of our study is to address this research problem, which we also regard a research gap. From this backdrop we formulated the following research questions.

RQ1: What factors increase or decrease the willingness of interviewed operative level experts to share supply chain data with their peers in the investigated platform?
RQ2: What supply chain data are the operative level experts willing to share and not share?

Next, we review the theoretical background of the study followed by a methodology section. We then present interview findings and end the article with a discussion and conclusions section.

2 The Theoretical Background of the Study

De Reuver et al. (2018) claims that platform research lacks conceptual clarity. He therefore advices researchers to clearly define concepts used and to specify the investigated phenomena, their digitality, and other aspects while reporting digital platform research findings. What factors characterize the DBE core as a DSC platform and the industry ecosystems governing that platform? The home page and the presentation materials of the DBE Core Ltd describe the enterprise as a multi-ecosystem platform company that is mandated to develop and operate a multi-sided digital platform in order to automate and integrate the exchange of business and technical product data between the enterprises of industry ecosystems and between industry ecosystems. The company "*aims to reduce the proportion of manually executed transactions that are characterized by large amounts of non-productive work, errors, waiting time, inflexible financing, insurance and logistics, as well as poor-quality data*" (DBE Core, 2018).

As a multi-sided platform (Hagiu & Wright, 2015) the DBE Core platform allows the members of industry ecosystems to collaborate but also to compete with each other (Corallo, Passiante, & Prencipe, 2007; Iansiti & Levien, 2004a, 2004b). Collaboration builds on jointly agreed documents and document contents, which make their automated exchange possible. On the other hand, each ecosystem partner may develop value-adding services to its (rest API) network end-point. For example, buyers and sellers may integrate their procurement and sales portals to the DBE Core platform and offer value-added information to their business partners in addition to the mere electronic exchange of documents. Engineering, data analytics, finance and other types of service providers may integrate their services to the DBE Core platform as well.

As a DSC platform the DBE Core platform is a technology (hardware, software and network) based solution that integrates and synchronises operations in a rapid, effective, flexible and scalable manner (Büyüközkan & Göçer, 2018). Use of the platform is offered as a service to reduce costs, to improve data quality and to boost innovations. Digital platforms (DSCs) include technological elements that are aligned with organisational processes (de Reuver et al., 2018). The DBE Core platform combines several open source technologies, such as rest API, blockchain and (UN/CFACT and XML) document message technologies. Their combination is used to automate the inter-organizational data exchange of sequential supply chain processes from manufacturing planning (e.g. request a catalogue) through procurement (e.g. order) and logistics (e.g. dispatch advice) to financing (e.g. advice remittance).

The focal biorefinery industry (forest, energy and chemical) companies headquartered in Finland with their major suppliers and the maritime industry with the country's three largest shipyards and their major suppliers constitute the two core industrial ecosystems behind the DBE Core platform. In addition to them major banks and finance industry opted to participate encouraged by platform-enabled trade finance business opportunities. Similarly, IS and IT technology vendors envision integration and cloud service and engineering companies see technical product data design business opportunities. The development and implementation work started from documents/data used in manufacturing planning and procurement supply chain processes and from the exchange of four technical product data categories. In early 2019, focal companies of the cargo/freight transportation and forwarding ecosystem (air, rail, sea, road) joined the platform development as it proceeded to multimodal logistics processes.

The focal partners of the two industrial ecosystems with their customers and supplier networks are mostly global corporations operating in 100-150 countries. Why do so diverse enterprises and industrial ecosystems collaborate in the development, implementation and governance of the DSC-type DBE Core platform? The potential of significant cost savings and other benefits drive the interests of each company and ecosystem. Large corporations also appear to believe that envisioned benefits are best achievable through (multi-)industry collaboration. The presentation materials of the DBE Core Ltd describe: "*Large companies have developed company proprietary solutions and met the limits of this approach. The conclusion is: it is necessary to agree the content and the form of transactions at ecosystem (=industry) level for inter-organizational data exchange automation to happen*" (DBE Core, 2018). Pilots executed in the biorefinery and maritime industries, that is in process and project industries, proved that similar jointly agreed business documents could be used in both industrial ecosystems. Moreover, the large buyers of these industrial ecosystems are usually the customers of the same global suppliers. Recently, multi-modal logistics pilots have been significant drivers for the investigated platform development. In these pilots, biorefinery cargo and related freight documents have been transported through corridors linking several European Union countries and also cross-EU-border to non-EU countries.

Enterprises execute their digital business strategies (Bharadwaj, El Sawy, Pavlou, & Venkatraman, 2013), which include the sharing of digital assets and digital extensions to supply chains (e.g. Rai, Patnayakuni, & Seth, 2006). The collaborative and multi-dimensional nature of (digital) business ecosystems (Adner, 2017) is also visible in the DBE Core platform and its industrial ecosystems. From the perspective of (future) platform and business ecosystem research it is interesting that the platform, the platform company and several industrial ecosystems have amalgamated through a platform governance model into a platform-sharing multi-ecosystem entity, where the parts are no longer separated (e.g. Cusumano & Gawer, 2002; Gawer & Cusumano, 2014; Wareham, Fox, & Giner, 2014).

With behavioural willingness to share data we understand the sharing of such proprietary and business critical data between ecosystem partners (through the platform) that creates value to customers/partners (Li & Lin, 2006). According to prior research willingness to share data is impacted by environmental and technological uncertainty, intra-organisational facilitators such as top management support, and inter-organisational relationships such as good relationships between ecosystem partners, trust, shared vision and connectivity (Fawcett, Osterhaus, Magnan, Brau, & McCarter, 2007; Li & Lin, 2006). We reasoned that the governance of data may also influence willingness to share data. Governance of data is currently executed primarily as a single organization practice (Weber, Otto, & Österle, 2009; Weill & Ross, 2005). In an ecosystem, the governance of data is established with transparent rules agreed by ecosystem partners, whose interests may differ. So far, just a few studies have investigated the governance of data in platform contexts and even fewer the governance of data in platform ecosystems (Schreieck, Wiesche, & Krcmar, 2016). Those studies have focused on platform owners' perspective (Lee, Zhu, & Jeffery, 2018) whereas our study focuses on user perspective. Finally, we note that willingness to share data has typically been investigated as a trust issue in prior research. Contrary to this, the technologies deployed in the DBE Core platform build on the assumption that parties do not (need to) trust each other. Blockchain is advocated as a trust technology. Smart contracts, cryptography, public and private keys, distributed ledgers, and consensus in the validation of transactions are applied to provide trust trough technology. Consequently, we did not review behavioural social-psychological trust research for this reason.

3 Methodology

We used the case study research methodology and followed the guidelines of Yin (2014). We selected this research methodology because we wanted to study the phenomenon of data sharing willingness in its real-world context (Yin 2014). We collected data from two technically independent research projects - on the basis of respective industrial ecosystems - and report their results separately. However, these research projects are interconnected as they have participated to the development of the DBE Core platform. Thus, we regard our article a single case study research as we focus on the willingness of operative level officers to share data through the use of a DSC platform.

We wrote a case study and interview protocol with an interview drama prior to interviews. Half a dozen supply chain professionals and academics evaluated the questions of the final interview instrument to ensure that clear, well defined and easy to understand constructs are used. We tested the interview questions and the drama with two pilot interviews at a shipyard. As no needs for changes we detected we included these interviews into the interview data. For triangulation purposes (Yin, 2014), we used other materials (e.g. research project memos on data sharing) and kept an interview journal, into which the interviewer made notes about the atmosphere of each interview, about interviewee actions and about events during an interview. Connections between interviews were documented as well.

We conducted interviews both in the maritime and the biorefinery industry ecosystem research. The maritime research project has 22 partners. We excluded 10 banks, IS service providers or logistics operators from interviews. The biorefinery project has 26 partners and again we excluded non-industry companies from interviews. The three largest global biorefinery corporations head-quartered in Finland as well as the three largest shipyards operating on global markets are among the partners of these projects. In summary, we contacted all buyer and supplier companies of the two research projects and interviewed all experts that agreed to be interviewed. Some companies, especially in the biorefinery research project, were unwilling to be interviewed due to sensitivity of the subject. We deemed that interviewees had to be limited to the participants of these research projects as the interviewees needed to have at least heard about the aim to automate supply chain data exchange through a DSC platform. The rationale of the platform development was discussed above. A shipyard director described the expected benefits of the platform*: "We do not want to continue the manual checking of electronic invoices against (manual) orders and logistics documents to detect whether or not they match to invoices. Too many of them do not. Supply chain transaction data need to flow automatically all the way from quotations to invoices and payments. Although there is room to improve our internal processes, we cannot achieve alone what we want. We are only able to that together with our suppliers. Since some of them supply* *also our competitors and/or companies in other industries it is necessary to agree at our industry ecosystem level and hopefully also across industries what data and documents are exchanged and how. Close cooperation with the biorefinery industry is warmly welcome for this reason."*

In the maritime industry, we interviewed 17 sourcing and accounting experts from 11 companies and in the biorefinery industry 8 experts from 4 companies. The backgrounds and organizational levels of the 25 interviewees varied, although most were sourcing, procurement or accounting managers, or executives in smaller companies. Interviews were carried out between December 2017 and September 2018. The duration of interviews ranged from 35 to 85 minutes. Maritime industry interviews were done by one of the authors and process industry interviews by a master's thesis student supervised by the authors. Two Interviewees were present in one interview but responses were registered separately. Table 1 shows the distribution of the interviewees by industry and between buyer or supplier companies. Selection of the interviewees was based on their position in a partner organisation: we opted to interview persons that actually share commercial and/or technical product data with their partner companies and hence have clear perceptions about potential benefits and challenges. An interviewee was asked to describe her/his evaluations about her/his company's willingness to share supply chain data in general at an organizational level and in details at data attribute level.

Table 1: Numbers of companies and interviewed persons by industries

	Maritime industry	Biorefinery industry
Number of companies	22	26
- buyers	- 4	- 3
- Suppliers (+other)	- 8 (+10)	- 10 (+13)
Number of interviewed persons	17	8
- buyers	- 10	- 7
- suppliers	- 7	- 1

We followed the enhanced interactive (multi-stage) interview method (Dahlberg, Hokkanen, & Newman, 2016) and organized the interview setting as described in details by them. During the interview of 16 semi-structured questions (Myers

& Newman, 2007; Yin, 2014), we followed an incomplete script, which facilitated the placing of additional clarifying questions if needed. This article addresses only interview questions and data on factors promoting/preventing data sharing willingness and perceptions about sharable and non-sharable data attributes.

Displaying interview questions on a screen helped both the interviewee and the interviewer to focus on interview questions. Seeing the typed entry of an answer in real-time on a screen helped the interviewee to correct potential interpretation errors immediately and to "co-create reality" between the interviewee and the interviewer. Interviews were also recorded after asking an interviewee's permission to do that. The listening of the recording immediately after an interview was used to complement the written script into an interview narrative. It was then sent to the interviewee for review and acceptance.

We analysed interview responses question by question, and report here findings to those four interview questions that address our research questions. We started data analysis by reading interview narratives, by identifying primary concepts used in them and by described them. Next, we used the nVivo software to code the interview material and to validate the manually detected primary concepts. Some primary concepts were enhanced, e.g. the final concept "situational factors" was combined from primary concepts "globalisation" and "market situation". Similarly, "technical instructions" was included into "planning materials". The final concepts were abstracted and described from the content of each node. One author created the nVivo concepts and the second author repeated the same to validate nVivo results. Disagreements were discussed until a consensus was reached. The final list of concepts, their frequencies in both industry ecosystems and descriptive quotes are presented in tables 2-5. Methodologically, we regard the analysis and the development of the concepts as the first step in theory building (Eisenhardt, 1989).

4 Results

4.1 Perceptions about Willingness to Share Data

We discovered 12 concepts descriptive for increasing and 9 concepts descriptive for decreasing the willingness to share supply chain data. Tables 2 and 3 disclose the most often mentioned concepts with representative quotes.

Table 2: Factors increasing the willingness to share data through a DSC (the DBE Core) Platform - perceived benefits of supply chain data sharing

Concept	# in maritime	# in biorefinery	Representative quotes from interviewee narratives
Control (of supply chain processes)	10	2	"Control of the entire order could be easier, would a full order message chain be available, e.g. to place additional orders or to change orders." (supplier) "In general, improving the fluency of material flows and order-delivery chains is good." (buyer)
Further development (of supply chain processes)	9	1	"Objective to make physical documents redundant with an electronic portal, managers' desire to share data digitally with reduced efforts." (supplier) "Objective to use fewer e-mails." (buyer) "Business benefits through additional sales, more efficient operations, and better customer service." (supplier)
Resource savings	6	3	"The decrease of manual work, interventions and double-tasking reduce the risk of inferior quality and improve efficiency, productivity." (supplier)

			"The huge number of different standards has created the desire to make data better available through ecosystem collaboration." (supplier)
Data quality	6	0	"Possibility to audit information, traceability, confirmation of correct information." (buyer) "Enhancing quality: meaning both the quality of supply chain communication and data." (buyer)
External pressures	1	4	"We must keep up with our customers." (buyer)

Ability to control supply chain processes was the most frequently mentioned increasing concept. Better availability of data and real-time status information about supply chain processes were also often mentioned. Controlling and developing supply chain processes are similar to the ideas of improving an organisation's operational performance and supply chain partners acting as one entity (Prajogo, Oke, & Olhager, 2016). Prajago et al. underline the importance of long-term relationships as a trust building mechanism between ecosystem members. This research provides supporting evidence. Lack of trust was seen to decrease data sharing willingness, see Table 3. One interviewee suggested that an open multisided DSC platform is a difficult concept, as some ecosystem partners are new. Long-term trust-relationships have not yet developed. We conclude that trust provided by (blockchain) technology appears a novel idea to the interviewees and may need actions to be behaviourally adopted.

Surprisingly, cost savings were mentioned only indirectly as means to replace manual work, improve efficiency or have better access to data. Biorefinery industry interviewees mentioned most often external pressures to share data via a DSC platform. Keeping up with customers described external pressures. The analysis of our interview journal led to the discovery of one concept, situational opportunity, that the nVivo software did not detect. It was vaguely present in five interviews as shown in Table 2. Situational opportunity was described as an unexpected opportunity to further develop inter-organizational supply chain processes whereas further development of supply chain processes was described as an intra-organizational issue. *"Current global situation and technical development are such that they enable these types of actions (=platform development) and make them sensible."* This quote from one of the maritime industry interviews defined the situational opportunity created by the connections between global markets and global environmental concerns.

Interviewees from both industries mentioned diverse factors similar to prior research (Dinter, 2013; Dreibelbis et al., 2008) that decreased data sharing willingness, such as the poor quality of internal data, the fragmented status of internal ISs and lack of competent resources. Integrations between internal processes and ISs and the DBE Core platform ISs and processes were perceived highly complex. One interviewee explained that his company currently waits and sees how other companies are integrated to the platform and join only after that. Interviewees regarded data sharing a strategic decision with the need to provide executives sufficient amounts of knowledge for decision making. Detailed product data was considered highly sensitive and making data sharing impossible, especially in the maritime industry. Interviewees discussed data protection and other information security issues, such as technology or people risks. Some feared technology related continuity risks others feared viruses, hackers and/or unauthorized access.

Table 3: Factors decreasing the willingness to share data through a DSC (the DBE Core) Platform

Concept	# in maritime	# in biorefinery	Representative quotes from interviewee narratives
Internal factors	8	4	"My company has own old-fashioned ISs." (supplier) "Several internal issues need to solved, such as resourcing, updates to internal processes." (supplier) "This is a strategic decision presuming that executives have sufficient understanding of relevant issues" (buyer) "We have confidential product line data." (buyer)

			"Reliability of internal data is an issue. We do not want to share incorrect information that may cause misunderstandings." (buyer)
Risks	9	1	"Possible interruptions caused by telecom, hackers, data security risks in general." (supplier) "Risk of too detailed product data delivered." (buyer) "Cyber risks, such as information ending up to wrong places and/or persons, other possible vulnerabilities. Viruses from the ecosystem." (buyer)
Trust	9	1	"Too many actors in ecosystems: transporters, suppliers, banks, customers at different levels." (supplier) "In procurement is it possible to strengthen the inner circle through the formation of a shield." (buyer)
Situational factors	5	2	"Market activity is still low, this and next year appear more promising with ISs competing. Time will determine the best ISs/platform and integration options to various ISs/standards." (supplier) "Are there enough benefits to us as compared to inputs needed (depends on the size of the ecosystem and number of transactions in it)." (supplier, buyer)
Costs	2	3	"What is the price tag of such platform and integrations?" (supplier)

Interviewees also wished to see more concrete and measurable benefits. A few interviewees explained that their companies conducted so few business transactions in the two industries that they were unsure about the existence of benefits. The inclusion of value-adding partners, e.g. banks was seen important, as well as the openness of the platform allowing easy entry of new partners. Concerns for expected platform and integration costs were an issue in both industries.

4.2 Perceptions about Sharable and Non-sharable Data

Tables 4 and 5 show what data items the interviewees regarded sharable and non-sharable. We analysed operational-level experts' responses on two levels. Firstly, on company level, that it, what an interviewee believed was her/his company's attitude to data sharing. Secondly, on data attribute/item type level, that is, what data items an interviewee perceived either sharable or non-sharable. Beliefs about companies' attitudes varied greatly. At the other extreme were a few interviewees who claimed that their companies would not like to hide any information from trusted ecosystem partners. Most interviewees, however, described limits to the access rights of data in order to protect business and trade secrets.

Most interviewees perceived planning data sharable via a DSC platform. They wanted to ensure access to standardized data items, measurements and codes. Automatic transmittance of invoices and payments was also widely supported. Ability to carry data from proposals through orders and logistics to invoices and payments is the core of supply chain data exchange automation. This platform functionality was seen to benefit smaller companies but appealed also to larger corporates. Better visibility to partners' schedules facilitated by schedule data sharing was seen as a means to optimize processes and to meet deadlines. This finding is in line with Devaraj et al. (2007) and Prajogo et al. (2016) findings.

A biorefinery industry specific finding mentioned in over the half of the interviews was the willingness to share technical product data instructions and guarantee information through a DSC platform. Due to differences in technical product data and manufacturing, this concept did not appear in maritime interviews.

Most interviewees wanted to protect data about their competitive advantages, capabilities and know-how. They also wanted to ensure that customers were unable to copy and share drawings and innovation data with parties that are able offer similar products and services or to benefit from copied and shared data in other ways.

Table 4: Data attributes perceived sharable

Concept	# in maritime	# in biorefinery	Representative quotes from interviewee narratives
Planning material data	8	1	"It would be beneficial to receive planning and project information through the system." (supplier) "The sharing of drawings and documents is essential to us, since we work with several design suppliers in a geographically wide area. Ability to control design entities is important." (buyer) "PLM data can be easily shared" (buyer)
Invoices and payments	6	2	"Invoicing information automation." (several byers and suppliers) "We want to receive the same invoice data as suppliers to reduce erroneous interpretations." (buyer) "We want to see the link between projects and invoices, e.g. additional / changed orders should be linked automatically to invoices." (buyer)
(Project) schedules	4	2	"There could be a rough schedule related to deliveries and time-tables. Schedules change all the time, and providing exact timetables is not possible. We expect that persons

			viewing a rough schedule understand its meaning." (buyer)
Instructions, guarantees	0	5	"Customer-specific maintenance instructions." (supplier) "Guarantee information." (buyer)
Bilateral information	4	1	"Information necessary to share in bilateral business. We do it already but mediums and formats differ." (supplier) "We only want to share data on a supplier basis on our mutual business transactions." (buyer)

Prices, profit margins and costs were other typical sets of data attributes that interviewees did not want to share. Shipbuilding is a project industry where each ship is unique – and has a unique price. Non-sharable business secret, know-how, detailed project structure and management accounting data were described in multiple ways. Even though interviewees were willing to share planning information and schedules, detailed drawings were non-sharable.

Table 5: Data attributes perceived non-sharable

Concept	# in maritime	# in biorefinery	Representative quotes from interviewee narratives
Competitive advantage	10	5	"Matters that could interrupt normal business should they become known to competitors." (supplier) "Dimensioning, matters related to own empirical knowledge, design know-how." (buyer) "Issues relevant to competitive advantage." (several buyers and suppliers)
Price data	10	2	"For example, pricing information should not to be shared if

			competitors can see it." (several suppliers and buyers)
Internal sensitive data	7	2	"Detailed project structure information." (buyer) "Managerial accounting information." (many buyers and suppliers) "Sums of contracts, terms, payment terms, options, projects' technical details." (buyer)
Business sensitive drawings	6	0	"All information related to products' shape." (buyer) "Information about components, exact manufacturing pictures." (supplier) "Detailed design information of products." (several buyers and suppliers)

5 Discussion and Conclusions

In this study, we interviewed 25 sourcing and accounting specialists. Ability to control supply chain processes increased willingness to share data. We discovered 11 other factors increasing the willingness to share supply chain data and 9 factors that decreased data sharing willingness. Five most frequently factors respectively were shown in Tables 2 and 3. This is our answer to RQ1. We discovered that the interviewees perceived planning materials, invoices and three other data item types sharable as shown in Table 4. Detailed price, competitive advantage, detailed drawings and internal process data reported in Table 5 were considered non-sharable. This is our response to RQ2.

It was a surprise that cost savings was not an important factor for increasing the willingness to share data. Prior research, e.g. Corallo et al. (2007) and Nachira et al. (2007) have reported cost savings as the main driver for ecosystem participation and for the sharing of data between partners, competitors included. Cost savings have also been one of the main benefits that the designers of the

DBE Core platform have promised to deliver. In our study, ability to control supply chain process, to have better quality data and other benefits proved more important. Cost savings had, however, an indirect role in several benefits. This unexpected finding is amenable to future research.

Other findings on factors increasing the willingness to share data are more in line with the findings of prior research in an investigated novel context, where a multi-sided platform and multi-industry ecosystems are amalgamated through the development, implementation and governance of a DSC platform operated by a neutral multi-ecosystem company. Trust and long-term inter-organizational relationships (e.g. in Li & Lin, 2006) as well perceptions about benefits achievable over one's own benefit through cooperation (Iansiti & Levien, 2004b) were detected to increase data sharing willingness similarly to prior studies. Trust delivery through technology instead of human behaviour and cooperation between non-trusting partners appear interesting future research venues.

We found a new factor, situational opportunity, that promotes willingness to share data during the existence of such opportunities. At the time of this study, willingness to try new ISs technologies created such opportunities. Our findings regarding factors that decrease willingness to share data support the findings of prior research.

We regard the present article as the first step to describe theoretically (Eisenhardt, 1989; Santos & Eisenhardt, 2005), how systemic business value (Mikkonen, 2011) is created and divided in multi-industry ecosystems that collaborate by sharing data between industry ecosystem partners and between industry ecosystems via digital platforms. The single case study conducted in one country and in a specific type platform and ecosystem context constitute the main limitations of our study. By repeating interviews in the same industrial ecosystems over time, by interviewing experts from finance, logistics and other industries in several countries and by comparing the DBE Core type platforms to proprietary platforms such as Tradelens could be used to remove the main limitations of this research. Despite of these limitations, we believe our study contributes to platform and ecosystem research. We encourage researches to investigate the automatic exchange of (supply chain) data through platforms in multi-ecosystem and/or multi-modal contexts.

Our study has offered several practical advices to the developers of the DBE Core platform. As a generic advice to practitioners, we encourage them to pay attention to behavioural data sharing concerns and to the governance of data in platforms and ecosystems.

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Exergaming Experiences of Older Adults: A Critical Incident Study

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Abstract Exergaming is a form of digital gaming requiring physical effort from the player. There has been a growing interest towards exergaming in academia. However, only a very limited number of exergaming studies have given a voice to older adults and investigated their experiences. This study investigates what kinds of exergaming experiences are perceived as the most meaningful ones among older adults (referred in this study as people over 50 years of age). That is, the experiences which they perceive or remember as "unusually positive or negative". To meet this purpose, this study takes a qualitative approach and uses the critical incident technique, a well-established technique to collect and classify observations of human behavior. The findings suggest that for older adults, the most meaningful positive experiences of exergaming are more due to hedonic and social aspects than utilitarian aspects, although also utilitarian physical activity benefits are valued. The most meaningful negative experiences are due to issues with technology/game or personal physical limitations. Based on the findings, practical implications are also presented.

Keywords: • Exergaming • Exergames • Digital Wellness • Older Adults • Critical Incidents • User Experience •

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1 Introduction

Digital gaming has become highly common in our present society and is today one of the most popular forms of entertainment in the world. Many major technology companies along with a growing number of investors put more and more focus into the gaming industry. Digital gaming is also a rising topic of research in many fields, including information systems (IS) science. One very interesting form of digital gaming is exergaming – a combination of the words exertion and games (Mueller et al., 2016). Exergaming refers to "a form of digital gaming requiring aerobic physical effort – exceeding sedentary activity level and including strength-, balance-, or flexibility-related activity – from the player that determines the outcome of the game" (Kari & Makkonen, 2014, p. 2). During the past decade, researchers have become increasingly interested in exergaming and especially in its potential to provide physical activity and health outcomes (Kari, 2014; Maddison et al., 2013) as well as novel play experiences (Mueller et al., 2016). Studying exergaming has been deemed important (Kari, 2017) for various reasons, for example, exergames are potential in providing entertainment combined with health and wellness related benefits. Whilst the interest towards exergaming has increased in academia, so far the majority of the research has focused on their design and physical aspects instead of user experiences and perceptions. Even though the number of studies focusing on the user-centric aspect of exergames has increased recently, there is still a dearth of understanding on the usage of these games (Kari, 2017). Moreover, as stated by Loos (2017, p. 261) only a very limited number of exergaming studies have given "a voice to older adults" and investigated their experiences. Digital gaming in general is limitedly researched among older age groups (De Schutter & Brown, 2016; Pearce, 2008), yet, they form a group of devoted players having distinct needs and interests (Pearce, 2008).

Wellness related technologies and IS in general are still typically designed for younger populations, yet their growing need and potential also among older users has been presented (e.g., Carlsson & Walden, 2017). As digital games have become a popular pastime (De Schutter & Brown, 2016) and are widely played also among older age groups (Kinnunen, Lilja & Mäyrä, 2018), it is imperative to conduct more research on the experiences older adults have with exergames. Increasing the understanding on the older adults' IS and exergaming use experiences is essential especially for the developers of exergames in terms of being able to provide this particular user group the kinds of exergames that take into account their needs and wants, which would likely make the games more accepted, and thus, advance their adoption and diffusion. In addition, it can also be considered important for several other stakeholders, such as the health and well-being actors as well as the society at large, in terms of offering new ways to conduct physical activity and to motivate people towards it. Overall, exergames could be a potential tool in the fight against the increasing sedentary lifestyle and the problems resulting from it. The health benefits of physical activity are well documented, and recent studies show that becoming physically active even later in adulthood can still provide these benefits (Saint-Maurice et al., 2019).

To address the aforementioned research gap, this study investigates exergaming experiences of older adults (defined in this study as people over 50 years of age). More precisely, this study examines older adults' most meaningful exergaming experiences, i.e., critical incidents. That is, the experiences which they perceive or remember as “unusually positive or negative” (Edvardsson & Roos, 2001, p. 253). Such experiences are typically highly influential for human behavior (Flanagan, 1954).

The main research question this study seeks to answer is: What kinds of exergaming experiences older adults perceive as the most meaningful ones and how are the resulting feelings?

In addition to providing further understanding on this topic, this study also answers the calls by Liu et al. (2013) to conduct more IS research on digital games and Loos (2016) to conduct more qualitative studies giving voice to the experiences of older adults playing exergames in natural settings. The study is exploratory in nature and follows a qualitative approach. It is based on a thematic analysis of data collected from 34 older adults through a qualitative survey build using the critical incident technique (CIT) (Flanagan, 1954).

2 Background

2.1 Exergaming

Today, there is an increasing number of different types of exergames. All the biggest gaming console lines as well as computers offer technology and games that enable exergaming in home setting. There are also various portable devices with different sensor technology, such as hand-held consoles and smart phones that provide possibilities for exergaming across different settings and locations. Indeed, exergaming can be conducted in various settings, such as senior centers, medical centers, and fitness centers (Lieberman et al., 2011), as well as in school and work environments (Maddison et al., 2013). Besides the console- and mobile-based exergames, also other types of exergames are available, for example, the ones available in arcades or the ones embedded into exercise apparatus. Existing exergaming solutions can also utilize, for example, climbing walls (Kajastila & Hämäläinen, 2014; Valo Motion, 2019a), trampolines (Kajastila, Holsti & Hämäläinen, 2014; Valo Motion, 2019b), and virtual reality spaces (e.g., Zero Latency, 2019). Whilst the popularity of these kind of "larger" exergaming solutions is steadily increasing, the console- and mobile-based exergames that are commercially available are still the ones that are typically most accessible to the users (Chamberlin & Maloney, 2013; Kari, 2017) and mostly used among older adults. While exergaming seems to be more common in the younger than the older age groups, there is a user base also among older adults (Kari, Makkonen, Moilanen & Frank, 2013).

Exergaming has been limitedly studied among older adults. Whilst there are numerous studies conducted with older adults as participants, they have mostly been related to physical and wellness aspects, balance and falls prevention, or rehabilitation (Nguyen et al., 2017), with only a few touching the subject of user experience (e.g., Loos, 2017; Pyae et al., 2016). Overall, the related findings have been promising. For example, the systematic review by Nguyen et al. (2017) concluded that 75% of the reviewed papers found games to have positive impacts on the well-being of the elderly. Stanmore et al. (2019) conducted an exergaming intervention for people aged 55 years and older and concluded that exergames may be used to improve balance, reduce pain and the fear of falling, and are a cost-effective fall prevention strategy in assisted living facilities. Kappen, Mirza-Babaei & Nacke (2018) conducted a systematic review and identified a taxonomy of exergames with 9 categories and 19 themes of exergame applications for older adults' physical activity, which could be further grouped into three broader clusters: training, rehabilitation, and wellness. They also concluded that exergames can contribute to the improvement of health and wellness goals of older adults. Pyae et. (2016), who in their study touched also the subject of user experience, found that there are numerous age-related aspects that should be considered when designing exergames for the ageing population, for example, related to controllers, user interface, usability, and safety.

2.2 Critical Incidents

Critical incident is an experience that the person "perceives or remembers as unusually positive or negative" (Edvardsson & Roos, 2001, p. 253). Critical incidents generally are particularly influential for human behavior (Flanagan, 1954). For example, a single critical negative incident may overrule a set of average positive incidents and lead to unwanted behaviors, such as discontinuance with the product or service (Cenfetelli, 2004). Research has shown that critical incidents have a substantial role in forming user perceptions towards products, services, their providers, and thus, in forming customer relationships (Edvardsson & Strandvik, 2000; Payne, Storbacka & Frow, 2008). Thus, they are seen as the most meaningful experiences people have.

Studying the most meaningful experiences, i.e., the critical incidents potentially pose important implications for both research and practice. Previous research has examined critical incidents in several IS related contexts, for example, online shopping (Holloway & Beatty, 2008), mobile applications (e.g., Salo & Frank, 2017) and mobile services (e.g., Gummerus & Pihlström, 2011; Salo, Olsson, Makkonen, Hautamäki & Frank, 2013), augmented reality (Kari, 2016), and self-service technologies (Meuter et al., 2000), but to the author's best knowledge, not in exergames. This study reveals central critical incidents occurring with exergames among older adults.

3 Methodology

To conduct the study, a qualitative approach was chosen. Qualitative research aims to understand people, their sayings and behavior, and the social and cultural context they live in. Central aim is to understand real life phenomena and find new knowledge. One key benefit of qualitative research is that it enables the researcher to see and understand the underlying contexts in which decisions are made and actions take place (Myers, 2013).

To collect the data, an online survey was administered among Finnish consumers during a three-month period in late-2015. The invitation to answer the survey was distributed through different discussion forums of varying topics and through different social media channels. The survey was build and administered by using the LimeSurvey online survey software. The survey questionnaire was based on previous literature on exergaming and critical incident technique (CIT). Further, a qualitative pre-test phase was conducted with fellow IS scholars and based on this, final improvements to the questionnaire were made before launching it. The survey questionnaire included several sections, among others, one about the most meaningful experiences, i.e., the critical incidents. Some of the other sections gathered information outside the purpose of this study. The sections used for this study surveyed the participants' background and the critical incidents. To collect the critical incidents and their descriptions, the CIT was used (Flanagan, 1954).

CIT is a well-established technique involving a set of procedures (Flanagan, 1954) "to collect, content analyze, and classify observations of human behavior" (Gremler, 2004, p. 66). CIT allows the respondents to describe the actual (positive or negative) incidents in their own words. Flanagan (1954) points that CIT is not a single rigid set of rules leading the data collection but rather "a flexible set of principles which must be modified and adapted to meet the specific situation at hand" (Flanagan, 1954, p. 336). CIT has been widely used as a research method across different research fields (Butterfield et al., 2005) including IS (Gogan, McLaughlin & Thomas, 2014), and it has been proven to be a sound research method and well suited for obtaining insights on a previously undiscovered phenomenon (Andersson & Nilsson, 1964; Gremler 2004; Meuter et al. 2000) such as critical exergaming experiences among older adults. Hence, CIT fits the purpose of collecting critical experiences well. Central advantages of

CIT include that the critical incidents are easy to remember and describe and that the respondents report highly important and relevant experiences. Hence, CIT enables to create an accurate and in-depth record of events (Grove & Fisk, 1997), which provides a rich set of data (Gabbott & Hogg, 1996). Obviously, CIT also has certain limitations (Bitner, Booms & Tetreault, 1990; Gremler, 2004). For example, it only gathers crucial incidents and experiences instead of regular ones.

In planning the survey, prominent and widely cited research papers utilizing CIT (Bitner et al., 1990; Meuter et al., 2000) were used. Only the respondents who had actual experience of playing exergames were asked to report their critical incidents. The respondents were asked to describe one single critical incident they had experienced in as much detail as possible. More precisely, the respondents were first asked to "Think of a time when you had an outstandingly positive or negative experience [with exergames]", followed by a question: "Was this a positive or a negative experience?" Then, to let the respondents describe the incident in their own words, the following open-ended questions were used (translated from Finnish to English): 1) Describe in as much detail as possible: what were you doing and what happened?; 2) What exactly caused the positivity/negativity of the experience?; 3) Why do you feel that this was a significant experience for you concerning exergaming?; and 4) As an outcome of the experience, how did you feel?. The respondents were also asked what was the game related to the reported incident.

The data was analyzed using thematic analysis, which is the most widely used method of analysis in qualitative research (Guest, MacQueen & Namey, 2012). Thematic analysis is a method for "identifying, analyzing and reporting patterns (themes) within data" (Braun & Clarke, 2006, p. 79). Thematic analysis enables to organize and describe the data set in rich detail and to interpret the research topic from various aspects (Braun & Clarke, 2006). To assist in conducting the analysis, guidelines from Braun and Clarke (2006) and Patton (2002) were applied. As they suggest, these guidelines were applied flexibly to fit the research questions and the collected data. In addition, the checklist for CIT content analytic studies by Gremler (2004) was applied to further guide the analysis. More precisely, first, the incident descriptions were read and reared to familiarize with the data and all the interesting features were marked. Then, common tendencies were recognized. Based on the incident descriptions and the recognized tendencies, recurring themes were identified and analyzed in more detail. In doing this, a spreadsheet program was used. As suggested by Braun and Clarke (2006), instead of a linear phase-to-phase process, the analysis process was a recursive one, i.e., the analysis moved back and forth between the different phases. Finally, the report was produced.

4 Results and Findings

The survey was able to reach 230 respondents in the target group of this study, out of which 34 (14.8 %) had experience with exergames and reported their critical experiences. These 34 formed the sample used in the analysis. Out of the reported experiences, 18 were positive and 16 were negative. 23 of the experiences had taken place with console-based exergames, 9 with mobile-based exergames, and two with other platforms. In terms of gender, the sample was quite balanced as there were 15 female and 19 male respondents. The age of the respondents varied between 50 and 68 years, and the mean age was 56.9 years (SD 5.2 years). The description of the sample can be seen in Table 1.

Table 1: Description of the Sample (N = 34)

	n	%
Gender		
Male	19	55.9
Female	15	44.1
Other	0	0
Age		
50–59	26	76.5
60–69	8	23.5
Occupation		
Paid employment	19	55.9
Self-employed	1	2.9
Unemployed	4	11.8
Pensioner	10	29.4

4.1 Positive Experiences

When examining the situations where the most meaningful positive experiences took place, it was apparent that almost all experiences took place during game play when the user was playing the game him/herself (possibly with others). There were two instances where the specific experience had occurred after playing the game, though were still highly related to the previous gaming session.

The most notable things that lead to the positive experiences were fun and enjoyment, sense of getting physical activity, achieving something in the game, and socializing with other people. Fun and enjoyment relates to the overall feeling of getting good entertainment or something amusing happening with the gaming activity. Sense of getting physical activity relates to the player breaking a sweat or feeling physically exerted. Achieving something in the game could be related to either achieving some in-game goal but also to more personal feeling of achievement with the game. Socializing with other people relates to other people playing an important role behind the experience and the experience being shared with others.

The reasons why the respondents felt that the experience was significant for them concerning exergaming most notably related to them finding or realizing something new in one way or another. For example, concerning a new way to be physically active, a new way of spending time with friends or family, or a new form of entertainment. Another occurring reason was the sense of achievement.

Overall, such positive experiences naturally lead to positive feelings. Most occurring feelings resulting from the described positive experiences were the feelings of joy, satisfaction, and good mood. Joy could be either personal or shared. Satisfaction could be related to the user him/herself or towards the game. Good mood was related to general good feeling resulting from the experience. There were also few mentions of getting a so called “wow-effect”, when the game play had led to some unexpected positive experience and left the player positively surprised.

4.2 Negative Experiences

When examining the situations where the most meaningful negative experiences took place, similar to positive incidents, it was apparent that most experiences took place during game play when the user was playing the game him/herself (possibly with others). However, compared to positive incidents, there were few more instances where the specific experience had occurred in between actual game play or right after or during stopping the game play.

The most notable things that lead to the negative experiences were technical issues and physical incapability. There were also few instances of mildly hurting oneself or another player whilst playing. Technical issues relate to the game freezing or not working properly, possibly leading to undesired pauses in gaming or stopping the gaming altogether. Physical incapability relates to not being physically able to conduct all the movements required by the game, for example, the game demanding such movements that were no longer possible or feasible at given age. Hurting oneself could take place by doing a wrong kind of movement that resulted in pain or by swinging an arm or a leg and hitting something external to the game such as furniture or another player, in which case the other player might have gotten hurt.

The reasons why the respondents felt that the experience was significant for them concerning exergaming most notably related to perceiving the games too hard to use or not being of adequate technical quality. Being too hard to use could be related to either perceiving that the game was not designed and meant for their age group (physical capability) or to personal skills with new technologies or games. Technical quality related more to how well the game functioned. If the experience was injury or hurt related, this was the main reason, but could also be related to physical (in)capability.

Overall, such negative experiences naturally lead to negative feelings. Most occurring feelings resulting from the described negative experiences were the feelings of disappointment, frustration, and bad mood. Same as satisfaction, disappointment could be related to the user him/herself or towards the game. Frustration could be related to either the game and technical issues or to oneself when not being able to play the game at a sufficient level. Bad mood was related to general bad feelings resulting from the experience.

5 Conclusion

The purpose of this study was to increase the understanding on how older adults perceive and experience exergaming. Specific focus was on examining older adults' most meaningful exergaming experiences, i.e., critical incidents. The main research question was: What kinds of exergaming experiences older adults perceive as the most meaningful ones and how are the resulting feelings? The study followed an exploratory qualitative approach and was based on a thematic analysis of older adults' actual critical exergaming experiences.

According to the results, the most meaningful experiences older adults have with exergaming typically occur while they are personally playing exergames, be it alone or together with others. The most meaningful positive experiences seem to be due to fun and enjoyment, sense of getting physical activity, achieving something in the game, or socializing with other people. These kinds of experiences were likely to lead to feelings of joy, satisfaction, and good mood. The most meaningful negative experiences seem to be due to technical issues (i.e., the game freezing or not working properly), not being physically able to conduct all the movements required by the game, or hurting oneself or another player while playing. These kinds of experiences were likely to lead to feelings of disappointment, frustration, and bad mood.

In general, the findings suggest that for older adults, the most meaningful positive experiences of exergaming are more due to hedonic and social aspects than utilitarian aspects, although also utilitarian physical activity benefits are valued. Thus, in designing and marketing exergames targeted either for older adults directly or for older adults as one of the target groups, it would be sensible to highlight the enjoyment and social aspects, while also implying about the games potential to provide physical activity and related benefits. To promote meaningful exergaming experiences of older adults, games should provide good entertainment, possibilities to play and socialize with others, and an adequate amount of physical activity and manageable goals which can be achieved by the players. Considering the value of social aspects, exergames could also be used to promote intergenerational gaming.

The most meaningful negative experiences of exergaming among older adults are mostly due to technological issues with technology/game or personal physical limitations or incapability to conduct the movements required by the game. Thus, the characteristics of this user group of older adults should be considered when designing the games. For example, the issues with technology or games may not be solely due to the games and devices themselves, but could also be due to the novel user interfaces of exergames, which might not be familiar to this user group. To overcome this, a clear and enjoyable onboarding would be beneficial. And should the onboarding already be able to offer some forms of achievements, that would be even better.

Considering the issues related to physical incapability, the games should be designed bearing in mind that there are most likely certain movements that are not completed as fluently in this age group as among younger people. Thus, the games should be implemented not just with different in-game difficulty levels but also with optional levels of physical difficulty, and the controlling of the game should be modified accordingly. A step further would be if the user would be able to inform the game if not wanting to use certain limbs or certain movements for the game play. Finally, to prevent injuries or hurting oneself, the games and especially how they are controlled should be designed in a way that does not require extreme movements. It would also be sensible to inform the players before the gaming starts that how much space should be reserved for safe gaming experience to avoid hitting furniture or alike. Furthermore, some sort of digital coaching (cf., Kari & Rinne, 2018; Kettunen & Kari, 2018) features could be implemented that remind about the importance of warming up before setting into a more intense session of exergaming. This warming up could of course be built into the game, so that the first ten minutes or so of the gaming would be physically less demanding and include some easy stretching.

To summarize the contribution, from a theoretical perspective this study increases the understanding on a growing but limitedly researched player group that is older adults and on their exergaming use experiences by uncovering their most meaningful exergaming experiences. At the same time, it also answers the calls by Liu et al. (2013) to conduct more IS research on digital games and Loos (2016) to conduct more qualitative studies giving voice to the experiences of older adults playing exergames in natural settings. From a practical standpoint, the findings are used to contribute practical implications that can be utilized by the different actors in the industry and society working with exergaming.

6 Limitations and Future Research

This study has some limitations to be noted. First, since the time of the data collection, some novel exergaming concepts have become better known and more popular, such as augmented reality and virtual reality exergames. Thus, the collected experiences in this study are limited to those exergames that were available during the time the data collection took place. However, as the thematic analysis focused on general themes instead of game-specific nuances, the findings can also inform about the use and design considerations for more novel exergames. Second, all the respondents were under 70 years of age with most being between 50 and 60 years of age. Whilst this can be seen as its own segment, the critical experiences of even older people might be different. Third, although providing important insights about older adults' exergaming incidents, this study did not examine the effects of those incidents to the users' behavioral outcomes, such as use continuance. This type of investigation would be important as well.

The study also provides avenues for future research. Future studies could investigate how critical exergaming incidents affect the users' future exergaming behavior and use of exergames. Future studies could also focus on the experiences of even older adults, a group still very much under-researched. Further, other data collection methods, such as interviews could also be utilized to investigate different aspect of critical incidents in this age group. Furthermore, future studies could draw from the insights and methodology of this study in investigating different aspects of older adults' technology and digital gaming experiences. It would also be valuable to repeat this study to accumulate knowledge on the experiences with the very latest technology. A different kind of, yet highly interesting research avenue would be to investigate the ability of exergames to promote intergenerational gaming. Overall, it would be important to conduct more studies on the actual exergaming experiences of the older age groups.

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Exploring Online Customer Experience Formation: How do Customers Explain Negative Emotions during Online Shopping Encounters?

TIINA KEMPPAINEN, MARKUS MAKKONEN & LAURI FRANK

Abstract We investigated online customer experience formation by using customers' own explanations of their negative emotions during their online shopping encounters. Survey data from 1,786 Finnish online shoppers were used to identify customers who experienced strong negative emotions during online shopping encounters (N = 215) and the causes of their negative emotions were then analyzed in depth from their written descriptions. Our findings indicated that customers attributed most of their negative emotions to online store characteristics, including user interface, product and service range, pricing, and trustworthiness; however, some negative emotions were also attributable to factors outside of the online store's control, including individual consumption habits and financial constraints, ecological issues, and family concerns. Our findings demonstrate the multidimensionality of customer experience and highlight the importance of better understanding the different factors that can influence the customer experience.

Keywords: • Online Customer Experience • E-Commerce • Online Shopping • Online Shopping Encounter • Emotions • Attribution Theory • Qualitative Study •

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1 Introduction

Given the rise of e-commerce and customer expectations thereof, understanding the online customer experience has become critical to online businesses' survival. Previous research has indicated that providing a superb online experience positively influences customers' online buying behaviors (Bridges & Florsheim, 2008), while negative experiences can cause substantial damage to a company's reputation and customer relationships (Svari et al., 2011). Given this, the causes and consequences of customers' online experiences have been well identified in various marketing and information systems studies, and several models and measurements have been developed to understand the influence of specific corporate actions and characteristics, as well as how they affect customer experience as an outcome (e.g., Cho & Park, 2001; Novak, Hoffman & Yung, 2000; Rose et al., 2012), including optimal flow experiences (e.g., Skadberg & Kimmel, 2004). Many studies have also investigated the interactions between online service providers and customers (e.g., McLean & Osei-Frimpong, 2017), and studied customer experience as a process.

However, despite significant attention from practitioners and academics alike, discussions of online customer experiences have been dominated by a focus on how firms can orchestrate the experience for customers, and key elements of customer experience have often been studied using only predefined firm-led attributes. Online customer experience research is therefore still rather limited and fragmented (Kawaf & Tagg, 2017; McLean & Wilson, 2016). As Rose et al. (2012) noted, while identifying the components of online service quality can provide a starting point for the exploration of online customer experiences, such experiences are the result of much more than customers' reactions to service stimuli. Formation of customer experience can include many other important factors in addition to those that are visible to the company. Studies that focus exclusively on firm-led service settings ignore how a customer's online experiences may be influenced by factors beyond the firm's control (Trischler, Zehrer & Westman, 2018) and what the customer perceives as most heavily impacting their online experience (Kawaf & Tagg, 2017). Marketing researchers have therefore recently called for a greater focus on consumer perspectives (e.g., Heinonen & Strandvik, 2018; McColl-Kennedy et al., 2019), and researchers are increasingly recognizing the need to understand the holistic nature of customer experiences (Ordenes et al., 2014) in both online and offline contexts.

The present study explores customer experience from the customer perspective and highlights the customer's primary role as an experience constructor, in contrast to the dominant provider-led approach. Survey data collected from online shoppers at 18 Finnish online stores is used to identify customers who experienced strong negative emotions during their online shopping encounters. We then use a qualitative approach to analyse customers' written comments describing their emotions during online shopping encounter, using attribution theory (Heider, 1958) to explain how individuals make sense of events and assign causes to them. We suggest that when customers construct their customer experience (which is in this study understood as an outcome of customer's online shopping encounter), negative emotions and cognitive explanations given to emotions during the encounter are responsible for customers' negative experiences. As previous research has indicated that negative experiences influence customer loyalty (Roos, Friman & Edvardsson, 2009), word-of-mouth (Svari et al., 2011), complaints, (Bougie, Pieters & Zeelenberg, 2003), repurchase intentions (Grewal, Levy & Kumar, 2009), and attitudes toward the service provider (Davidow, 2003), it is therefore important to understand what causes negative experiences and how customers make sense of their online shopping encounter.

This study is organized into five sections. The next section discusses the theoretical background of this study, including online customer experience and attribution theory. Section 3 presents the methodological choices for the empirical study, and Section 4 presents our empirical findings. Section 5 discusses the contributions and managerial implications of this study.

2 Theoretical Background

2.1 Online customer experience

Online shopping behavior has been widely studied in the marketing and information systems literature of the past decade. Online shopping experience (Izogo & Jayawardhena, 2018), online customer experience (McLean & Wilson, 2016), online customer service experience (Klaus, 2013), and user experience (Hassenzahl & Tractinsky, 2006) have all been variously used to refer to the same essential concept. However, while scholars agree on the importance of the online customer experience, no consensus exists on its precise definition or constituents. Nonetheless, the psychological constructs of cognition and affect have been consistently identified as influential components (e.g., Gentile, Spiller & Noci, 2007): it has been suggested that customers engage in both cognitive and affective processing during their consumption encounters, and that, in so doing, they construct new meanings, which are then stored in their memories (Rose et al., 2012). Previous studies have also investigated how emotions contribute to customer intentions, such as online shopping intentions (Koo & Ju, 2010), post-purchase intentions (Kuo & Wu, 2012), repurchase intentions (Gountas & Gountas, 2007), and impulse buying (Vonkeman, Verhagen & Van Dolen, 2017). It appears that online shopping triggers various emotions simultaneously and that the presence of one emotion neither excludes nor guarantees the presence of another (Pappas et al., 2014; Pappas, 2018).

When operating in online environments, customers encounter numerous stimuli capable of influencing the cognitive and affective dimensions of their experiences (Hoffman & Novak, 2009; McLean & Wilson, 2016). A significant amount of research has therefore examined the features of high-quality e-commerce platforms and how different online store attributes directly affect online customer experiences within the business-to-consumer context (e.g., Cho & Park, 2001; Novak, Hoffman & Yung, 2000). However, such online customer experience studies have largely focused on corporate elements, and other potential elements influencing the customer experience have been less studied. Furthermore, very few studies have explored the mechanisms through which customers process and interpret their online service encounters. As Tuunanen and Govindji (2016) noted, traditional approaches in information systems development have focused on improving the efficiency and effectiveness of organizational processes. However, systems designed to target consumers should place greater emphasis on customer perspectives, and it is critical that online firms should understand the socio-psychological aspects of service usage. Gaining such insights will require the use of new approaches and theoretical lenses—such as attribution theory.

2.2 Attribution theory

Heider's (1958) attribution theory explores how people explain the events and behaviors that they encounter in daily life. Attributions—the inferences that individuals make about the causes of events and behaviors—are made to understand and explain individual experiences and to plan future actions accordingly. Attribution theory proposes that attributions can be classified as either internal or external. In an internal or "dispositional" attribution, individuals assign causality to something within individual's control, such as effort or personal factors (e.g., abilities, traits, or emotions). In an external attribution, causality is attributed to situational or environmental factors that are outside individual's control. For instance, when an individual believes that something happened due to her own ignorance, she is making an internal attribution; however, if she blames the circumstances then she is making an external attribution. The attribution process includes two basic errors: fundamental attribution error and self- serving bias (Miller & Ross, 1975). Fundamental attribution error refers to the fact that individuals tend to make internal attributions when focusing on external behaviors; that is, people tend to emphasize an agent's internal characteristics rather than external factors when explaining someone else's activities. Self- serving bias, on the other hand, occurs when individuals attribute positive events, such as a personal success, to one's internal factors, while attributing negative events, such as a personal failure, to external factors.

Consumer attributions affect customer satisfaction with a service and their post-purchase behaviors (Iglesias, 2009), among other aspects of consumer behavior, with important implications for companies. Laufer (2002) suggested that when failures or unexpected outcomes occur, customers can experience psychological discomfort, which in turn makes them search for the causes of failure in order to avoid repeating them; likewise, consumers seek to understand the causes of positive experiences in order to be able to repeat similar experiences (Martinko, Harvey & Dasborough, 2011). As Jackson (2019) noted, attributions associated with a positive outcome and a high expectation of future success lead to a greater willingness to approach similar tasks in the future than activities associated with negative outcomes. In marketing, most attribution studies have investigated customers' reactions to service or product failure (Iglesias, 2009; Weiner, 2000). For instance, Tam, Sharma and Kim (2014) found that customers attributed a negative service delivery outcome more strongly to a service employee or firm, while they attributed positive service delivery outcomes more strongly to themselves. Attribution theory has also been used to investigate customer experiences in the context of tourism. Jackson, White and Schmierer (1993) suggested that tourists attributed positive tourism outcomes to internal factors and blamed negative tourism experiences on external factors. External and internal attributions have also been identified in studies of negative emotions; for instance, Westbrook (1987) and Oliver (1993) both argued that individuals' emotions are related to external factors, such as situations or circumstances, as well as to internal factors.

3 Methodology

Study data were collected via an online survey conducted in cooperation with 18 Finnish online stores between September and December 2018. The stores included different types of business-to-consumer (B2C) shops that sold clothing, cosmetics, music, electronics, groceries, and home, decoration, and recreation products and accessories. Customers at these online stores were shown a link to the survey on a tab that appeared after they had successfully placed an order. In the survey, respondents were first briefly asked about their demographics and online shopping habits. Respondents were then asked about the emotions they had experienced during their online shopping encounter. Emotions were measured using a set of 28 specific emotions; the related questions and measurement scales can be found in Laros and Steenkamp (2005). Negative emotions included anger (angry, annoyed, irritated), frustration (frustrated, discontented, disappointed), fear (afraid, nervous, worried), sadness (depressed, sad, guilty), and shame (embarrassed, ashamed, humiliated); positive emotions included contentment (contented, confident), peacefulness (calm, peaceful), optimism (optimistic, encouraged, hopeful), joy (happy, pleased, joyful), and excitement (excited, thrilled, attracted). Respondents were asked to rate all these emotions on a scale from 1 to 7, where 1 indicated that they had not experienced that specific emotion at all while 7 indicated that they had experienced that specific emotion very strongly during the online shopping encounter. In a subsequent open-ended section of the survey, respondents were asked to describe in their own words the emotions they had experienced and to explain the causes of their strongest positive and negative emotions. Respondents were also given an opportunity to comment on the topic or the survey itself.

In total, 1,803 respondents completed the online survey. However, 17 respondents had to be dropped from the study due to invalid or missing data, resulting in a sample size of 1,786 respondents. From these, we identified respondents who experienced strong negative emotions during their online shopping encounter; an emotion that differed by more than two standard deviations from the average value of that emotion was considered a strong emotion. The number of respondents with at least one such strong negative emotions was 387. We then excluded all respondents who did not also comment on their negative emotions related to the online shopping encounter or whose comments were unclear; the final number of included respondents was 215. These respondents were customers of 17 different online stores; however, most of them (142) had shopped at a specific store selling groceries, from which the majority of all survey responses were also collected. Most respondents were female (87.9%), under 40 years old (59.5%), shopped online at least monthly (77.2%), and had previously shopped in the store that was specifically inquired about in the survey (64.7%). Respondents' descriptive statistics are reported in Appendix 1.

We then analyzed the data provided by the 215 respondents in the open-ended section of the survey. Comment length ranged from 2 words to 429 words. Using NVivo software, the comments were first coded as either internally or externally attributed based on their overall content and most frequent attribution. Comments that included two or more distinct points were split into separate comments for analysis. Each comment was coded multiple times before tallying the final counts and categorizations of the negative emotions expressed by the respondents. It is also important to note that although the main themes were identified based on the attribution counts, this study was based on an interpretive approach, and understanding, rather than quantifying, was the principal objective.

4 Results

We identified 349 attributions from the data. Customers had various external and internal explanations for their perceived negative emotions during online shopping encounters, which could be divided roughly into three main groups: online store (239 attributions; external), sociomaterial environment (28 attributions; external), and the self (82 attributions; internal). These themes are analyzed below.

4.1 Results

As expected, customers attributed their negative emotions mainly to online store characteristics. User interface was an important cause of negative emotions (109 attributions), as were store offerings (114 attributions, including both product and service range [74 attributions] and pricing [40 attributions]). Trustworthiness (16 attributions) was also mentioned relatively frequently. These attributions and sample quotes are reported in Table 1.

Table 1: External attributions: online store

Attribute	Count	Sample quotes (translated)
User interface	109	
Checkout difficulties	30	"Irritated when ordering as the online store claimed my home address does not exist." (Female, 34)
Product search difficulties—product arrangement and filter options	20	"I had to put a lot of effort into finding suitable products for myself. It caused frustration." (Female, 70)
Order management problems—shopping cart functionality	17	"Negative emotions are caused by the fact that the number of items cannot be changed without removing the product completely. This has almost ended my purchase process on two occasions." (Female, 37)
Lack of information	14	"The information was quite incomplete in the product descriptions. It caused a little bit of frustration and forced me to go to other pages to find information." (Female, 30)

Unintuitive navigation interface	12	"An awkward encounter. The shop was a bit confusing, and I didn't even know what to click at first." (Female, 19)
Purchase process duration	11	"It took a lot of time to order, which irritated me." (Female, 36)
Other	5	—
Product and service range	74	
Desired product was not available	32	"All the products that I wanted to order were not available. That was frustrating." (Female, 37)
Limited product range	17	"Negative feelings about the relatively narrow range and products that are unsuitable for me." (Male, 54)
Items became unavailable during the purchase process	10	"I was sad as the lovely thing I just noticed was out of stock when I tried to put it in my shopping cart." (Female, 45)
Product quality	6	"I just read a negative review about the headphones, but I ended up buying them anyway because 'there's no better'; I feel anxiety, excitement, disappointment, worry, frustration." (Female, 35)
Lack of delivery destinations	5	"I got frustrated because I couldn't get delivery where I wanted. I was close to cancelling the entire order." (Female, 30)
Other	4	—
Pricing	40	
Expensive product prices	12	"The affordability and versatility of the products did not meet my expectations, which to some extent caused disappointment. Probably my expectations were unrealistic." (Male, 37)
Quantity discounts	12	"When I tried to reach the limit for free shipping, I got frustrated." (Male, 28)
Unclear or misleading pricing	6	"Negative emotions were raised because I checked the real prices of products. I felt

		disappointed because the 'real' prices at the shop were marked much higher than they actually are." (Female, 52)
Expensive shipping costs	6	"Frustrated because I had to pay for delivery." (Female, 61)
Other	4	—
Trustworthiness	16	
Company reliability	9	"Many web pages are maintained by fraudsters, so there is always some fear when dealing with a new online shop." (Female, 19)
Delivery reliability and convenience	7	"I am a little uneasy about whether the products I purchased actually are in stock and if I have to contact the shop because of product exchange issues." (Female, 27)
Total	239	

User interface includes an online store's visual design, interaction design, and information infrastructure. Consistent with previous literature (e.g., Nielsen, 1999), our findings indicated that this was an important cause of negative emotions and highlighted its importance. In particular, negative emotions were often attributed to the checkout and finalization processes. Customers described confusion and a variety of problems regarding discounts, payments, and authentication; the causes were mostly due to technical issues and errors but also included some concerns regarding unclear instructions and terms of service. In addition, product search difficulties and order management were significant causes of negative emotions. Lack of information (e.g., product reviews, stock status, and descriptions and images) and unintuitive overall navigation of an interface made customers feel that the purchase process was complicated. Purchase process duration also caused negative emotions, as shopping was often perceived as taking time away from other tasks or as not saving time compared to shopping in brick-and-mortar stores.

Negative emotions related to product and service range were linked to customers' unmet expectations when a desired product was not sold or was out of stock, or when the product range was considered too limited in general. A few customers also attributed their negative emotions to doubts about product quality; groceries were a particular source of concern since they are perishable. A lack of options, including delivery options, caused feelings of disappointment. Customers also cared a lot about e-commerce pricing and had price expectations in mind before beginning to shop. They experienced disappointment when products or services were more expensive than they expected or could afford. Quantity discounts triggered negative emotions because customers felt that they added extra pressure while shopping; chasing a discount limit was considered stressful and obliged the customer to buy something that they would not necessarily have bought otherwise. Misleading pricing, such as falsifying normal prices, made customers feel defrauded. In general, a store's trustworthiness was considered important, and many respondents expressed doubts about e-commerce companies. Thus, not being able to draw conclusions about a company or its delivery reliability based on the information provided led to negative emotions.

In summary, customers had high expectations for their online shopping encounters, and they easily construed their experience as negative if the customer journey did not proceed quickly or as expected due to constraints imposed by the product selection, service offerings, or the overall store environment. Customers wanted to find what they were after quickly and to access relevant information in a logical, convenient manner (Nielsen, 1999).

4.2 External attributions: Sociomaterial environment

Even though customers mostly attributed their negative emotions to external factors related to the online store, external attributions were also assigned to the wider sociomaterial environment—the context in which the experience takes place and in which both the company and the customer operate. Within this, ecological issues (13 attributions) were particularly important, followed by family concerns (8 attributions) and purchase context (5 attributions). These attributions are reported in Table 2 with sample quotes.

Table 2: External attributions: sociomaterial environment

Attribute	Count	Sample quotes (translated)
Ecological issues	13	“Negative emotions are mainly due to all the unnecessary stuff that is produced, sold, and thrown away on this overloaded planet.” (Female, 29)
Family concerns	8	“Negative emotions were caused by the sluggishness of the internet connection/computer, as well as the coughing and questioning spouse next to me.” (Female, 34)
Purchase context	5	“I feel ashamed that I ‘have to’ buy waste food because of my financial situation.” (Female, 21)
Other	2	—
Total	28	

Previous research has found that environmental consciousness and concerns have profound effects on consumer behaviors (Schlegelmilch, Bohlen & Diamantopoulos, 1996; Andorfer & Liebe, 2012). Furthermore, consumers are increasingly willing to embrace “green”, environmentally preferable purchasing (Joshi, 2016). Consistent with these studies, our findings indicated that environmental issues also influenced customer experiences as concerns about ecological issues caused negative emotions during customers’ online shopping encounters. Respondents cited climate change, “throw-away culture,” waste, overconsumption, reckless and selfish attitudes, and the excessive production of single-use items as sources of anxiety during their shopping encounters.

A number of respondents also attributed their negative emotions to their personal social environment. Family members were blamed for either causing disruptions or failing to participate sufficiently in the purchasing process. Other external context factors also caused negative emotions; for example, purchasing necessary items, such as groceries, was noted to be an automatically negative event for some respondents. In addition, not belonging to the main target group of a shop, for instance a man shopping in a “woman’s” store, and buying "leftover" products which were perceived as being not good enough for other consumers, were perceived as embarrassing.

In sum, these findings show that customers' experiences were affected by emotions beyond those directly triggered by the online company. The formation of customer experience in an online context can be influenced by individuals' physical and social environments, including other people's actions (Ruiz-Mafe, Tronch & Sanz-Blas, 2016), trends and social norms, including the customs, traditions, and beliefs of a particular group of people at a given time (Ivanova-Gongne, 2015).

4.3 Internal attributions: The self

Although attribution theory posits that negative issues are often attributed to external factors (Miller & Ross, 1975), our findings indicated that negative issues were also attributed in part to internal factors regarding oneself, and matters which oneself can impact. In particular, three main themes emerged: one's consumption habits (30 attributions), one's financial constraints (18 attributions), and one's uncertainty regarding a purchase (16 attributions). These themes, along with other less prominent ones, are presented with sample quotes in Table 3.

Table 3: Internal attributions

Attribute	Count	Sample quotes (translated)
One's consumption habits	30	
Unnecessary purchases	15	"Negative emotions were caused by the fact that I bought futile, not-so-necessary stuff." (Female, 25)
Lack of self-discipline	11	"I feel guilty and frustrated when I have to consume and give in to my consumption needs." (Female, 41)
Self-indulgence, self-rewarding	4	"I felt slightly guilty when I thought about buying expensive luxury and wellbeing products!" (Female, 27)

One's financial constraints	18	"Negative emotions were mainly caused by my own monetary situation." (Female, 33)
One's uncertainty regarding a purchase	16	"Guilt and the negative feelings were raised by the total amount of the order and the consideration of whether I made good purchases and purchased materials that I will for sure use. I wouldn't want to throw anything in the trash." (Female, 40)
One's skill at online shopping	6	"My shopping was affected by not having used the site before. So, I didn't know how to use it." (Female, 25)
One's carelessness or mistakes while shopping	5	"I was annoyed when I obviously clicked negligently and lost a product momentarily." (Female, 51)
One's bad mood	4	"This was so-called comfort shopping. I was feeling really sad and thought I'd distract myself when I decided to go shopping for cosmetics that I had been planning to buy for some time." (Female, 26)
Other	3	—
Total	82	

Internal attributions were mostly linked to one's personal consumption habits and inner conflicts related to guilt triggered by shopping. Negative emotions were attributed to purchasing unnecessary items, making impulse purchases, surrendering to shopping desires, and self-indulgence, and mostly reflected customers' disappointment with themselves due to their perceived loss of self-control. Many respondents reported feeling embarrassed by their consumer behaviors and self-indulgence; for example, buying a luxury item for personal consumption instead of investing in a necessary item for a family member caused individuals to feel like a "bad person". This guilt was partly explained by one's financial constraints and uncertainty regarding a purchase. However, while many respondents indicated that spending money in general caused them anxiety in spite of any justifications and the general necessity of shopping, some respondents indicated that their negative emotions were more dependent on a specific context: spending money caused negative emotions only if there was something more important that should have been purchased instead. Negative emotions were thus most strongly connected to impulse purchases and purchases of less critical items.

In addition to personal consumption habits, insufficient skill as an online shopper triggered negative emotions. Some customers indicated not having enough experience with online shopping or with a particular store, and thus being afraid of making mistakes or of being unable to complete a purchase. Some respondents also blamed themselves for making mistakes during their online shopping encounter and thus experienced negative emotions. In addition, preexisting "bad moods" were reported as affecting customers' overall experiences; such moods could provide the initial inspiration to shop but could also cause individuals to not enjoy the shopping encounter.

In summary, our findings showed that internal attributes and personal considerations could affect customers' experiences. However, the findings indicated that internal factors such as self-perceptions, past experiences, skills, and the perceived meanings of purchases are inevitably influenced by socially constructed mechanisms, including the ideals and norms by which people understand and experience themselves as subjects (Shankar, Cherrier & Canniford, 2006). Feeling guilty about shopping—a perception of doing something wrong—is an example of this. While previous research has demonstrated that customers experienced feelings of guilt during their decision-making processes related to consumption (e.g., Burnett & Lunsford, 1994), our findings indicated that guilt, among other socially influenced, self-related constructs, can also formatively influence customer experiences.

5 Discussion and conclusions

The purpose of this study was to increase the field's understanding of how online customer experiences are formed. We therefore studied how customers explained their negative emotions during online shopping encounters. This customer-oriented approach contributes to the current provider-led understanding of online customer experiences and adds to the small number of previous studies that focused on online experience as constructed by customers (Izogo & Jayawardhena, 2018; Kawaf & Tagg, 2017; Klaus, 2013).

First, unlike many online customer experience studies (e.g., Cho & Park, 2001; Novak, Hoffman & Yung, 2000; Rose et al., 2012), we did not focus on the influence of the online store environment on customer experience or measure the components of customer experience. Instead, we applied a holistic, qualitative perspective in which online experiences were described by the customers themselves, in their own words. We were thus able to better understand customers' logic (Heinonen & Strandvik, 2018) and how customers made sense of their online store visits. We concluded that multiple external and internal factors beyond an online provider's control can contribute customer experiences. Nonetheless, our results are consistent with prior studies on online customer experience that highlight the role of service providers (Cho & Park, 2001; Constantinides, 2004; Koo & Ju, 2010), since, as expected, most of our respondents' negative emotions were caused by online store features (e.g., user interface, product and service range, pricing, trustworthiness). These findings are also consistent with attribution theory's concept of self-serving bias (Miller & Ross, 1975), which suggests that individuals tend to blame external factors for negatively perceived issues and events. Our findings also support attribution theory's hypothesis that individuals make sense of events and issues with both external and internal attributions (Heider, 1958).

Overall, our findings indicate that, while the role of user interface on customer experience is widely acknowledged in the existing literature, online customer experiences are not constructed in a vacuum, and that other contexts, operators, and issues are also important; consumers engage in many activities other than those that are visible to companies (Heinonen & Strandvik, 2018). From a customer's point of view, external factors outside of a corporate website, such as sociomaterial environment (including social norms, the behaviors of others, trends), can cause negative emotions during shopping encounters. Furthermore, our results highlight the important role of internal, self-related factors on customer experience. During their shopping encounters, customers engaged in self-reflection on their behavior and evaluated their personal performance and persona in the context of their purchasing behaviors. Overall, our findings suggest that customers want to feel in control of their consumption behaviors and the shopping encounter, and that all external and internal factors that threaten their sense of control contribute negatively to their experiences.

Second, our findings indicate that customers could experience strong negative emotions even if their online shopping encounter concluded in a purchase, thus making it a successful encounter from the service provider's perspective. The findings implicate the complexity of customer experience and that a positive outcome (purchase) from a provider perspective cannot be equated with an overall positive customer experience. This has important implications for companies since previous research has shown that negative experiences can influence customer loyalty (Roos, Friman & Edvardsson, 2009), repurchase intentions (Grewal, Levy & Kumar, 2009), and attitudes toward the service provider (Davidow, 2003). Our findings thus highlight the importance of understanding the whole customer journey during online shopping encounters, including both positive and negative contributing factors. Although our findings indicate that the causes of customers' negative emotions during shopping encounters can never be fully controlled by a service provider, providers can nonetheless consider contributing factors when designing and implementing online services. By studying and better understanding customers' concerns and the processes from which customers derive meaning, service providers can modify their services to improve the factors that contribute to customers' negative meaning-giving. Further research with a variety of additional research methods is required to fully understand both the external and internal contributors to customer experience in both online and offline contexts. Such findings could be utilized in service design with the goal of creating more customer-friendly and customer-oriented services..

Appendix A: The descriptive statistics of the respondents (N = 215)

	N	**%**
Gender		
Male	26	12,1 %
Female	189	87,9 %
Age		
19–29 years	69	32,1 %
30–39 years	59	27,4 %
40–49 years	42	19,5 %
50–59 years	29	13,5 %
60–69 years	10	4,7 %
Over 70 years	6	2,8 %
On average, how often do you shop online?		
Daily	1	0,5 %
Weekly	54	25,1 %
Monthly	111	51,6 %
Yearly	44	20,5 %
Less than yearly	5	2,3 %
How many times have you shopped in this online store?		
Never	76	35,3 %
1–3 times	83	38,6 %
4–10 times	41	19,1 %
Over 10 times	15	7,0 %

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Process Mining in The Rail Industry: A Qualitative Analysis of Success Factors and Remaining Challenges

KOEN SMIT & JORIS MENS

Abstract This paper aims to identify success factors and remaining challenges relevant to the practice of process mining in the rail industry. Process mining is a method for analyzing processes based on event logs. In a case study, we examine three process mining projects performed at the largest rail organization in The Netherlands. Experiences gained in these projects are compared to success factors specified in literature. The projects were analyzed using observations, secondary data collection and semi-structured interviews. We were able to identify all success factors specified in literature in the case study. In addition, several new success factors are identified. These concern challenges regarding the implementation of process mining software, intra-organizational knowledge sharing and continuous availability of event logs. For the additional success factors identified, it was not yet possible to determine if they are industry specific or generic in nature.

Keywords: • Process Mining • Business Process Management • Success Factors • Challenges • Rail Industry •

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1 Introduction

Business processes are among the most important assets of an organization. They must therefore be properly managed and controlled. The concept of a business process is defined by (Hammer & Champy, 1993) as: "*[...] a collection of activities that takes one or more kinds of input and creates an output that is of value to the customer.*" The management and control of business processes is referred to as Business Process Management (BPM), defined by (Weske, 2012) as: "*[...] concepts, methods, and techniques to support the design, administration, configuration, enactment, and analysis of business processes.*"

Several existing models describe capabilities required for proper BPM. Popular examples of these are 1) the Business Process Lifecycle (Weske, 2012), 2) the BPM cycle (Dumas, La Rosa, Mendling, & Reijers, 2013), 3) the Process Lifecycle (IBM Knowledge Center, 2018) or 4) the BPM framework (Jeston & Nelis, 2014). Business processes must be managed in an agile fashion to consistently add value in a changing environment. This includes redesigning and adapting processes to changing strategies or requirements. Most BPM models therefore include a cyclic approach for continuous improvement. Nearly all BPM models include a phase to analyze the as-is situation and use this as input for improvement of the business process. One way to analyze the as-is situation of a business process is Process Mining. Process Mining (PM) is defined as (van der Aalst & Weijters, 2004): "*the method of distilling a structured process description from a set of real executions.*" Possible key benefits of PM are its 1) objectivity, 2) bottom-up approach, 3) ability to simulate or predict based on process data, 4) visualization of process execution for stakeholders, and 5) ability to identify bottlenecks (Claes & Poels, 2012).

The current body of knowledge on PM shows many contributions focusing on the technical organization and implementation of PM. See for example (De Leoni, van der Aalst, & Dees, 2016; De Medeiros & Günther, 2005; De Medeiros & Weijters, 2005; Suriadi, Andrews, ter Hofstede, & Wynn, 2017; Tax, Sidorova, Haakma, & van der Aalst, 2016). To the knowledge of the authors, not many contributions focus on the success factors and remaining challenges regarding the implementation of PM in practice. The success factors and remaining challenges present in the current body of knowledge seem to be either generalized (Claes & Poels, 2012; Mans, Reijers, Berends, Bandara, & Rogier,

2013) or applied in industries other than the rail industry. See for example (De Medeiros, Weijters, & Van der Aalst, 2005; Homayounfar, 2012; Li, Reichert, & Wombacher, 2011). We aim to derive success factors and remaining challenges in the context of the rail industry and add these to the body of knowledge. This paper poses the research question: '*Which success factors and challenges regarding PM are relevant in the context of the Dutch Rail Industry?*'

The remainder of this paper is structured as follows. The next section describes the research background and related work regarding BPM, PM, and success factors and challenges relation to PM in the current body of knowledge and in practice. The section 'Research Method' elaborates and justifies the research approach. In the data collection and analysis section, the operationalization of the research method describes how the data was collected and analyzed by the research team. In the 'Results' section, the success factors and remaining challenges relevant to a large rail organization are presented. Based on this, the discussion, conclusion and future research directions are presented in the last two sections.

2 Background and Related Work

Although the body of knowledge on BPM features numerous quality frameworks that guide organizations in managing business processes, we adhere to the business process lifecycle framework of Weske (2012) (Figure 1). The framework describes how process mining is integrated within the practice of BPM.

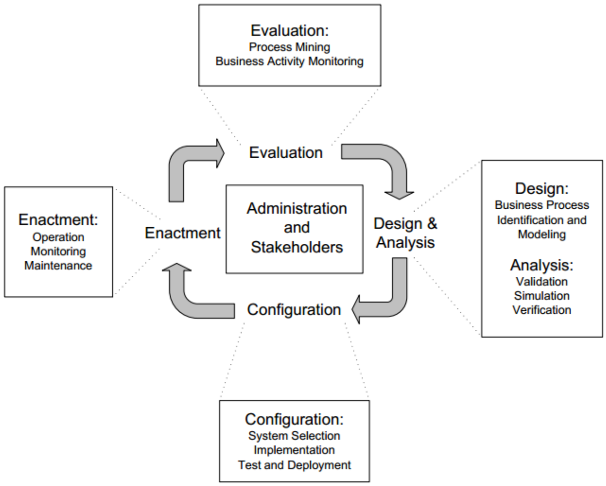

Figure 1: Business Process Lifecycle (Weske, 2012)

According to the Business Process Lifecycle, a business process undergoes several phases during its lifecycle and makes use of different concepts and technologies (Weske, 2012). When viewing the Business Process Lifecycle in Figure 1 in the context of PM, the phase 'Evaluation' stands out because it features PM as one of its key activities. It is important to note that PM also plays a central role in the design and analysis of business processes, as the identification and modelling of business processes are key benefits of PM (Claes & Poels, 2012). Additionally, van der Aalst, a leading researcher in the PM research domain, states that PM is a bridge between data mining and BPM (van der Aalst, 2011).

According to the Process Mining Manifesto, the goal of process mining is to discover, monitor and improve processes by extracting knowledge from event logs (Van Der Aalst et al., 2011). Event logs are the starting point for process mining and contain at minimum a case ID, an activity and a timestamp in order to algorithmically create process models (van der Aalst, 2012). Process mining capabilities are offered nowadays by both academic tools (e.g. PROM (Van Dongen, de Medeiros, Verbeek, Weijters, & van Der Aalst, 2005)), as well as commercial software (e.g. Celonis, Fluxicon Disco, ProcessGold) (Mans et al., 2013).

As described in the previous section, a significant number of contributions in the body of knowledge on PM have a technical orientation, while lacking the (organizational) adoption aspects of PM initiatives (de Schepper & Groeneveld, 2018). One way to examine PM adoption is to zoom in to success factors that contribute to adoption at organizations, and the challenges that are faced. To ground the discussion about (critical) success factors, a definition of a success factor is provided: "*those few things that must go well to ensure success for a manager or an organization, and, therefore, they represent those managerial or enterprise areas that must be given special and continual attention to bring about high performance.*" (Boynton & Zmud, 1984). In the context of this definition, we search for organizational challenges and success factors in the rail industry.

To discover challenges and success factors in the rail industry, we draw forth upon one key contribution in the field of PM regarding success factor identification. In their work, Mans, Reijers, Berends, Bandara, and Prince (2013), propose a model that comprises several PM as well as neighboring areas to consider in terms of (critical) success factor identification. The following areas need to be considered when identifying and analyzing success factors in the context of PM (Mans et al., 2013).

Project specific factors

- Management support: *The involvement and participation of senior management, and their ongoing commitment and willingness to devote necessary resources and time of senior managers to oversee the process mining efforts.*
- Project management: *The management of activities and resources throughout all phases of the process mining project, to obtain the defined project outcomes.*
- Resource availability: *The degree of information available from the project stakeholders during the entire process mining analysis.*

Process mining factors

- Process miner expertise: *The experiences of the person conducting the mining, in terms of event log construction, doing process mining analysis and knowledge of the business processes being mined.*

- Process mining approach: *The extent to which a process miner uses a structured approach during the entire process mining analysis.*

IS related factors

- Data & event log quality: *The characteristics of the raw data and subsequently constructed event logs.*

Several challenges regarding process mining still exist. Although many technical challenges have been overcome in the past years, e.g. challenges described in (Tiwari, Turner, & Majeed, 2008), many organizational challenges still seem to impact the outcomes of PM initiatives (Mans et al., 2013). The body of knowledge on PM, to the knowledge of the authors, does not contain contributions that identify or reflect upon challenges specifically regarding the rail industry. In other fields such as healthcare (Rojas, Munoz-Gama, Sepúlveda, & Capurro, 2016) or tourism (Lux & Rinderle-Ma, 2017), such studies do exist and are essential to reveal industry-specific challenges and success factors for process mining. For example, the work of Rojas et al., (2016) identified that one industry-specific aspect was hindering effective visualization of mined process models, which is that the healthcare domain features complex and less-structured processes. Our work is a first attempt to explore such (industry-specific) challenges regarding PM initiatives in the rail industry.

3 Research Method

The goal of this study is to reveal (industry-specific) success factors and remaining challenges regarding PM initiatives in the rail industry. The maturity of the PM research domain, regarding non-technological research, is nascent. In nascent fields, an appropriate focus involves identifying new constructs and establishing relationships between identified constructs (Edmondson & Mcmanus, 2007). Many researchers use explorative qualitative research methods to do so. We therefore conduct a qualitative study, using case study data collection and analysis to gather empirical evidence on success factors and open challenges. A case study approach helps us develop context-based descriptions of the phenomenon studied (Myers, 1997).

A single case study is utilized, further characterized by an embedded style design (Runeson & Höst, 2009). Within the context of the Dutch rail industry, one organization will be selected (the case) in which multiple PM projects (units of analysis) are evaluated against the success factor areas described in the previous section. This organization will be further referred to as 'the organization'.

4 Data Collection and Analysis

Data for this study was collected over a period of twelve months; from January until December 2018, through three PM projects at the organization. The case study features a multi-method approach, composed of 1) secondary data collection and analysis, 2) semi-structured interviews, and 3) observations. The selection of the participants in the case study should be based on the group of individuals, organizations, information technology, or community that best represents the phenomenon studied (Strauss & Corbin, 1998; Strauss & Corbin, 1990). For this study, the phenomenon studied is represented by organizations and individuals that deal with the planning, execution and evaluation of PM projects in the Dutch rail industry.

In the context of our study, a case was defined as a single process mining project aimed at the derivation of a model of a business process, with the end-goal of improving the business process. Improvement meaning the mitigation or removal of bottlenecks and/or increase conformance levels, among other factors.

The largest Dutch organization in the rail industry (in terms of FTE's and number of passengers) was selected for this research. The organization employs over twenty-thousand people and has a need to innovate and continuously improve business processes. These characteristics provided the best fit for selecting multiple 'mature' PM projects. The selection of cases was done in collaboration with the innovation team responsible for introducing process mining within the organization. The research team defines a 'mature' PM project as being completed recently (after January 2018) and involving the planning, execution and evaluation of a business process using PM. This criterion was defined because the organization performed multiple PM projects, however not all projects have reached the maturity deemed necessary to study the full spectrum of success factors.

The organization's innovation team is the primary team tasked with process mining projects at the organization and was therefore suitable for collaboration during this study. The innovation team consults other organizational departments on process mining practices and implementation.

The research team and the innovation team selected three projects that were deemed suitable for analysis in this study. The selected cases are described in detail in the Results section, followed by a presentation and mapping of success factors and remaining challenges regarding these projects. First, the data collection and analysis method is explained in the following sub-sections.

4.1 Observation

In the context of this study, observations were conducted as a data collection technique and as a project monitoring type. According to (Zelkowitz & Wallace, 1998), project monitoring type observation has no direct influence on the methods being used later and its data (mostly historical lessons learned) is solely utilized for some immediate analysis. One observation was performed for each PM project described in this paper. Observations were performed during an on-site visit at the department where the analyzed business process is performed, including a guided tour and explanation by an employee familiar with performing the process. Because the observer is an employee of the organization and not seen as an external researcher, this reduces the risk of introducing bias in the data collection from observation (Wohlin et al., 2012). The observations were performed by a member of the innovation team. Notes were taken to gather domain knowledge and to identify possible process bottlenecks to later study using process mining. Observation duration was at least one and a half hours per project.

4.2 Secondary data collection

Secondary data collection was used in addition to observations. Secondary data encompasses documentation produced during the execution of the PM projects. For each project, a Project Initiation Document outlines the goal, planning, and hypotheses for the respective project. At the end of each project, an advisory report presents the findings of project to the owner of the business process and describes lessons learned regarding performing the PM project. The PID is around five pages long and the advisory report around fifteen pages long. These documents were produced by a process mining expert within the innovation team.

4.3 Semi-structured interviews

Lastly, semi-structured interviews were utilized as a data collection technique. For each PM project, at least six meetings were organized with a bi-weekly frequency. Stakeholders in these meetings varied over time depending on what was discussed. Stakeholders included the process owner (usually a manager in the department), employees within the department, systems administrators, and database administrators. The duration of each interview was 45 minutes and notes were taken by members of the innovation team. These notes contain action points with regards to challenges regarding the PM project at hand as well as an evaluation of the project's progress.

4.4 Analysis

Due to the confidentiality of the data supplied by the organization, the analysis of the data was conducted solely by open coding, see also (Strauss & Corbin, 2015). Another limitation was that the data could only be analyzed on-site at the organization. With open coding, the researchers coded specifically on three aspects: 1) PM success factors (keeping in mind the definition of a success factor provided in section 2), the category (Mans et al., 2013) which the identified success factor belongs to, and 3) open challenges regarding PM. For example, some meeting notes included information regarding the difficulty of receiving data sets when the required business process logs are not locally accessible (from the department itself) and need to be accessed using a formal request, which takes a lot of time, thus hampering the project's progress.

5 Results

The case study encompasses three PM projects within the organization, performed in chronological order. After giving an outline of each process analyzed, we describe the success factors and challenges identified during these projects. These are mapped to the success factor categories specified in literature by (Mans et al., 2013). We conclude this section by describing the challenges that remain after the success factors are mapped to the model from literature.

Project A (Locker retention): A process mining project was conducted to analyze the ideal maximum retention time for luggage lockers. Customers can rent a luggage locker at the train station. A fee is charged per day of use, with a maximum of three days. Lockers still in use after the three-day limit are emptied by staff, and contents are held by the lost & found department. A late fee is charged to customers who eventually retrieve their belongings from this department. Emptying lockers and holding their contents is a labor-intensive and costly procedure. Process mining was used to determine if the operation of removing locker contents could be delayed, thereby reducing the number of times this operation must be performed. It was found that for most late lockers, the contents are eventually retrieved by the customer within ten days. Delaying the emptying of late lockers up to ten days saves considerable time and resources by staff from the lost & found department. Meanwhile, the customer can still be charged a late fee through the locker management system.

This process is relatively simple and includes a limited number of activities and possible process paths. Process mining was used mainly because its time-sensitive nature allows us to test hypotheses related to deadlines, such as overdue rental periods.

Project B (Service desk): The organization's service desk is responsible for coordinating the (unplanned) maintenance and repair of assets in train stations (such as escalators, elevators and lighting) as well as structural parts of the station building (windows, roofing, etc.). The service desk coordinates several contractors to carry out repair & maintenance activities, who are bound to completion timeframes through an SLA. Process mining was performed to find out (1) if contractors were completing their work within the set timeframe, (2) if there were superfluous fields/activities in the service desk's software that could be eliminated, and (3) which method of requesting repairs at the service desk provides the shortest lead time (e-mail, app, or telephone). Based on the findings of the project, some SLAs were renegotiated, and an optimized process was implemented when the department transitioned to a new version of their software.

This process is characterized by high complexity and unpredictability because of the unplanned nature of the interruptions. The process involves a large variety of parties performing human tasks.

Project C (Wheelset overhaul): The organization's technical workshop performs the process of overhauling train wheelsets. This process involves removing the steel wheels from the axle, re-profiling the wheels, performing several tests and applying protective paints before the wheelset is reassembled. This process was recently modernized using a robotized production line to improve the quality, precision, and safety of the overhaul. Because the production line is relatively new, some teething problems occurred. Thanks to process mining, it was found that some stations in the production line could cause unexpected delays. These stations were then deployed in parallel configurations so that delays would not cause backing up of the entire production line.

The process is characterized by being relatively straightforward, with a set order of a activities in the production line. The process is highly automated with few human tasks and produces detailed event logs for process mining.

5.1 Success factors for process mining in practice

In this sub-section we describe to which extent the success factors identified in literature were present in the process mining projects described above. This helps us to identify how these success factors have influenced these projects, how the organization can improve its success factors and which challenges remain.

- Management support: Management support for process mining was high in all projects, since it was identified as one of the technological trends that the organization wants to invest time and resources in. This allowed the innovation team to gain experience and perform multiple projects.
- Project management: The team applied project management techniques already present at the organization and was successful in obtaining the defined project outcomes. However, due to the specific nature of process mining projects, new skills had to be learned to perform project management in these projects successfully.

- Resource availability: Resource availability was decent, since the necessary stakeholders were willing to contribute their knowledge to the product. This is because specific problems faced by the stakeholders were the reason for initiating the process mining projects. They were therefore intrinsically motivated to achieve the end-goal of the project. More difficulty was faced in identifying and extracting the necessary data for process mining, as this was a new type of information that wasn't normally requested in the organization.
- Process mining expertise: PM expertise was gained by following a formal training course with a supplier of process mining software and gaining experience by performing process mining projects. The expertise grew over time.
- Process mining approach: The team applied a structured approach using. However, over time more experienced was gained in how to specifically acquire and extract the necessary data for process mining. Therefore, the process mining approach became more structured as more projects were performed.
- Data & Event log quality: Data quality was mixed. Gathering the correct data and 'grooming' it into a suitable format was one of the biggest challenges of the projects described. On a technical level, not all systems initially recorded the necessary data to create an event log or the data was cumbersome to access and extract. On a functional level, meetings with stakeholders were needed to interpret the data and to find out which activity in the 'front-end' of the process resulted in which 'back-end' logging of the activity, to give meaning to the process models that were mined.

For mapping the practical experiences describe above with success factors to those found in literature, we classify the presence of these factors in each project into three categories in Table 1 below. These categories are 'low', 'moderate', and 'high'. Low meaning that the success factor was barely or not at all present during the project, 'Moderate' meaning that the success factor was identified but not to the full extent described in the model, and 'High' meaning that the success factor was fully identified.

Table 1: Extent of success factor identification in case study projects

	Project A	Project B	Project C
Project specific factors			
- Management Support	High	High	High
- Project Management	Moderate	Moderate	High
- Resource Availability	Moderate	Moderate	High
Process Mining Factors			
- Process Miner Expertise	Moderate	Moderate	High
- Process Mining Approach	Moderate	High	High
IS Related Factors			
- Data & Event Log Quality	Moderate	Moderate	High

Remaining challenges

After discussing the success factors and how they were found in practice, challenges regarding process mining remain. We outline these challenges as follows:

- Availability and characteristics of process mining software: Process mining software is required to perform PM analyses. A large variety of software packages is available on the market. These have differing software architectures, such as a standalone desktop application, or SaaS applications which perform process mining in a cloud-based environment. To assess which software best fit the needs of the organization, several such solutions were tested. It was found that some SaaS-solutions focus specifically on continuous monitoring of business processes by connecting directly with back-end databases. Since our projects were focused more on analyzing a post-hoc dataset manually extracted from a database, we found more use in a flexible standalone desktop application. Selection of process mining software is also influenced by architectural constraints within the organization's IT landscape. Another challenge was finding a suitable licensing scheme for the organization, where the need for process mining software scaled up or down over time. In conclusion, organizations will need to consider how process mining software fits into their overall application landscape and any IT-related policies that may apply. Organizations will need to consider which licensing scheme best fits their needs and financial constraints, with suppliers offering for example, per-user or per-process licensing schemes.

- Knowledge building and knowledge-sharing: In a large organization such as the organization studied in this paper, knowledge sharing between departments is challenging. In earlier years, it was found that different departments were exploring process mining on their own, without necessarily having knowledge of other PM initiatives within the organization. This led to a variety of process mining software being purchased without a centralized vision, as well as differing policies regarding data availability. In recent months a centralized innovation portal was launched which helps mitigate this problem by listing process mining as one of the key technological trends within the organization. Existing process mining projects, articles, and expert contact information is published in this portal, allowing for increased knowledge propagation. Depending on their characteristics, organizations must find a suitable way to make sure process mining knowledge is secured and propagated to gain the most benefit from their efforts.

- Availability and distribution of event logs: Another challenge faced is that for each process mining project performed, many manual steps were needed to identify and extract the necessary data for process mining. This is caused by each system having its own method of logging event data, with different levels of granularity and suitability for mining. Policies for accessing this data differ, depending on data confidentiality and ownership. To overcome these challenges, the solution is two-fold: (1) When designing system requirements for new or changing systems, event logging must be integrated to ensure availability and enable easier extraction when needed. (2) Event logs should be distributed through a centralized portal, so that they are easily acquired in a suitable format.

> We have seen one such solution used in practice at another organization, where end-users could download event logs from several systems through a portal. This eliminates the many manual steps in acquiring process mining data.

The remaining challenges identified in this case study were not yet identified in literature, and therefore extend the set of possible success factors. The next sections describe limitations of this study, future research directions and the implications of these findings.

6 Discussion and Future Research

As is the case with all empirical research, this research has its limitations. The first limitation concerns the generalizability of the identified success factors and challenges toward the entire organization as well as the Dutch rail industry. The generalizability towards the organization is grounded by the fact that the innovation team involved in this study are part of many PM projects throughout the organization. Therefore, as the organization is by far the largest organization in the rail industry in the Netherlands, the results are partly generalizable towards the Dutch rail industry. Future research must include results from more organizations in this industry to be able to analyze a larger dataset before generalization can be achieved.

Although this study features three cases with varying characteristics, the research team could not identify rail industry-specific success factors or challenges. This does not imply that rail-specific factors are completely nonexistent in the organization or in the entire rail industry. Such success factors and challenges are context dependent, which should also be investigated in future research. The processes selected in this case study are a locker rental process, a service desk process and a technical overhaul process. While these process are performed within a rail organization specifically, it can be said that such processes are not unique to the rail industry and similar processes are possibly present in other (transport) industries. This may limit the extent to which the identified success factors and challenges are specific to the rail industry.

The possibility for future research into success factors and challenges is made evident by the fact that the current body of knowledge on PM has a predominant focus on technical capabilities and lacks information on organizational capabilities regarding PM implementation and adoption. The current body of knowledge does not contain many empirical studies that focus on success factors and challenges regarding specific industries. A final interesting direction for future research is why some PM projects fail to reach maturation or continuously add value to the process. Future research should focus on how process mining can be more structurally embedded in process improvements methods of the organization.

7 Conclusion

The goal of this research was to answer the following research question: "*Which success factors and challenges regarding PM are relevant in the context of the Dutch Rail Industry?*" To do so, an embedded case study was applied at the largest organization in the Dutch rail industry. To ground the identified success factors, the PM success factor model of (Mans et al., 2013) was utilized. The results show that the organization has process mining on the R&D agenda and has sufficient management support. Because of this, resources were allocated to explore and execute PM projects throughout the organization. Data quality is mixed at the organization to affect the efficiency of PM initiatives, which is similar to experiences regarding data quality of PM projects in the body of knowledge. Also, one contingency factor seems to affect the efficiency and effectiveness of PM projects, which is the size of the organization. Large organizations are prone to initiate several isolated PM initiatives without intra-organizational knowledge propagation. The organization studied found that a central knowledge portal that tracks PM projects proved effective in creating awareness and sharing knowledge among different departments.

It seems that using the success factor model from literature in combination with data collection and analysis of the selected cases did not yield any industry-specific success factors or challenges. It appears that the extent in which these factors are encountered depends more on other properties such as the size or culture of the organization or the characteristics of the process analyzed.

The research yielded three additional challenges that were not specifically mentioned in the PM success factor model of (Mans et al., 2013). These challenges concern 1) the characteristics of process mining software such as licensing schemes and the ability of the software to fit into the organizational IT landscape and policy constraints, 2) Applying knowledge management practices to secure and propagate knowledge on process mining within the organization, and 3) incorporating event logging in the design of information systems, as well as making event logs available through a centralized portal for increased ease of access. Overcoming these challenges may lead to additional success factors that contribute to achieving the desired goals of process mining projects.

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The Business Rule Type Jungle: An Explorative Analysis

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Abstract Decisions and business rules are essential Components of an organization. Combined, these components form a basis for securing the implementation of new laws, regulations and internal policies into processes, work instructions and information systems. To ensure proper implementation, business rule types must be taken into account, as the functions per type may be different. The current body of knowledge on decision and business rule management offers some insights into different types of business rules, however, these types are often presented as a secondary focus of a contribution or set in stone without proper evidence supporting these claims. This study therefore aims to explore the different business rule types utilized in the body of knowledge as well as practice. This will form a basis to determine possible overlap and inconsistencies and aid in establishing the functional differences between the defined business rule types. By applying a literature review, semi-structured interviews and secondary data analysis, we observed that the current body of knowledge shows serious diffusion with regards to business rule types, the same holds for practice. Therefore, future research should focus to research these differences in detail with the aim to harmonize the proliferation of business rule types.

Keywords: • Business Rules Management • Business Rules • Types • Comparison • Explorative Analysis •

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1 Introduction

To achieve pre-determined goals, organizations need to make decisions. Decision-making processes depend on the rules that apply within an organization (Kardasis & Loucopoulos, 2004). These rules, often defined as business rules, guide business behavior in accordance with the business policy which is established on the basis of internal or external provided criteria, e.g. (Weiden, Hermans, Schreiber, & van der Zee, 2002; Zoet, Smit, & Leewis, 2015) Morgan (2002) specifically defines a business rule as: "*a statement that defines or constrains some aspect of the business intending to assert business structure or to control the behaviour of the business.*" In this paper, we adhere to this definition. Business rules can best be managed separate, i.e. from processes and data, which is often referred to as Business Rules Management. BRM is defined as: "*a systematic and controlled approach to get a grip on business decisions and business logic to support the elicitation, design specification, verification, validation, deployment, execution, governance, and monitoring of both business decisions and business logic*" (Smit, 2018). Business rules are the cornerstones, together with data, of business logic, which is defined as: "*a collection of business rules, business decision tables, or executable analytic models to make individual business decisions*" (Object Management Group, 2016).

Business rules can originate from many different sources, for example, external organizations. Furthermore, external criteria can be imposed by the government, an example of this is the general data protection regulation law defined by the European Union, which aims to protect the privacy of European citizens. When this law was implemented, all organizations processing data from European citizens needed to change their business rules on handling personal data (European Commission, 2018). Besides this, organizations also add their own business rules which depend, for example, on business strategies or agreements made within the organization. As a result of changing laws, which change at an increasing rate and become increasingly complex (Self-reference, 2018), it is important that business rules are easily adapted, which is the first challenge. To realize this, business rules are often stored in a database separate from other aspects of the system. This enables the separation of concerns i.e. IT developers do not need to concern themselves with business practices while business practitioners have ownership of the business rules, also by the promise to be relieved from programming. Furthermore, it is possible to change the business rules without interfering with the IT department (Von Halle, 2001).

In addition to business rules originating from different sources, a second challenge that organizations face is that more business rules are being created over time. In time, more adjustments and exceptions will arise due to the increased amount of business rules to be used by a business. To create, store and manage these business rules it is useful to give them a classification (Hay, Healy, & Hall, 2000; Madeyski, Śmiałek, Hnatkowska, & Huzar, 2016). In this process, researchers and software developers use their own classification scheme with different rule types, give different names to rules with the same goal or apply different levels of subtypes, often without any design rationale, see for example Wan-Kadir & Loucopoulos (2004) and Bauer (2009). As a result, it is difficult to communicate and make decisions regarding business rules types. Besides making the communication about business rules easier, a common classification scheme will increase the transferability of business rules between and within organizations. This study aims to identify the hypothesized diffusion of business rule types in the current body of knowledge as well as in practice. To do so we defined the following research question: "*What business rule types exist in literature and practice and how do they differ?*"

The remainder of this paper is structured as follows. The next section will provide background and related work regarding business rules, classification schemes and their development, thus providing a clear overview of the current body of knowledge. In the third section, the research method is described, which justifies the type of research that is chosen and how it affects the research techniques utilized. The fourth section will describe the data collection and data analysis, detailing the application of the research techniques. This is followed by the fifth section, which gives an overview of the results, showing the diffusion of the categorization of business rule types in the body of knowledge and practice and a proposal for a standard categorization based on semantic characteristics rather than mere labels. Next, in section six, the conclusions regarding this study are drawn by providing an answer to the research question. The final section will consist of the discussions and recommendations for future research.

2 Background and Related Work

BRM consists of nine capabilities as can be derived from its definition in the previous section. A capability is defined as "*an ability that an organization, person, or system, possesses*." (The Open Group, 2011). How a capability is realized by an organization depends on the situation in that specific organization, i.e., what technology or tooling is available, the maturity of the available technology, the available knowledge, and the available resources. Knowledge regarding business rule types is mainly required as part of the elicitation, design and specification capabilities, however, are also relevant with regards to the verification, validation, deployment, and execution capabilities of BRM.

Contributions regarding business rules types and classifications are published by Von Halle, Ross and the Business Rules Group, which are utilized in many other subsequent contributions to the body of knowledge. The first classification Von Halle coined was published in 1997 in "*The business rule roadmap*" (von Halle, 1997). This classification consisted of definitions, facts, constraints and derivations. A few years later Von Halle published a new classification scheme that contained the rule types: term, fact, mandatory constraint, guideline, action enabler, computation and inference (Von Halle, 2001). In this classification, rules were split into rules constraining information on behalf of the business event (constraints and guidelines), rules enabling other action on behalf of the business event (action enablers) and rules creating new information on behalf of the business event (computations, inferences). In Von Halle's opinion, constraints, computations and inferences deserve the most attention because these guide and restrict behavior in the case of constraints and create knowledge in the case of computations and inferences (Von Halle & Goldberg, 2006, 2009; Von Halle, 2002). This is more important for the business than presenting information. Moreover constraints, computations and inferences are the kind of rules that are often used in commercial rule products and give rise to a debate between database and application professionals (Von Halle, 2001).

Ross wrote several books about business rules and published papers in several magazines. Ross used to split business rules in two types, namely integrity constraints (rules that always yield true) and conditions (rules that may yield either true or false) (Steinke & Nickolette, 2003). In a contribution from 2003, however, Ross added a few more rule types, which resulted in classifications consisting of facts, terms, rules, constraints, derivations, inferences, timing, sequence and heuristics (Ross, 2003, 2013).

A third line of research is developed by the Business Rule Group. This is a group of experienced practitioners working in public and private sectors dealing with business rules. The goal of the Business Rules Group is to formulate statements and supporting standards in relation to the nature and structure of business rules and the relationship between business rules and business architecture and the way an enterprise is organized (Business Rules Group, n.d.). From the start, the Business Rules Group focused on business rules who could be implemented directly into information technology. In 2000, the Group published a paper in which, amongst others, a classification scheme for business rule types was proposed. This scheme consisted of the following types: structural assertions (divided into terms and facts) action assertions (which can be divided into a condition, an integrity constraint or an authorization) and derivations (divided into a mathematical calculation or an inference) (Hay et al., 2000).

The body of knowledge on BRM and business rule types does not contain, to the knowledge of the authors, a contribution that examines the state of business rule types from a meta-level perspective, also identifying challenges with regards to possible overlap and inconsistencies.

3 Research Method

The goal of this study is to explore the different business rule types utilized in theory and practice and analyse possible overlap and inconsistencies. To select an appropriate research method, one should look at the maturity of the research field (Edmondson & McManus, 2007). The maturity of the business rules management research field with regards to business rule types is nascent and the (scientific) contributions often secondarily focus on business rule types, see also the previous section. In nascent fields, an appropriate focus involves identifying new constructs and establishing relationships between identified constructs. To do so, researchers use explorative qualitative research methods. Therefore, we conduct a qualitative study and, through a multi-method approach comprising a literature review, qualitative semi-structured interviews and secondary data analysis, we search for business rule types and their rationales. A multi-method approach is utilized to create richer and more reliable research results (Mingers,

2001). Given the maturity level of the research domain, this becomes even more important as it allows for a thorough understanding of the phenomenon and its context being researched (Runeson & Höst, 2009).
With regards to the literature review, a descriptive review is conducted in which the focus lies on the empirical as well as the conceptual evidence (Paré, Trudel, Jaana, & Kitsiou, 2015). The scope of a literature review that positions a research question by addressing the theoretical foundations is often characterized by an implicit search process and data extraction process (Kitchenham et al., 2009). However, explicit criteria were applied and are discussed in the next section. The semi-structured interviews were selected to identify the rationale and context of the business rule types in practice, which is harder to grasp when solely utilizing a literature study.

4 Data Collection and Analysis

Data collection for this study was conducted over a four-month period (between November 2018 and February 2019). Data collection for this research paper comprised a combination of three different sources, 1) the body of knowledge on business rules, 2) semi-structured interviews and 3) a set of requirements from seven Dutch governmental organizations regarding decision management and business rules management systems selection. By collecting and analyzing these three data sources we were able to compare and partly triangulate the results. Furthermore, such a combination allows for a richer exploration of the phenomenon studied, by also describing the context in which these business rule types are utilized (Myers, 1997).

Literature review
To ground our literature review with regards to its quality, rigor and transparency, we address the query identification, query combination and operationalization, search strategy and exclusion criteria.

- Query identification; To identify relevant queries, one should look at the scope and goal of the research study. In this case, the research scopes comprises business rule types.
- Query combination and operationalization; Based on the identified queries, a combination scheme with the following terms and operators

was followed: "business rule" OR "business rules" AND "type" OR "types" OR "classification" OR "categorization" OR "category" OR "class".

- Search strategy; Google Scholar was used as main search database due to the fact that it has a higher coverage compared to other search engines or individual database searches (Amara & Landry, 2012; Franceschet, 2010; Harzing & Alakangas, 2016; Wildgaard, 2015).
- Exclusion criteria; Papers or books must be written in English or Dutch for them to be included. Also, identified sources must be available via the internet to be included. No specific date criterion was applied.

Semi-structured Interviews

Data collection for this research is conducted using a semi-structured interview approach. Semi-structured interviews are conversations which are led by a set of predetermined questions/topics. These questions are open-ended and open to interpretation. Utilizing this style of interviews allows the data collection phase to yield better data aiding the identification of business rule types utilized in practice, their rationale and the context in which they were applied (Miles & Gilbert, 2005; Neuman & Robson, 2014).

Eleven business rules management practitioners were interviewed during a four month period (between November 2018 and February 2019). Nine participants were selected from the governmental sector, while two were selected from the commercial (tooling) sector. In total, the participants originated from seven different organizations. The participants had the following roles: two enterprise architects, three business rules analyst, one business rules architect, two business rules consultants, and one business rules management project manager. The average duration of an interview was 45 minutes. The selection of the participants was done based on a combination of snowball sampling (Goodman, 1961) as well as convenience sampling during a Dutch BRM conference for governmental organizations.

During the interviews, an interview protocol was used, to help understand how different organizations deal with the management of business rules. The interview protocol consisted of the following questions: 1) *Which type of business* *rules are used in your organization?* 2) *Are the business rules stored in a (separate) database?* 3) *Does your organization employ a classification for business rule(s) (types)?* and 4) *What is this classification based on?* e.g. on a classification from a vendor of business rules engines or on scientific research?

Additionally, the researchers analyzed a set of 1029 requirements to derive business rule types and their rationales. This data was provided by Dutch governmental organizations, which contained information about the requirements with regards to decision management and business rules management systems that must be implemented to support their digital services.

Data analysis

All data, originating from the literature review, semi-structured interviews as well as the secondary data collection, was analysed using thematic coding. To do so, the research team established a coding scheme that was followed during this process, based on meta-data that is useful to compare functionally different business rule types. The following attributes were coded during this process: 1) business rule type label, 2) subtypes, 3) function 4) synonyms, 5) rationale, and 6) examples, according to the ordering/elaboration, dimension and unit coding families defined in Strauss & Corbin (2015). This process was performed by two researchers individually. Then, based on these attributes, an analysis was performed by three researchers. The third researcher conducted sample-wise checks of the coding during this process. The identified business rule types are analyzed using a nominal comparison, due to the explorative nature of this study (Mahoney, 1999). Nominal comparison allowed us to compare and differentiate between business rule types using the six coding attributes described earlier in this paper. The results of this process are presented in the next section.

5 Results

In this section, the results of the literature review, semi-structured interviews and secondary data analysis are presented. When the identified business rule types are described using an example, one uniform example context is utilized. This context concerns the malnutrition check for patients at a hospital, see also (Smit, Zoet, & Berkhout, 2016).

5.1 Business rule types according to literature

As described in the previous two sections, a literature review is conducted to identify business rule types in the body of knowledge.

Table 1: Rule type identification results (body of knowledge)

BR Type	**Process rule**	**Process rule**	**Process rule**	**Process rule**	**Process rule**	**Derivation rule**	**Derivation rule**	**Validation rule**	**Constraint rule**	**Constraint rule**	**Constraint rule**	**Constraint rule**	**Constraint rule**	**Definition rule**	**Definition rule**	**Definition rule**	**Definition rule**
BR Subtype	**Trigger rule**	**Precondition rule**	**Postcondition rule**	**Sequence rule**	**Data requirement rule**	**Calculation rule**	**Inference rule**		**Action assertion rule**	**Authorization rule**	**Visibility rule**	**Presentation rule**	**Persistency rule**	**Activity definition rule**	**Actor definition rule**	**Data definition rule**	**Relation definition rule**
Bauer, 2009						X	X	X									
Boyer et al. 2011		X				X	X							O	O	O	O
Date, 2000						X	X		O	O	O	O	O				
Ferreira & Simoes, 2016	X	X	X	X	X		X										
Von Halle, 2001						X	X			X				O	O	O	O
Ghose et al, 2007	O	O	O	O	O				X	X							
Goedertier et al, 2008	X	X	X	X					O	O	O	X	O				
Graham, 2007									X	X				X			
Hay et al., 2000						X	X		O	O	O	O	O				X
Herbst et al., 1994					X	O	O							O	O	O	O
Holmberg et al., 2010		X	X			O	O							O	O	O	X

Jayaweera et al., 2009		**X**				**O**	**O**							**O**	**O**	**O**	**O**
Kardasis et al., 2004	**O**	**X**	**O**	**O**	**O**	**O**	**O**							**X**	**X**		
Kovacic, 2004	**O**	**O**	**O**	**O**	**O**												
Lemmens et al., 2013	**O**	**X**	**X**	**O**	**O**	**O**	**O**		**O**	**X**	**O**	**O**	**O**				
Madeyski et al., 2016		**X**				**X**	**X**		**O**	**X**	**O**	**O**	**O**	**X**	**O**	**X**	**O**
Morgan, 2002						**X**			**X**			**X**					
Group, 2017						**O**	**O**		**X**	**X**			**X**				
Park et al., 2004		**X**		**X**		**O**	**O**		**X**								
Ross, 2001				**X**		**O**	**X**										
Schlosser et al., 2014		**X**							**O**	**O**	**O**	**O**	**O**	**O**	**O**	**O**	**O**
Steinke et al., 2003						**O**	**O**		**O**	**O**	**O**	**O**	**O**	**O**	**O**	**O**	**X**
Taylor, 2011						**O**	**O**	**X**		**X**							
Von Halle, 2001		**X**				**X**	**X**		**X**	**O**	**O**	**O**	**O**				
Von Halle et al., 2006	**X**	**X**		**X**		**X**	**X**		**X**	**O**	**O**	**O**	**O**				
Wagner, 2002	**X**					**O**	**O**		**X**	**X**							
Wan-Kadir & Loucopoulos, 2004	**X**	**X**							**X**	**O**	**O**	**O**	**O**				
Wang et al., 2014	**O**	**O**	**O**	**O**	**O**									**O**	**O**	**O**	**O**
Wang, 2017	**X**	**X**				**O**	**O**			**X**		**X**			**X**		**X**
Weiden et al., 2002		**X**	**X**	**X**						**X**		**X**			**X**		**X**
Witt, 2012		**X**	**X**	**X**	**X**				**X**	**X**					**X**	**X**	**X**
Zoet, 2014		**X**		**X**		**X**	**X**		**X**	**X**	**O**	**O**	**X**				
Zur Muehlen et al., 2007	**X**	**X**	**X**	**X**		**O**	**O**		**O**	**O**	**O**	**O**	**O**	**X**			

In Table 1, an overview is provided in which the archetypes are presented accompanied by its source. In total, 36 relevant sources were identified with the search queries described in the previous section. An X in Table 1 denotes the identification of the rule type and subtype, while an O denotes the identification of the business rule type only. For example, when a source states the importance of a definition rule and describes a definition rule, but does not describe what the focus of the definition rule is, i.e. actors, activities or relationships, the definition rule row is denoted with an O. When the focus of a definition rule is explained, the explained subtypes are denoted with an X. The labels of the business rule types described in this paper are derived from the body of knowledge by adhering to the label that was most identified for a given business rule type.

Business rule type descriptions

Based on the results of the literature study, five business rule archetypes were identified, which are 1) Process rules, 2) Derivation rules, 3) Validation rules, 4) Definition rules and 5) Miscellaneous rules. Furthermore, 16 business rule subtypes were identified. The subtypes are described under its corresponding archetype.

Process Rules

A process rule focuses on constraining business processes by defining triggers, activity conditions or sequentiality. Literature analysis revealed five business rule subtypes.

1. Trigger rules causes operation, process, procedure, or rule to be executed when the given condition is true or on the occurrence of a certain event. For example: '*When a patient is registered, the process 'check malnutrition' is must be triggered and started.*'
2. Precondition rules indicate conditions that must be met before a task is performed. For example: '*The malnutrition of a patient may be checked when 1) the patient is not in intensive care, and 2) the patient has a waist width of 120cm or more.*'

3. Postcondition rules indicate conditions that must hold after execution of the task. For example: '*The calculation must yield a malnutrition risk score to be able to determine the malnutrition risk.*'
4. Sequence rules control over the execution of tasks, i.e. the sequencing of tasks within a certain process. For example: '*First the patient has to be checked for direct organ damage after which the BMI is measured. When the BMI is measured, the patient is asked about the food intake pattern.*'
5. Data requirement rules specify the required information flow between tasks. Describe situations in which a task needs information from another task to be able to execute. For example: '*During the BMI measurement activity, the height and weight of the patient as well as the age of the patient must be available.*'

Derivation Rules

A derivation rule focuses on deriving information from collected facts. Literature analysis revealed two subtypes:

1. Calculation rules use a mathematical calculation to derive a new arithmetic value. For example: '*The BMI of the patient is calculated as the weight of the patient in kilograms divided by the height of the patient squared. The patient weight is 52 kilograms and the patient height is 162 centimeters. This results in a BMI index of 19,8.*'
2. Inference rules create new information from existing information. The result is a piece of knowledge used as a new fact. For example: '*When the weight loss of the patient is between 5% and 10%, the weight loss risk points must be set to 1. One of the sub-decisions is 'calculate weight loss risk points' which inferences the amount of risk points based on the weight loss percentage of the patient.*

Validation Rules

A validation rule focuses on checking input value(s) against predetermined values resulting in true or false. No subtypes were identified regarding validation rules. For example: '*The data entered with regards to the weight loss percentage has a maximum of two decimals.*'

Definition Rules

A definition rule focuses on constraining aspects of the business by defining them. Literature analysis revealed four subtypes:

1. Activity definition rules constrain business process elements such as activities by providing a definition. For example: '*During the activity 'determine BMI score' the nurse or physician has to collect the weight, length and age of the patient.*'
2. Actor definition rules constrain actor elements such as roles and attributes by providing a definition. For example: '*The nurse is responsible for the calculation of the patient's BMI score. The physician is responsible for determining the food intake pattern.*'
3. Data definition rules constrain data by defining what comprises the data that represents a fact in the real world. For example: '*BMI is calculated by dividing your weight (in kilograms) by your height (in meters squared).*'
4. Relation definition rules constrain the relationship and its attributes between process elements, actors and/or data by providing a definition. For example: '*Each patient can only have one contact person, which is either a nurse or physician.*'

Miscellaneous Rules

Additionally, five business rule (sub)types were identified that could not be clustered in terms of functionality:

1. Action assertion rules specifies constraints on the results that actions can produce. For example: '*The value that results from the BMI calculation must be between 12 and 60.*
2. Authorization rules specifies who is authorized to perform an action. For example: '*Only nurses with a malnutrition screening certificate level two are authorized to perform malnutrition checks independently, without a physician.*'
3. Visibility rules constrains dynamically the visibility of data within the context of an activity according to the properties of the activity, the data in its state space and the agent that has been assigned to the activity. For example: '*When a physician logs into the malnutrition system, the BMI, weight of*

the patient and other data can be registered. However, when nurses with level one or no certificates login to the system, no patient data can be registered.'

4. Presentation rules define how the system presents itself to the user, how work and tasks are to be organized. For example: '*The user interface for the nurse contains a maximum of three registration fields and one button to submit the data into the system.*'
5. Persistency rules determine how long certain information in an organization should be kept available. For example: '*The patient data regarding malnutrition may be stored until the patient is discharged.*'

Situational factors

Analysis of the body of knowledge also shows that several business rule types actually represent characteristics of other business rule types, and therefore are dependent on the context of the business rules (set). Therefore, these characteristics are reported in this paper as situational factors. The following factors are identified:

- Positive versus negative formulation

It is possible to formulate business rules in a positive or negative manner. A positive formulation focuses on something that is allowed while the remainder is not allowed. An example of this is: '*A nurse may see the BMI score, weight loss percentage and food intake values of a patient.*' Thus, at the same time, this means that the nurse is not allowed to see other information about the patient. A negative formulation focuses on what is disallowed. An example of this is: '*A nurse may not see the patient address details, health insurance details, and job-related details.*'

- Mandatory versus non-mandatory

Business rules that are mandatory need to be followed, and do not allow for alternative approaches. An example of this would be: '*For each patient, it is mandatory to register a BMI score to determine a malnutrition risk score.*' A physician may not override this rule as the BMI score is required to determine a malnutrition risk score of the patient. Non-mandatory rules are guidelines that can be overruled given the circumstances. An example of this would be: '*For each patient,* *it is advised, but not mandatory to register the malnutrition data to determine the malnutrition level of a patient.*' Rules that are characterized as mandatory offer the mitigation of risk, however, are less flexible in execution when, for example, exceptions arise.

- Enforceable versus non-enforceable

Each of the identified business rule types, with the exception of definition rules, can be enforceable or non-enforceable. For enforceable rules it is possible to compel people to follow this rule, this applies for example to the rule: '*A physician and a nurse must enter his/her personal code to add, manage or monitor patient malnutrition data.*' Contrary to enforceable rules, some rules are hard or impossible to enforce, which are referred to as non-enforceable rules. An example of such a rule would be: '*A patient should always be greeted with a handshake.*'

- Monitorable versus non-monitorable

The monitorable factor indicates whether it is possible to monitor violations of rules. An example of a non-monitorable rule is: '*The patient is required to tell the nurse how much he or she has eaten during the last five days.*' It is impossible for the nurse to check whether the patient is telling the truth. A rule that is monitorable, however, is for example: '*The patient needs to gain 300 grams per day in weight during the first week.*'

Synonyms

In addition to the situational factors, the literature analysis also revealed multiple business rule types described that are exactly equal in terms of function. Therefore, these are labelled as synonyms for the business rule types presented in Table 1. Due to space constraints, this paper does not present all synonyms identified. However, to ground our claim, two examples of synonyms are provided. The first example comprises the business rule type *Derivation rule*, which is also referred to as an 1) *Informative rule*, 2) *Assumption rule* or 3) *Deductive rule*. The second example focuses on the situational factor, which often seems to be described as a business rule type, non-mandatory business rules. A non-mandatory rule is also referred to as a 1) *Behavioral rule*, 2) *Suggested rule*, 3) *Guideline rule*, or 4) *Advice rule*. In total, 30 synonyms were identified in literature.

5.2 Business rule types according to practice

As described in the previous two sections, several semi-structured interviews were conducted as well as 1029 functional requirements were analysed to identify business rule types applied in practice.

Analysis of semi-structured interview data

In total, eleven business rule management practitioners were interviewed to derive business rule types utilized in practice. In Table 2, these business rule types are described.

Table 2: Rule type identification results (semi-structured interviews)

Business rule type	Function	Subtype	Function
Process flow/rule	To guide sequentiality.	**Duration**	A rule to determine how long a business event may take.
		Action rule	A rule that expresses a set of conditions followed by the actions to take if the conditions are true.
		Technical rule	Represent specific loops in the action part of rules.
		Structural rule	A rule that constraints the relationships between metamodel elements.
		Action enable	Tests a condition and upon finding it true will initiate a business event, message or other activity.
Derivation/ decision rule	A rule that derives information from collected facts.	**Inference**	Create new information using existing information using logic.
		Calculation rule/computation	Create new information using existing information based on mathematical computation.
Validation rule	A rule that checks the input value(s) against predetermined values resulting in true or false.		

Miscellaneous rule types	N.A.	**Stimulus and response rule**	Constrains behavior by specifying when and if conditions must be true in order to trigger certain behavior.
		Operation constraint rule	Specify those conditions that must hold true before and after an operation to ensure that the operations perform correctly.
		Structure constraint rule	Specify policies or conditions about classes, objects and their relationship that should not be violated.

Analysis of secondary data

In addition to the semi-structured interviews conducted, a set of 1029 requirements with regards to BRM systems were analyzed. This resulted in the identification of eleven business rule types, see Table 3.

Table 3: Rule type identification results (secondary data)

Business rule type	Function	Subtype	Function
Process rule	A rule that focuses on procedure and sequence in order to guide a process.	Conversion rule	A rule that converts information to, e.g., a boolean value.
		Technical rule	A rule defined in the technical language itself (e.g. Java, C++).
Derivation rule/Decision rule	A rule that derives information from collected facts.	Inference rule	A rule that creates new information from existing information.
		Calculation rule	A rule that uses a mathematical calculation to derive a new arithmetic value.
Validation rule	A rule that checks the input value(s) against predetermined values resulting in true or false.		
Actor rule	A rule that defines the actor and its characteristics such as linked activities or authorization.		

Miscellaneous rule types	N.A.	Stimulus and response rule	A rule to define cause and effect relationships.
		Structure constraint rule	A rule that constraints the relationships between metamodel elements.

Situational factors

Consistent with the situational factors regarding business rule types found in the body of knowledge, situational factors were also identified during the analysis of business rule types in practice. The following three situational factors are identified:

- Mandatory versus guidelines

This factor is also identified in the body of knowledge and is utilized the same way in practice.

- Encourage, prevent or allow behaviour

In the governmental sector, business rules are often drafted to encourage behaviour, prevent behaviour or allow behaviour depending on the circumstances. Business rules are therefore classified as either encouraging, prevention or allow actions.

- External versus internal sources

The participated organizations all utilize internal and external sources to ground their business rules. External sources refer to law and regulations defined by regulating parties. Internal sources are defined on top of the external sources, to exert more or other control over the business, e.g. policies. For each defined rule, it is registered what the origin of the source is.

5.3 Literature versus practice comparison

For clarity, the identified business rule types from theory and practice are compared in figure 1.

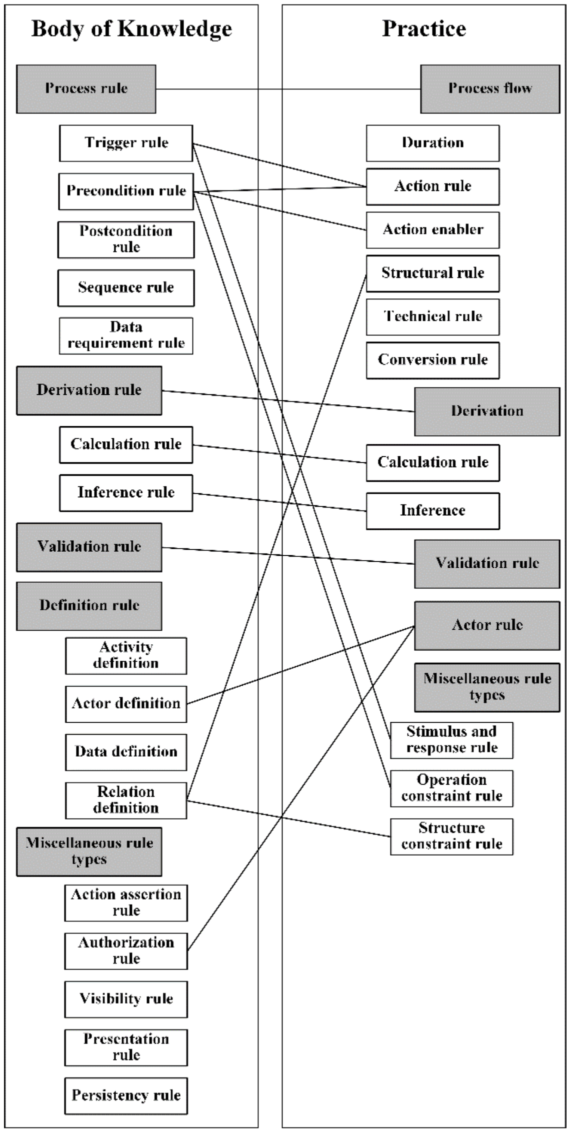

Figure 1: Mapping of business rule types (body of knowledge vs. practice)

6 Conclusions

The goal of this research was to answer the following research question: "*What business rule types exist in literature and practice and how do they differ?*" To do so, a multi-method approach was applied comprising the collection and analysis of the body of knowledge, semi-structured interviews data and secondary data regarding business rule types. This research shows that in the current body of knowledge, many business rule types are defined. However, analysis also shows that the current body of knowledge occasionally lacks proper functional argumentation and descriptions as well as proper examples of rule types. Rule types seem to be a secondary objective in such contributions. Additionally, the body of knowledge also shows large diffusion with regards to rule type labeling, which makes comparison and transferability much harder, as rule types are presented as new but are essentially synonyms of existing rule types. In total, 16 business rule subtypes were identified in the body of knowledge, divided over four rule type categories. All (sub)types identified differ in functionality and are accompanied with an example. After the body of knowledge was analyzed, data was collected from practice on business rule types. Similar to the body of knowledge, business rule types are applied which are functionally the same, but labelled differently. Analysis shows that the practitioners and their organizations involved in this research seem to utilize some contributions from the body knowledge, however, they mostly define business rule types themselves. Lastly, a comparison of business rule types utilized in theory and practice is presented in Figure 1. A close look shows that the body of knowledge and practice do utilize the same rules in a functional perspective to a large extent, however, also appear to use different labels. Concluding, we answered our research question by providing types of business rules utilized in theory and practice, which created an opportunity to analyse the differences.

7 Discussion and Future Research

This research has several limitations. First, when referring to practice, we refer to the Dutch governmental organizations that were included in this research. We do not claim that these results are generalizable towards the whole Dutch governmental sector or even larger than that. Given the fact that this research has an explorative focus, a small sample size is sufficient, however, future studies should incorporate larger sample sizes applying both qualitative and quantitative research methods to increase generalizability. Additionally, industries other than the government should be included in future research. The combination of semi-structured interviews and secondary data analysis provides a novel view of how business rule types are defined and utilized, however, we cannot fully claim that the organizations included do not utilize all business rule types identified in the body of knowledge, as these organizations utilize many different information systems and experts that work in a silo setting. Future research that focuses on establishing a uniform overview of business rule types in the body of knowledge with the help of a Structured Literature Review could help in forming a key contribution that can be utilized by practitioners. Such a contribution could also reduce the proliferation of business rule types applied in practice, possibly increasing the ease of collaborating regarding business rule identification and formulation between organizations. Lastly, this study examined how the business rule types differ within and between literature and practice, however, an interesting venue for future research would be to identify the rationale 'the why' of these differences.

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From the Inside Out: A Literature Review on Possibilities of Mobile Emotion Measurement and Recognition

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Abstract Information systems are becoming increasingly intelligent and emotion artificial intelligence is an important component for the future. Therefore, the measurement and recognition of emotions is necessary and crucial. This paper presents a state of the art in the research field of mobile emotion measurement and recognition. The aim of this structured literature analysis using the PRISMA statement is to collect and classify the relevant literature and to provide an overview of the current status of mobile emotion recording and its future trends. A total of 59 articles were identified in the relevant literature databases, which can be divided into four main categories of emotion measurement. There was an increase of publications over the years in all four categories, but with a particularly strong increase in the areas of optical and vital-data-based recording. Over time, both the speed as well as the accuracy of the measurement has improved considerably in all four categories.

Keywords: • Emotion • Recognition • Measurement • Mobile • Digital Transformation •

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1 Introduction

The digital transformation has been on everyone's lips for quite some time. It shows itself as a technological and societally process of change and affects nearly every aspect of everyday life. At the core of this transformation lies the transition from analogue to digital, from offline channels to online channels and the change of the real world to a virtual one. Broadband Internet and the prevalence of mobile devices as well as new digital products and services are pushing the digital transformation forward. This digital transformation is also linked to create new values to improve the relationship with the user (Amit & Zott, 2001; Hagberg, Sundstrom, & Egels-Zandén, 2016). Smartphones and newer wearables in particular offer new service possibilities and trend to change the users' behaviour as they are able to access the Internet anytime and anywhere (Blázquez, 2014). Because intelligent mobile devices are equipped with many different sensors, capable of measuring the user's situation, they can provide better and more personalized digital advice in the form of user-specific and situational information (Härtfelder & Winkelmann, 2016; Rohm & Sultan, 2006).

Especially inner states like emotions can provide good insights into the user's situation and thus into their needs (Brave & Nass, 2003). The technological progress, the cost and size reduction of hardware and the further development of sensors offer more and more possibilities for situation-oriented applications (Yurur et al., 2016). By now, some devices are even able to measure biofeedback and draw conclusions about the user's emotional state (Bachmann et al., 2015; Likamwa, Liu, Lane, & Zhong, 2013; Muaremi, Arnrich, & Tröster, 2013). Emotions are very important for human beings as they influence many aspects of their everyday life (Brave & Nass, 2003; Picard & Klein, 2002). An emotion-aware information system (IS) may therefore be capable of enhancing the communication with the user while increasing the user experience (Hussain, Peter, & Bieber, 2009; Peter & Urban, 2012).

As society and user expectations change, the adaptation of IS becomes more crucial. For IS and its underlying services, it is essential not only to be able to analyse and interpret user input, but also to react emphatically to the user's emotions (Frijda, 1993; Peter & Urban, 2012). Gartner predicts that by 2022 10% of personal devices will have emotional artificial intelligence capabilities, either on-device or via cloud services, compared to less than 1% in 2018 (Gartner, 2018a).

2 Research Goal

Since emotions are triggered by situations, smart mobile devices allow to support the user in these situations (Cabanac, 2002; Geven, Tscheligi, & Noldus, 2009). The research field of mobile emotion measurement is currently difficult to oversee due to the lack of standards and the numerous possibilities of the measurement (Geven et al., 2009). To create an overview and to present a state of the art of the current research by finding suitable categories of emotion measurement as well as applications is the subject of this systematic literature research. The underlying research question of this paper is: "How can emotions be measured in a mobile way?".

Human emotions are reflected in the human body in many ways. Depending on the current emotional state, facial expressions, gestures, speech or the heartbeat change, mostly in combination with each other (Hussain et al., 2009).

These changes must first be objectively depicted with the help of technology and thus made visible to the computer (Weerasinghe, Ranaweera, Amarakeerthi, & Cohen, 2010). Since a conventional information system is not able to recognize feelings through facial expressions, gestures or bio signals, additional hardware in the form of smartphones, smartwatches or other sensor equipment as well as associated software is indispensable (Ahmed, Kenkeremath, & Stankovic, 2015). Accordingly, this literature review also aims to identify how and for which purpose knowledge about human emotions can be analysed using mobile devices. Particular attention should be paid to the fact that the measurement is possible ubiquitously and situation-based.

Furthermore, this research should give an overview of the evolution and current types of emotion detection (e.g. biofeedback, facial recognition) as well as of previous research results.

3 Theoretical Background

An emotion is a reaction of the human body to an occurring stimulus like an event of a certain importance. At the same time, emotions lead to high mental activity and can contain high degrees of pleasure or displeasure (Brave & Nass, 2003; Cabanac, 2002). Since emotions manifest in different ways, many researchers try to pinpoint what kind of emotions exist and how they can be categorized (Lövheim, 2012; Plutchik, 2001; Russell, 1980). Emotions are typical human characteristics and have an impact on many aspects of our life, as they influence perception, rational thinking und decision making (Brave & Nass, 2003; Cabanac, 2002; Hussain et al., 2009; Picard, 1995; Reeves & Nass, 1996).

Since humans tend to treat computers like other humans, emotions are also a field of interest in IS research, especially human-computer interactions (Brave & Nass, 2003; Picard, Vyzas, & Healey, 2001). The emotional situation of the user can also be responsible for whether and how he interacts with an IS or other people. An emotion-aware IS therefore may be capable of enhancing the communication and cooperation between human und IS (Hussain et al., 2009). This in turn can lead to a better und more fitting adaptation to the user's situation and to an increased user experience (Peter & Urban, 2012). Thus, it seems reasonable and necessary to enable an IS to perceive, correctly interpret and adequately respond to human emotions (Reeves & Nass, 1996). Since the introduction of the first mass-market smartphone in form of the iPhone by Apple in 2007, the market developed rapidly and an increasing number of people is carrying more and more sensors in their everyday life (Al-Nafjan, Hosny, Al-Ohali, & Al-Wabil, 2017). For the first time it is also possible to derive emotions in a mobile way without the usage of additional equipment. In recent years, further simplifications have been made through the invention of fitness bracelets and smartwatches. Measurement of heart rate, skin conductance as well as voice recording and their transmission to a smartphone are common functional components (Yang, Chang, Chen, Chiang, & Hung, 2014). In a mobile environment, smartphones and smartwatches with their various biometric sensors offer an unobtrusive way of emotion measurement (Bachmann et al., 2015; Likamwa et al., 2013; Muaremi et al., 2013).

The mobile measurement of emotions is captured by Gartner in their well-known Hype Cycle as "Emotion Detection/Recognition". This field of research has been part of the Gartner Hype Cycle for several years. Figure 1 shows the development of this research field in the Gartner Hype Cycle from 2013 to 2018 (e.g. Gartner, 2018b).

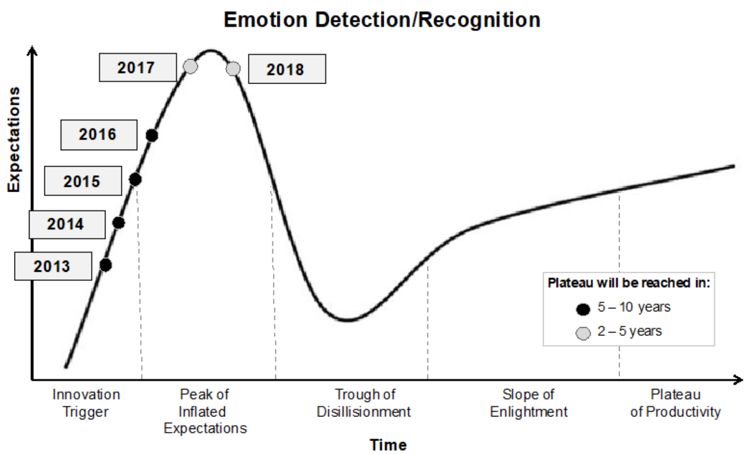

Figure 1: Evolution of "Emotion Detection/Recognition" in the Gartner Hype Cycle from 2013 to 2018

By the year 2018, it has just passed the peak of inflated expectations. According to Gartner, the productivity plateau will be reached in about two to five years. This evolution underlines the growing relevance of the topic, but it also reveals that it is not being used on the mass market yet. (Jannat, Tynes, Lime, Adorno, & Canavan, 2018). Currently, there are hardly any standards for emotion detection, recognition and application, which leads to proprietary developments in the form of in-house prototypes (Vinola & Vimaladevi, 2015). However, emotion measurement is the basis for the future-oriented field of emotional artificial intelligence or emotional AI.

4 Methodical Approach

The methodological approach of this structured literature review and analysis is based on the PRISMA statement by Moher et al. (2010). The research process for this paper is shown in Figure 3.

4.1 Literature Review

First of all, suitable search terms were created to identify the literature were created. The words emotion, measure and mobile form the root of the research question: "How can emotions be measured in a mobile way?". When developing the search query, however, attention was paid to both languages (English and German) and to synonyms of the words. Since the search via the German terms did only lead to one result in the final selection, the analysis using German terms will not be discussed further below. Finally, three categories with four search terms each, were created and Boolean operators were used to link the search terms. Thus, the three categories are linked by the AND operator. Within each category, the synonyms are linked with the OR operator (see Figure 2, left side). It should be noted that in category 2, verbs are mainly used, as they often include the noun (e.g. detect → detection, measure → measurement). Subsequently, the search query was applied to eleven different scientific databases (see Figure 2, right side).

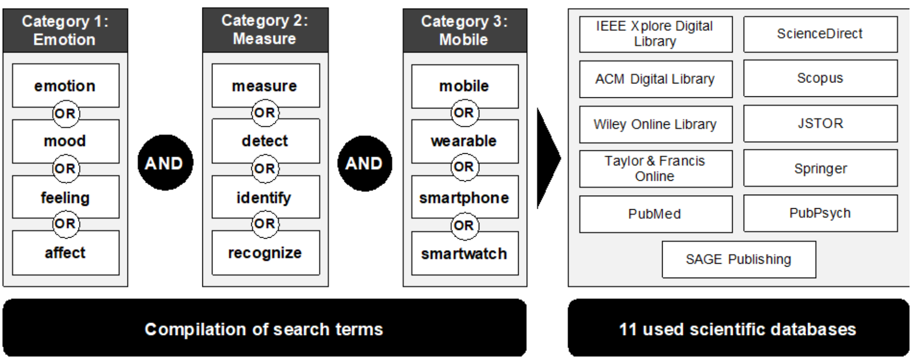

Figure 2: Categorization of search terms and used scientific databases

Since the search is carried out exclusively in the named scientific databases, the results are restricted to literature published in one of these databases. Due to the increasing relevance of the topic since the introduction of the first smartphone (iPhone) in 2007, the restriction begins with publication dates in 2007 and ends in 2018. In addition, the topics were restricted to IS-relevant areas like Internet of Things, Technology, Computer Science, Mobile Computing, Machine Learning. Besides, care has been taken to ensure that the literature was accessible at all time.

At the end of the identification phase, 5,356 entries were found in the scientific databases. However, 565 were deleted during the duplicate cleansing (see Figure 3).

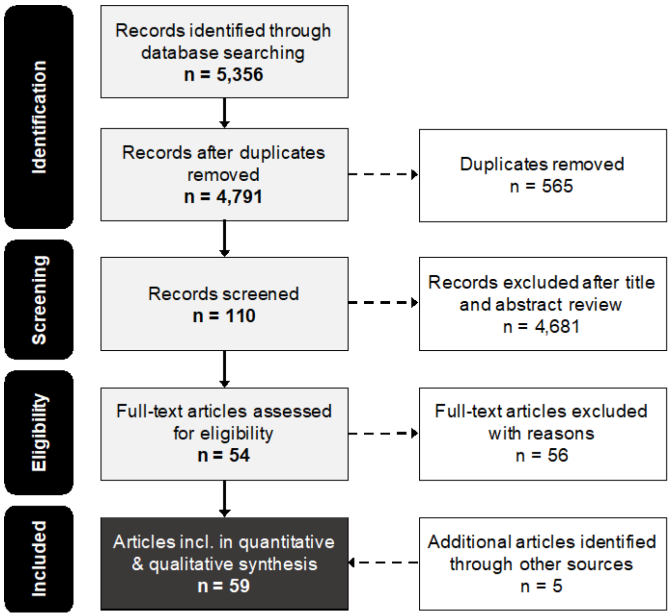

Figure 3: Process of literature selection for mobile measurement of emotions based on the PRISMA statement by Moher et al. (2010)

The literature selection comprises of two further steps. First, all titles and abstracts of the remaining literature were reviewed. Only the literature that dealt directly with the mobile measurement of emotions remained. All literature that did not contain at least two words from different keyword categories and despite previous restrictions fell into subject areas that cannot be used for this research was sorted out. The second step consisted of reading the full-text of the remaining 110 entries. This step also removed all entries that were not accessible as full text.

Finally, using a backward search, additional literature was found by reviewing the literature references of the selected 54 results. Care was taken to ensure that the additional literature also met the criteria mentioned above. Five additional entries were added during the backward search. Finally, 59 entries remained for the full-text analysis.

4.2 Structure of the Literature

The literature used for this paper was roughly structured in order to ensure clarity. For this purpose, the literature was divided into categories according to the various possibilities of emotion recognition. During the evaluation four essential categories were identified (see Figure 4). Optical emotion recognition analyses the user's facial expressions in order to derive his emotions from changes in the mimics. The acoustic emotion recognition concentrates on the voice and speech. In this way, tone, intensity, and tempo of voice are used for evaluation. The vital-data-based emotion recognition uses biofeedback (such as heart rate, skin temperature or skin conductance), which can be measured using different methods. Behavior-based emotion recognition is the recording of emotions using various behavior-related data (such as pedometer, location, light sensor, but also gesture recognition).

1. Optical emotion recognition (Face recognition) Quantity: 12	**2. Acoustic emotion recognition** (Speech recognition) Quantity: 13
3. Vital-data-based emotion recognition (Biofeedback recognition) Quantity: 24	**4. Behavior-based emotion recognition** (Gesture recognition) Quantity: 10

Figure 4: Main categories of identified literature

With the help of these categories it is possible to present and interpret the current state of research. This classification offers a further advantage with regard to the various possible areas of application, since different possible applications arise or disperse depending on the type of measurement. For example, optical recognition can hardly take place when the person being observed is in motion. In contrast, a measurement via biofeedback (vital-data-based) has no difficulties with such a field of application.

5 Evaluation

It is possible to measure emotions by evaluating optical, acoustic, vital-based or behavior-based information of a human. Due to the use of numerous definitions of the term emotion in the remaining literature, it was not possible to make further subdivision.

The definitions range from a simple division into pleasant and unpleasant to the use of complex emotion models like the Circumplex Model of Plutchik (Plutchik, 2001; Weerasinghe et al., 2010). For the purpose of the paper, emotion is defined as follows: An emotion is a pleasant or displeased reaction of the human body triggered by the conscious or unconscious perception of an event or situation (Brave & Nass, 2003; Cabanac, 2002).

5.1 Optical Emotion Recognition

Optical emotion recognition is based on the evaluation of existing image material (Al-Nafjan et al., 2017). For this, the facial expressions of the observed person must be recorded and interpreted. The measurement is often carried out either in a two- or three-dimensional way (Brand, Klompmaker, Schleining, & Weiß, 2012). Current research already tends towards a four-dimensional determination in which time is regarded as the fourth dimension (Kwak & Kim, 2018). These methods analyse facial features, such as eyes, nose and mouth as well as their position, distance and positioning to each other. Subsequently, different algorithms are used to derive emotions from these data.
For a better overview, the literature was further classified according to its research methods (see Table 1). A distinction is made between research in which an application is made available to a user, e.g. through a prototype, and studies which are set up without direct reference to a specific device.

Table 1: Optical Emotion Recognition / Research Method

Research Method	Literature	Number
Study	(Brand et al., 2012) (Kwak & Kim, 2018) (Jannat et al., 2018) (Canavan, Andujar, Yin, Nijholt, & Schotter, 2018) (W. Zhang et al., 2018) (Paleari, Benmokhtar, & Huet, 2009)	6
Application	(Hossain & Muhammad, 2017) (Masai et al., 2017) (Palaniswamy & Tripathi, 2018) (Gu et al., 2018) (Vinola & Vimaladevi, 2015)	6

The high number of studies clearly shows that optical emotion recognition has so far only been possible to a limited extent via mobile devices. Laboratory set-ups are often preferred due to the controllable environment and the computing power that is required. It is repeatedly pointed out that it is also possible to perform these experiments using a smartphone, but a detailed description or implementation is missing (Kwak & Kim, 2018). For a more in-depth analysis, the literature was also classified according to the type of data collection (see Table 2).

Table 2: Optical Emotion Recognition / Data Collection

Data Collection	Literature	Number
Local Binary Patterns	(Paleari et al., 2009) (Hossain & Muhammad, 2017) (L. Zhang, Mistry, Neoh, & Lim, 2016) (Masai et al., 2017)	4
Active shape model	(Palaniswamy & Tripathi, 2018)	1
Convolutional Neural Network	(Jannat et al., 2018) (Kwak & Kim, 2018) (W. Zhang et al., 2018) (Gu et al., 2018)	4
Unclassifiable	(Brand et al., 2012) (Vinola & Vimaladevi, 2015) (Canavan et al., 2018)	3

A large part of the research uses Local Binary Patterns (LBP) as a visual descriptor for image processing. This is already accepted as a standard after its introduction in 1994. Current research from 2018 additionally uses

Convolutional Neural Networks (CNN), which are based on LBP, to achieve better results (Gu et al., 2018). According to Kumar et al. (2017), LBP alone currently has the greatest benefit in relation to effort, with very good results.

Over the years, an increasing improvement in the accuracy and speed of emotion measurement is noticeable. While the accuracy of the research of Paleari et al. (2009) was still below 50 percent in 2009, the accuracy of current research has already risen to over 90 percent (Hossain & Muhammad, 2017; Masai, Itoh, Sugiura, & Sugimoto, 2016). Some measurement is already carried out in real time using smartphones. This supports the trend away from laboratory set-ups, as in 2009 (Paleari et al., 2009), towards the mobile measurement of emotions using smartphones in a mobile environment (Vinola & Vimaladevi, 2015).

5.2 Acoustic Emotion Recognition

Acoustic emotion recognition does not examine speech and words in the true sense, but rather parameters such as tone of the voice, intensity and tempo (Brand et al., 2012). The description of the production of an acoustic signal and the identification of emotions from these signals are not uniform, so that different approaches can be pursued (Park & Jang, 2015).

The selected literature for acoustic emotion recognition is structured by the research method (see Table 3). Many applications use microphones and processors, which could also be integrated into today's smartphones (Yoon, Cho, & Park, 2007).

Most of the studies use very short frames (length approx. 20ms), sometimes up to one minute, to measure emotions (Salekin et al., 2017; Yoon et al., 2007). Due to the high number of frames, high computing power is required. Instead, the applications typically use a longer frame of 5-15 seconds. These frames are further simulated linearly to reduce the computing power and thus make mobile measurement possible using common smartphones. One reason for the high number of existing applications is the increasing number and improving performance of virtual respectively speech assistants (Hossain & Nazin, 2018).

Table 3: Acoustic Emotion Recognition / Research Method

Research Method	Literature	Number
Study	(Vinola & Vimaladevi, 2015) (Yoon et al., 2007) (Salekin et al., 2017) (Ahmed, Chen, Fass, & Stankovic, 2017) (Jannat et al., 2018)	5
Application	(Weerasinghe et al., 2010) (W. Zhang et al., 2018) (Park & Jang, 2015) (Hossain & Nazin, 2018) (Rachuri et al., 2010) (Ahmed et al., 2015) (Gu et al., 2018) (Ma et al., 2018)	8

By classifying the literature according to the type of data collection, it is possible to analyse a temporal progression (see Table 4). While at the beginning of the observation period the characteristics of prosody (accent, intonation, frequency, etc.) were used (2007-2010), the Mel Frequency Cepstrum Coefficients (MFCC) have established themselves as the standard nowadays. In addition, research from 2018 also relies on neural networks (Canavan et al., 2018) or a novel method of micro-prosody, whereby only the frequency of the voice is used for emotion recognition. This should enable a reduction in the amount of data while maintaining the same accuracy (Hossain & Nazin, 2018). Hossain et al. (2018) give detailed descriptions of the functionalities and a comparison of the methods. In comparison, micro-prosody achieves the highest accuracy. In addition to the new features mentioned above, better filtering of background noise offers the possibility to detect emotions over greater distances. The microphone no longer has to be worn directly on the body. This also makes it possible to measure the emotions of several people within a room if they clearly differ in their vocal pitch (Hossain & Nazin, 2018; Salekin et al., 2017). Over time, more and more research is linking optical and acoustic emotion measurement to increase the accuracy of measurement (Vinola & Vimaladevi, 2015; W. Zhang et al., 2018). This measurement is most similar to human perception, in which many different parameters are combined to an overall impression of the emotional state. In addition, more emotions can be distinguished from each other as the distinguishing features become sharper (Brand et al., 2012; Peter & Urban, 2012).

Table 4: Acoustic Emotion Recognition / Data Collection

Data Collection	Literature	Number
Prosody	(Yoon et al., 2007) (Rachuri et al., 2010) (Weerasinghe et al., 2010)	3
MFCC	(Paleari et al., 2009) (Park & Jang, 2015) (Ahmed et al., 2015) (Salekin et al., 2017) (Ahmed et al., 2017) (W. Zhang et al., 2018) (Gu et al., 2018)	7
Micro-prosody	(Hossain & Nazin, 2018)	1
Convolutional neural network	(Ma et al., 2018) (Canavan et al., 2018)	2

5.3 Vital-data-based Emotion Recognition

The category of vital-data-based emotion measurement differs from the two preceding categories essentially as emotion recognition is not possible by simple observation. Here, direct contact between the person and the device or sensor is required (Brand et al., 2012). An advantage at this point is an inconspicuous measurement of the data (e.g. by a smartwatch) which can increase the comfort of the user (Di Lascio, Gashi, & Santini, 2018). Research in this field has been going on for a long time, as it is particularly relevant in the medical field (Geven et al., 2009). Furthermore, there is a direct correlation between biofeedback and a person's emotion (Haag, Goronzy, Schaich, & Williams, 2004). The subdivision of the literature according to the research method shows, as it was already the case with optical or acoustic emotion recognition, that laboratory set-ups are still used frequently (see Table 5). This is particularly due to the increased use in the medical field (Brand et al., 2012). Patients are not treated in their everyday environment, but in rooms that have been prepared for this purpose (Geven et al., 2009).

Table 5: Vital-data-based Emotion Recognition / Research Method

Research Method	Literature	Number
Study	(Leng, Lin, & Zanzi, 2007) (Geven et al., 2009) (Montgomery, 2010) (Perttula, Koivisto, Mäkelä, Suominen, & Multisilta, 2011) (Brand et al., 2012) (Guo et al., 2013) (Vinola & Vimaladevi, 2015) (Exler, Schankin, Klebsattel, & Beigl, 2016) (J. Zhang et al., 2016) (Subramanian et al., 2018) (Mehrotra & Musolesi, 2017) (Al-Nafjan et al., 2017) (Udovičić, Đerek, Russo, & Sikora, 2017) (F. Li et al., 2018)	14
Application	(Gluhak, Presser, Zhu, Esfandiyari, & Kupschick, 2007) (Hussain et al., 2009) (S. Li et al., 2014) (Huynh, Balan, & Lee, 2015) (Carrillo, Meza-Kubo, Morán, Galindo, & García-Canseco, 2015) (Yoon, Sim, & Cho, 2016) (Yasufuku, Terada, & Tsukamoto, 2016) (Zhao, Adib, & Katabi, 2016) (Lam & Szypula, 2018) (Di Lascio et al., 2018)	10

A list of the most frequently used biofeedback (such as skin conductance and heart rate) and their explanation can be found in Haag et al. (2004). A deeper subdivision of the vital-data-based emotion recognition can be made on the basis of the type of biofeedback that is used (see Table 6). In this way, a wide variety of application areas can be distinguished with regard to the sensors or wearables used. When using a smartwatch, the measurement is often limited to heart rate or skin conductance, while specially developed gadgets, such as the glove of the Fraunhofer Institute, record additional vital data like skin temperature (Hussain et al., 2009). Less mobile, but still frequently used, are measurements of brain waves.

Table 6: Vital-data-based Emotion Recognition / Data Collection

Data Collection	Literature	Number
Skin conductance /Skin temperature	(Lam & Szypula, 2018) (Yasufuku et al., 2016) (Huynh et al., 2015) (S. Li et al., 2014) (Guo et al., 2013) (Udovičić et al., 2017)	6
Heart rate	(Exler et al., 2016) (Bachmann et al., 2015) (Zhao et al., 2016) (F. Li et al., 2018)	4
Brain Waves	(J. Zhang et al., 2016) (Al-Nafjan et al., 2017) (Perttula et al., 2011) (Subramanian et al., 2018)	4
Combination	(Yoon et al., 2016) (Vinola & Vimaladevi, 2015) (Leng et al., 2007) (Brand et al., 2012) (Montgomery, 2010) (Geven et al., 2009) (Hussain et al., 2009) (Carrillo et al., 2015) (Gluhak et al., 2007) (Di Lascio et al., 2018)	10

In current research, the increasingly used smartwatches are rarely considered. Only two researches (Bachmann et al., 2015; Exler et al., 2016) use smartwatches for recording. In contrast, there are various in-house developments (Lam & Szypula, 2018; Yasufuku et al., 2016; Yoon et al., 2016) which are connected to a smartphone and are therefore not yet suitable for everyday use. Frequently, these still refer to a medical context and are intended for the preventive identification of dangers to mental and physical health (Yoon et al., 2016). It is assumed that with further technical development of smartwatches a similar performance in emotion recognition will be possible (Huynh et al., 2015; Lam & Szypula, 2018; S. Li et al., 2014). Zhao et al. (2016) show a unique selling point through the contactless measurement of biofeedback. This is done by acoustic resonances from the breathing sounds of humans, which are used to draw conclusions about the heart rate (Zhao et al., 2016).

5.4 Behavior-based Emotion Recognition

Behavioral emotion recognition is a less specific category for the identification of emotions. Here, a combination of several different data sources, which can be picked up by a mobile device, is used to determine emotions (Zhang, Li, Chen, & Lu, 2018). Emotion recognition can be performed by the input behavior of smartphone users (S. Ghosh, Ganguly, Mitra, & De, 2017; Likamwa et al., 2013), the recognition of gestures (Lee, Bae, Lee, & Kim, 2017) as well as by the combination of location, pedometer, smartphone usage and light sensor (Zhang et al., 2018). In the area of behavior-based emotion recognition, no clear trend can be identified with reference to the research method (see Table 7).

Table 7: Behavior-based Emotion Recognition / Research Method

Research Method	Literature	Number
Study	(Tsetserukou & Neviarouskaya, 2010) (Brand et al., 2012) (Yang et al., 2014) (Lee et al., 2017) (Kanjo, Younis, & Ang, 2019)	5
Application	(Coutrix & Mandran, 2012) (Likamwa et al., 2013) (Bachmann et al., 2015) (Surjya Ghosh, Chauhan, Ganguly, Mitra, & De, 2015) (Zhang et al., 2018)	5

Research is still in its infancy and no standard has been established (Kanjo et al., 2019). The studies mainly focus on the analysis of data, while the applications also deal with the integration of analysis methods into everyday life (Zhang et al., 2018).

The further structuring takes place under the mentioned possibilities of emotion recognition, whereby the recognition of gestures and the input behavior are summarized under the point of gesture recognition (see Table 8).

Table 8: Behavior-based Emotion Recognition / Data Collection

Data Collection	Literature	Number
Gesture recognition	(Brand et al., 2012) (Lee et al., 2017) (Likamwa et al., 2013) (Surjya Ghosh et al., 2015) (Coutrix & Mandran, 2012) (Yang et al., 2014) (Tsetserukou & Neviarouskaya, 2010)	7
GPS, light sensors, pedometers, smartphone use, etc.	(Kanjo et al., 2019) (Mehrotra & Musolesi, 2017) (Zhang et al., 2018)	3

The development over time shows a trend towards the use of more and more available data and the bundling of this data to measure emotions (big data analysis). The research by Coutrix & Mandran (2012) and Likamwa et al. (2013) use gesture recognition based on smartphone movement or typing behavior. Recent research tends to use data from as many available sensors as possible. For example X. Zhang et al. (2018) use data from light sensors, GPS, pedometers, smartphone use, as well as audio- and WiFi-usage. The challenge now is to develop a suitable algorithm that can unite the available data in order to identify emotions (Lee et al., 2017).

5.5 Temporal Development of Emotion Measurement

Figure 5 shows the development of the four categories of emotion recognition over time as well as the percentage distribution of all publications. The figure presents the identified literature in the form of four time intervals. There has been a significant increase in the number of scientific articles over the time period considered.

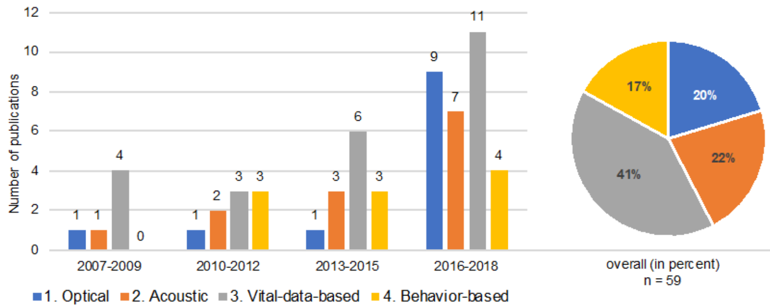

Figure 5: Development of publications over time in the four categories

The lack of literature in the area of behavior-based emotion recognition in the period from 2007 to 2009 shows up as conspicuous. Since very much information is required to analyse behavioral data (Zhang et al., 2018), one possible reason for this lack of literature could lie in the limited technological possibilities in gathering relevant data. With the increasing collection possibilities of data in the last years, this area is growing, but not yet particularly strong.

The development of optical and acoustic emotion recognition, is derived from the areas of speech recognition (e.g. speech assistants) and face recognition (e.g. Face-ID), which are already integrated into a lot of products on the market (W. Zhang et al., 2018). As mentioned before, attempts are being made to combine optical and acoustic emotion recognition (see Chapter 5.2).

Vital-data-based emotion recognition represents the largest share of research over the entire time period (41%). This increase can be explained by the growing implementation of sensors in smartphones and smartwatches (Di Lascio et al., 2018). Due to its suitability for everyday use, this type of emotion recording will presumably be given the highest priority in the future.

6 Conclusions and Outlook

The increasing degree of digitization and the constantly growing technological progress lead to changes in the society and everyday life. Especially smartphones and recently smartwatches offer new possibilities and trend to change the user's behaviour. The user is now able to access the internet anytime and anywhere (Blazquez, 2014). As the demands of every single person on IS are becoming more specific and individual, smart mobile devices offer capabilities for a better and more personalized digital advisory. One way to understand the situation of a human and to offer a situation-aware service is to measure and analyse his emotions.

Consequently, the focus of this systematic literature review was to collect and analyse current possibilities of mobile emotion measurement in IS research. The selection and evaluation of the literature was based on the PRISMA statement by Moher et al. (2010). Eleven databases served as sources for literature analysis to ensure a systematic approach. In this search, the three search term categories emotion, measure and mobile were used.

A total of 59 articles were identified (see Chapter 4), which can be divided into the four main categories of optical, acoustic, vital-data-based and behavior-based emotion recognition and further classified into subgroups (see Chapter 5). The analysis provides a good overview of the areas already researched and suggests future trends. It clearly shows that the relevance of this topic has grown continuously over time. It is noticeable that the speed as well as the accuracy of the emotion measurement has improved considerably. Current studies show an accuracy of at least 90% in all categories and it rises continuously. 10 years ago, the accuracy in some areas was still between 50% and 60%. Accordingly, many researchers are working on mobile emotion measurement in order to facilitate it in our everyday lives. At present, a large number of self-developed sensors are not yet able to be integrated into our mobile daily drivers, like smartphones or smartwatches. This will certainly change in the coming years with an even more digitalised life. The measurement of biofeedback is already most frequently represented at the beginning of the observation period. Due to the increased use of sensors in mobile devices, this method has the greatest potential for the future, since the unobtrusive measurement offers a comparatively large advantage. A major challenge is to transmit the acquired data to useful software, which can deliver a special value to the user. Since emotions can provide good insights into the user's specific situation and thus their needs (Brave & Nass, 2003), there are numerous application areas for the mobile emotion's measurement and usage. With virtual assistants and emotional AI as big future trends, upcoming systems and services should be emphatic (Gartner, 2018a). The big question is whether the society is prepared to reveal this personal data and whether a machine or system should be able to recognize every personal emotion.

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Designing a Comprehensive Understanding of Digital Transformation and its Impact

ZIBOUD VAN VELDHOVEN & JAN VANTHIENEN

Abstract Many researchers, managers, and companies are currently dealing with digital transformation. Yet, there exists a research gap on the exact meaning and scope of this transformation. In this paper, an in-depth literature study was performed and synthesized to inductively construct a conceptual framework that reconciles the distinct definitions and aspects of digital transformation. From the framework, we derived a novel and comprehensive definition of digital transformation which was validated against the literature and shown to be exhaustive. Furthermore, our definition explicitly explains why digital transformation is happening and accelerating. Researchers and practitioners can use the framework to position their work and to gain a better understanding of its wide scope and impacts. This work can be among the first steps towards a unified understanding of digital transformation.

Keywords: • Digital transformation • Definition • Business Transformation • Digitalization • Digital Transformation Framework •

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1 Introduction

In recent years, the increasing use of digital technologies has had a major impact on many aspects of our civilization. This rapid change is frequently called digital transformation (DT). Academic research on DT has mainly focused on two aspects. First, a significant body of research exists on the different impacts and changes DT has on society and business. Secondly, many papers provide guidelines, models, and lessons for companies to aid with their transformation. Despite the sheer amount of research, there is still no clear, well-agreed upon definition for DT (Goerzig & Bauernhansl, 2018; Haffke, Kalgovas, & Benlian, 2016). There exist significant semantic differences in the terminology used and several authors have suggested delimiting the various definitions (Morakanyane, Grace, & O'Reilly, 2017; Vial, 2019). Furthermore, this vagueness in understanding demonstrates the lack of a coherent theoretical frame that reconciles all aspects of DT (Henriette, Feki, & Boughzala, 2015).

This study seeks to address these research gaps by organizing the extant literature around a theoretical framework and by proposing a novel, and exhaustive definition. For that reason, three research questions are formulated:

- How is DT defined in the existing literature?
- How can the various aspects of DT be organized around an integrative framework?
- How can DT be defined in a comprehensive way?

To do so, this paper performs and synthesizes an in-depth terminology study to inductively develop a framework and definition of DT. The results of this study provide new insights into the nature of DT and can aid researchers and practitioners with framing their work. This work further highlights new research avenues and can be among the first steps towards a unified definition of DT.

The paper proceeds as follows: the next section discusses the methodology. In section 3, we give an overview of the literature study and analysis which are used in the next section as the basis for the construction of the DT framework. The framework is then used to introduce a sound and comprehensive definition of DT in section 5. The next section validates our work against the literature before giving the conclusion and future work in section 7.

2 Methodology

In line with the research questions, an inductive approach was conducted wherein observations from the literature, i.e. DT definitions, were analyzed for patterns which were used to develop a conceptual framework. This methodology is commonly used to build a construct of a phenomenon (Lodico, Spaulding, & Voegtle, 2010; Vial, 2019). First, we performed an in-depth terminology study in search of DT definitions. We started by reviewing the top results for 'digital transformation' in two databases (Scopus and Google Scholar) and extended this through a backward and forward search up to 115 articles. The articles include conference and journal papers but also highly cited professional papers, e.g. industrial reports, since we are interested in both sides. The papers were analyzed and their definitions, in total 13, were extracted. Then, the results were compared and completed with the findings of previous systematic DT literature reviews (Morakanyane et al., 2017; Vial, 2019) which resulted in a total of 17 unique definitions. Only original definitions, which do not paraphrase others, were kept. Secondly, we decomposed the definitions into frequent key components to identify the essential aspects of DT. Thirdly, we developed a DT framework which reconciles all the key components and from it, a novel and exhaustive DT definition was derived. Lastly, the definition and framework were validated against the existing definitions in the literature by positioning them on the framework.

3 Conceptual Groundwork

The terminology study resulted in 17 different DT definitions, as summarized in Table 1. A striking observation is the wide scope range: from using technology to improve the performance of a company (Westerman et al., 2011) to the changes in all aspects of people's life (Stolterman & Fors, 2004). This seems to confirm the lack of a universal definition.

Table 1: Definitions of Digital Transformation

#	Year	Authors	Definition of Digital Transformation
[1]	2004	Stolterman & Fors	'Changes that the digital technology causes or influences in all aspects of human life'
[2]	2011	Liu et al.	'Organizational transformation that integrates digital technologies and business processes in a digital economy'
[3]	2011	Westerman et al.	'Use of technology to radially improve the performance or reach of enterprises'
[4]	2012	White	'Arises from the blending of personal and corporate IT environments'
[5]	2013	Fitzgerald et al.	'The use of new digital technologies (social media, mobile, analytics or embedded devices) to enable major business improvements (such as enhancing customer experience, streamlining operations or creating new business models)'
[6]	2015	Schuchmann & Seufert	'The realignment of technology and new business models to more effectively engage digital customers at every touchpoint in the experience lifecycle'
[7]	2015	Solis	'The realignment of, or new investment in, technology, business models, and processes to more effectively compete in an ever-changing digital economy'
[8]	2016	Berghaus & Back	'Technology-induced change on many levels in the organization that includes both the exploitation of digital technologies to improve existing processes, and the exploration of digital innovation, which can potentially transform the business model'
[9]	2016	Demirkan, Spohrer & Welser	'The profound and accelerating transformation of business activities, processes, competencies, and models to fully leverage the changes and opportunities brought by digital technologies

			and their impact across society in a strategic and prioritized way'
[10]	2016	Hess et al.	'The changes digital technologies can bring about in a company's business model, which result in changed products or organizational structures or in the automation of processes'
[11]	2017	Morakanyane et al.	'An evolutionary process that leverages digital capabilities and technologies to enable business models, operational processes and customer experiences to create value'
[12]	2017	Reddy & Reinartz	'In traditional sense, digital transformation refers to the use of computer and internet technology for a more efficient and effective economic value creation process. In a broader sense, it refers to the changes that new technology has on the whole; on how we operate, interact, and configure, and how wealth in created within this system'
[13]	2017	Parviainen et al.	'Changes in ways of working, roles, and business offering caused by adoption of digital technologies in an organization, or in the operation environment of the organization. This refers to changes at process, organization, business domain and society level'
[14]	2018	Ebert & Duarte	'Technology-driven continuous change process of companies and our entire society'
[15]	2018	Goerzig & Bauernhansl	'A fundamental change process in enterprises initiated by new competitive advantages through the evolution of IT into an essential part of the value creation'
[16]	2018	Hinings et al.	'The combined effects of several digital innovations bringing about novel actors, structures, practices, values and beliefs that change, threaten, replace or complement existing rules of the game within organizations, ecosystems, industries or fields'

[17]	2019	Vial	'A process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies'

By analyzing the DT definitions, it is possible to decompose them into the most frequent (f) key components: *use of digital technologies (f:17), new business models (f:9), internal operations (f:8), customer experience (f:4), society transformation (f:4), change process (f:4), organizational transformation (f:3), digital innovation (f:3), digital economy (f:3), organizational transformation (f:3), value creation (f:2), and products and services (f:2).*

4 Constructing the Digital Transformation Framework

To reconcile the various characteristics of DT, all the key components above are organized around a conceptual framework, illustrated in Figure 1. The framework summarizes the key components and the DT literature in three axes, their segments, and the interactions between the axes. The axes represent the three transformations that can be extracted from the components: business transformation (*internal operations, products and services, organizational transformation, and new business models*), digital technologies transformation (*digital innovation*), and society transformation (*society transformation*).

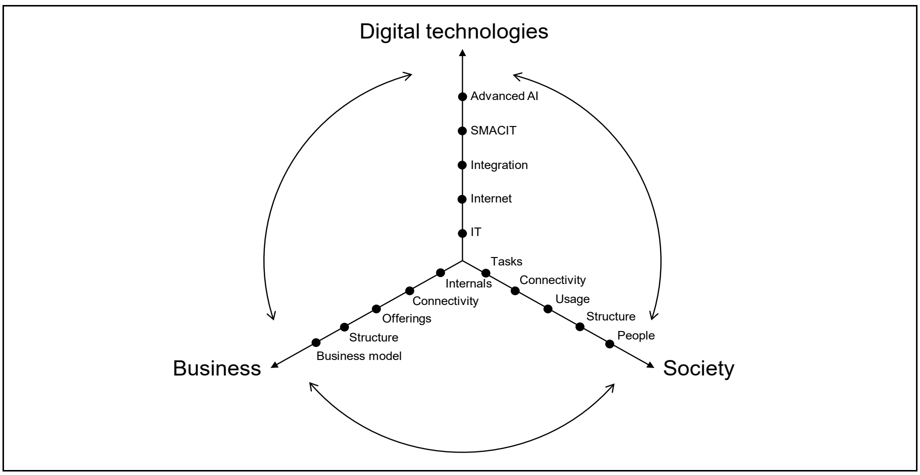

Figure 1: The Digital Transformation Framework

Digital technologies transformation, i.e. *digital innovation*, is represented by the vertical axis in Figure 1. Many digital technologies that are steering DT can be accredited, of which five important waves in the past 50 years are mentioned chronologically (Carter, 2018; Porter & Heppelmann, 2014; Singh & Hess, 2017). While the last wave, advanced artificial intelligence (AI), is still in its early stages, it is included because many businesses see it as a potential technology for DT in the near future (Carter, 2018; HM Government, 2017).

- IT: automation of isolated activities, and problem calculations
- Internet: inexpensive, ubiquitous connectivity and information sharing
- Integration: more affordable, widespread computing power and possibilities
- SMACIT: social media, mobile, analytics, cloud computing, and Internet of Things
- Advanced AI: tasks that normally require human intelligence

Business transformation, the left axis, can be understood as the changes in organizations to bring about significant performance improvements or *value creation* (McKeown & Philip, 2003). A growing number of aspects of the business are changing, which we summarize in 5 categories inspired by the keywords and related work (Kane et al., 2017; Venkatraman, 1994; Wade, 2015). The categories are ranked chronologically, as these aspects frequently change in this order (Morgan & Page, 2008; Venkatraman, 1994).

- Internals: changes in *internal operations*, technology, and labor
- Connectivity: changes in the connection between processes, businesses, and entities
- Offerings: new or enhanced *products and services*
- Structure: changes in the structure, roles, and culture, i.e. *organizational transformation*
- *Business model*: changes in business scope, management, and strategy

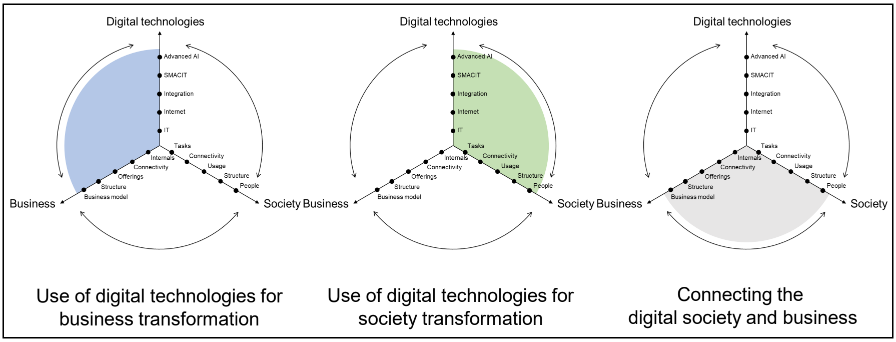

Figure 2: The Segments of the Digital Transformation Framework

In the scope of DT, the business changes are brought by the increased exploitation and *use of digital technologies* (Venkatraman, 1994; Wade, 2015), as represented by the left segment in the DT framework (see Figure 2). The simple use of new technologies for the same way of working in these aspects is not enough; businesses must transform their approaches in these aspects (Earley, 2014). Ideally, the companies should aim to integrate the digital technologies to change all aspects, and eventually the business model itself (Kane et al., 2017). This means that each aspect of the business should be optimized given the current digital technologies.

It is important to note that these aspects do not always change in this order. For example, a company can be digitalizing its business model while maintaining its old structure. Furthermore, the change process above can reiterate for every new digital technology wave. Hence, it is a process in which various business aspects can change subsequently and simultaneously with different digital technologies.

Society Transformation is represented by the right axis and can be understood as the changes happening in people, customers, and societies over time. In the context of DT, it is about the changes happening due to the increased *use of digital technologies*, as represented by the right segment in the DT framework (see Figure 2). People are becoming increasingly digitalized because they adopt digital technologies in every aspect of their lives. This affects their acceptance of digital trends, their identity, their notion of privacy, their work, the way they communicate, and the way they live (Hanelt et al., 2015; Schwab, 2015). As customers, their consumption patterns, notion of ownership, demands, and product knowledge have changed intensively (Berman, 2012; Schuchmann & Seufert, 2015; Schwab, 2015). As an aggregated effect, this also happens with the entire society (Ebert & Duarte, 2018). In brief, these changes can be summarized in five categories. Similarly to the business changes above, we argue that these changes usually happen in this order but do not have to. Likewise, these changes can happen subsequently and simultaneously with different technologies.

- Tasks: changes in isolated tasks and activities
- Connectivity: changes in communication, informedness, and network
- Usage: changes in products and services used in daily life
- Structure: changes in work-life balance, habits, and routines
- People: changes in people's values, notion of ownership, identity, and way of living

The connection between society and business, and the *customer experience* are changing too, represented by the bottom segment of the DT framework (see Figure 2). The digital businesses are increasingly being connected to the digital society through the linking of the private and corporate IT (Parviainen et al., 2017), or the co-creation of value between digital customers and digital businesses (Gray et al., 2013). This includes digital interactions, distribution (Lanzolla & Anderson, 2008), cooperation, information sharing and co-specialized investments (Katsamakas, 2014). Several important digital players have profited from this digital connection such as Airbnb, Uber, and eBay.

Lastly, the changes that happen along the three axes cannot be considered as a single event or one-time exercise. Instead, it is a continuous *change process* fueled by digital innovations and breakthroughs (Krell & Gale, 2005; Parviainen et al., 2017) in which the different transformations become increasingly connected. Several authors refer to this interconnected state as the *digital economy* (Hinings et al., 2018; Liu et al., 2011; Solis, 2015).

5 What is Digital Transformation?

5.1 Introducing a Novel Definition

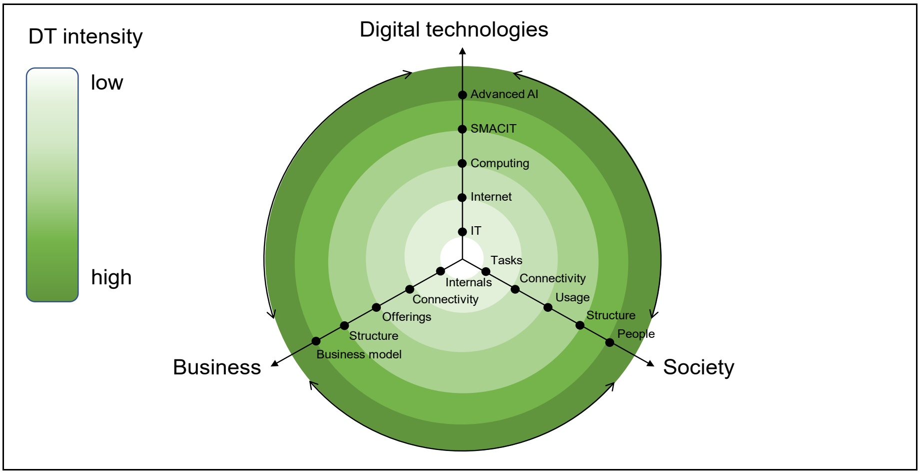

Figure 3: The Digital Transformation Process

We argue that DT concerns the entirety of the changes above. Thus, it can be understood as the circular motion towards the outer edges of the DT framework in which digital technologies iteratively bring forward more changes in business, society, and their connections, shown in Figure 3. We expand this idea, by arguing that DT is happening and steered by the increased interactions between these developments, illustrated by the two-headed arrows between the axes in the framework. This makes the different transformations intertwined which dramatically increases the DT's velocity (Bharadwaj et al., 2013; Demirkan et al., 2016), scope and impact. Thus, the following DT definition is proposed:

> *Digital transformation is the continuously increasing interaction between digital technologies, business, and society, which has transformational effects and increases the change process's velocity, scope, and impact.*

5.2 The Interactions

Between digital technologies and business. New digital technologies or innovation pressure businesses into digitally transforming due to the risk of competitors gaining a competitive edge by adopting those technologies (Bharadwaj, 2000; von Leipzig et al., 2017). This vulnerability has also been referred to as digital Darwinism: only the most responsive enterprises to digital innovation survive (Schwartz, 2002; Solis, 2015). In turn, this threat leads businesses to adopt a more risk-promoting culture and structure to become more agile and innovative (Kane et al., 2015), which can be the key to future success (Christensen, Raynor, & McDonald, 2015). This cohesion between digital innovation and business is becoming increasingly imperative such that a digital strategy, which consolidates both strategies (Sebastian et al., 2017), and new executives functions such as Chief Digital Officers (CDOs) are often introduced (Singh & Hess, 2017).

Vice versa, businesses influence digital technologies by imposing quality standards, adopting certain technologies, and demanding specific solutions (Baden-Fuller & Haefliger, 2013). The government can also play a significant role in this relation: it can decide what practice is appropriate for digital disruptors, the time lag between innovation and policy legitimation, and can influence the standard-setting through its purchasing power (Hinings et al., 2018).

Between digital technologies and society. Digital technologies influence society into digitally transforming by offering improvements, exciting products, and convenient services in daily life. Vice versa, society can influence the digital innovation by its adaption of certain digital technologies, its purchase behavior, and its demands (Baden-Fuller & Haefliger, 2013; Risselada, Verhoef, & Bijmolt, 2013).

Between business and society. Digitalized businesses foster the DT of societies by offering more services, convenience, and benefits to their digital customers. For example, many transport companies offer small discounts for ordering tickets with their app versus from the kiosk. This nurtures customers to adopt this digital service, who in turn put more pressure on the companies that do not yet offer this service. Digitalized businesses also impact the job market, such as the creation of the digital skills job gap (Westerman & McAfee, 2012), the rising number of jobs that can be replaced by machines (Guest, 2014), and changes in the type of work (Parviainen et al., 2017).

In turn, the digitalized society heavily influences businesses. First, customers demand the same digital convenience they experience in their private lives when interacting with businesses. Hence, businesses must deliver convenient digital interactions at every touchpoint in the customers experience lifecycle (Schuchmann & Seufert, 2015). Secondly, digitalization influences customers' behavior: customers are less loyal, more informed, tolerate fewer errors and form higher expectations (Henriette et al., 2015; Horlach, Drews, & Schirmer, 2016). Thirdly, not only the customers but employees become more demanding about their working conditions (Solis, 2015; Westerman et al., 2011).

5.3 Example of DT Interactions

As an example of how these interactions steer DT, the history of Netflix is modeled on the framework in Figure 4. Netflix started as an online DVD rental/delivery company. When internet technologies that allowed for streaming of videos were adopted by customers (1), Netflix was influenced to digitalize some of their products (2) and opened its streaming service (3). In turn, this fostered the digital service acceptance of society (4), and due to the success, Netflix started transforming its organizational structure (5) to focus on streaming services and by confining the DVD rentals. In a similar fashion started the shift towards mobile (6, 7, 8 and 9). Now, Netflix's business model is online-streaming only (10). This fostered the acceptance of digital business models in society (11). Consequently, this caused pressure on other media companies to digitalize their business models (12), for example, the streaming services boom we witness today (McDonald & Smith-Rowsey, 2016).

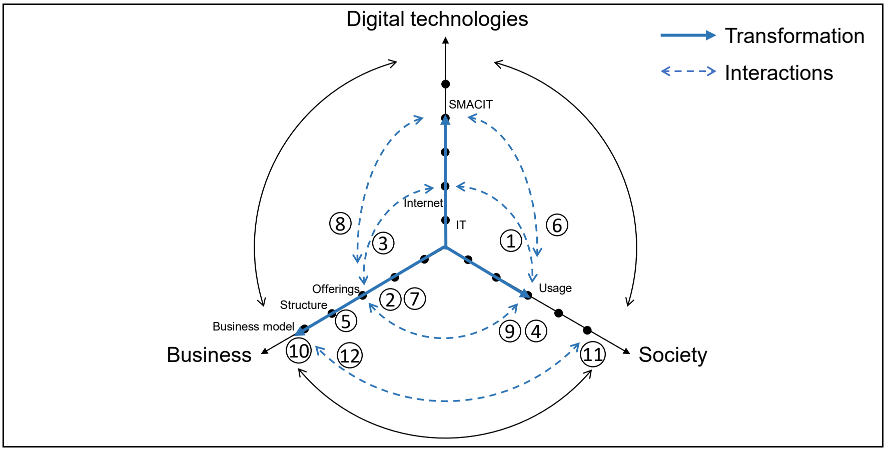

Figure 4: Netflix Case Example

5.4 Related Terminology in the Literature

Prior research has argued that DT is characteristically different from previous IT-enabled transformations due to its larger external impact (Ismail, Khater, & Zaki, 2017), its digital interactions and distributions (Lanzolla & Giudici, 2017), the network competition (Katsamakas, 2014) and more. Other authors, such as Vial (2019) argue that DT is an evolution of IT-enabled transformation. The DT framework provides a comprehensive answer to this problem, as the inner circles can be understood as what was previously called IT-enabled transformation and the outer circles of what several authors limit their definition of DT to. Thus, the DT framework explains both terms as part of the DT process but with different scopes.

In light of the increased literature that highlights the importance of being customer focused when embarking DT in businesses (Berman, 2012; von Leipzig et al., 2017; Weill & Woerner, 2015) and the rise of peer collaborative companies, e.g. Booking, it is argued that digital business transformation concerns the exploitation of both the opportunities brought forward by digital technologies, and by the digital society. In a similar fashion, the digital society transformation considers the use of digital technologies for changes in society and the changes in their relationship with businesses. Finally, the digital technologies innovation includes the increased use in business and society, and their respective reversed influence, as illustrated in Figure 5.

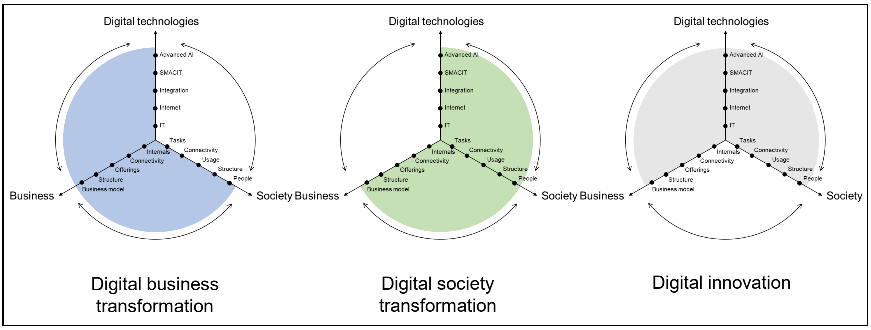

Figure 5: The Digital Transformation of Business, Society, and Technology

6 Validation of the Digital Transformation Framework

It is possible to validate the DT framework and definition against the definitions found in the literature by positioning these on the framework, as shown in Figure 6, Figure 7 and Figure 8. The definitions are placed on the DT framework as circular segments to indicate their scope. Three different figures and several distinct colors were used solely for clarity purposes. The spherical segments overlap such that the outer segment also includes the inner segments; for example, definition 2 extends definition 3. It is worth noting that all definitions could be placed on the DT framework, and their ensemble takes the form of the framework, which lends some validity that the framework and definition are consistent with the literature.

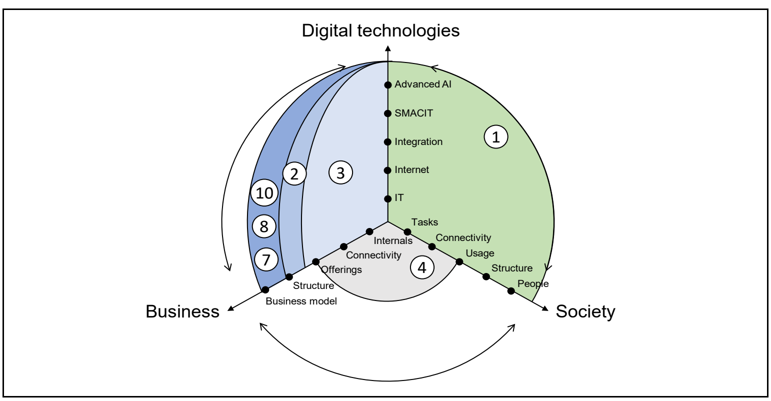

Figure 6: Validation Part I

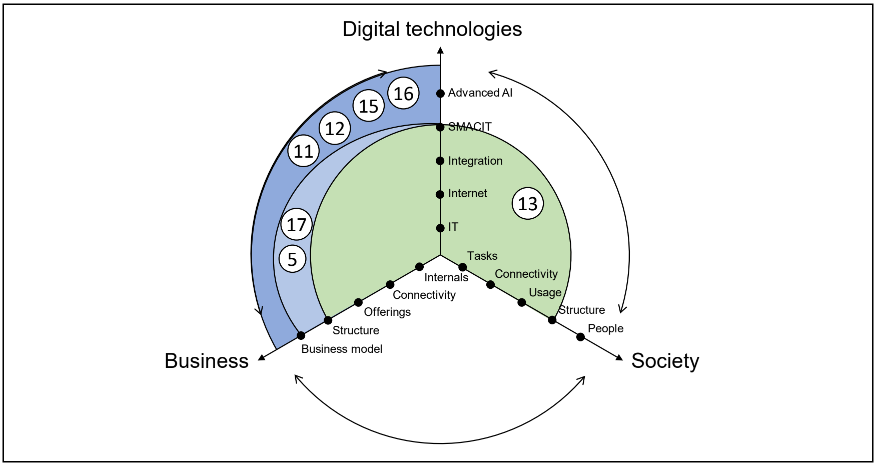

Figure 7: Validation part II

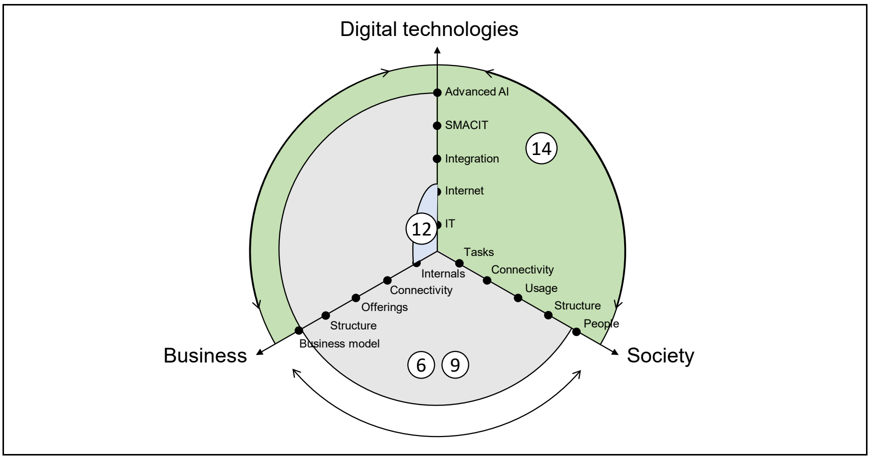

Figure 8: Validation Part III

7 Conclusion and Future Work

Digital transformation has received a great deal of attention in research but lacks a unified definition. In this paper, we contribute to the information systems research literature by providing a conceptual framework that reconciles the various aspects of DT and use it to formulate a novel and comprehensive DT definition, which were validated against the literature. These findings assist an understanding about the scope, forces, and impact of DT and can be among the first steps towards a unified definition, which is the key element of a well-developed scientific discipline (Torgerson, 1958). Additionally, practitioners and researchers can use the DT framework to frame their work.

In future work, the following use cases of the DT framework will be investigated:

- Modeling a company's current state on the DT framework together with its customers allows for the identification of DT opportunities and threats. This could be seen as misalignments between the axes.
- Second, by modeling several companies, or even countries, on the framework, the DT framework could be used as a comparison tool.
- Third, by giving weights to the respective segments and transformations, the DT framework can be used as a maturity tool or to derive DT metrics from.

Despite its exploratory nature, this study offers novel insights into the concept of DT and raises intriguing questions regarding the nature and the impact of the interactions between digital technologies, society, and business. In future studies, considerably more research will need to be done to determine how these interactions impact and shape DT, and to validate the framework empirically. Moreover, future research should be conducted to better understand how businesses can exploit the opportunities brought by a digital society.

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Social Media and Electoral Predictions: A Meta-Analytic Review

MARKO SKORIC, JING LIU & KOKIL JAIDKA

Abstract Can social media data be used to make reasonably accurate estimates of electoral outcomes? We conducted a meta-analytic review to examine the predictive performance of different features of social media posts and different methods in predicting political elections: (1) content features; and (2) structural features. Across 45 published studies, we find significant variance in the quality of predictions, which on average still lag behind those in traditional survey research. More specifically, our findings that machine learning-based approaches generally outperform lexicon-based analyses, while combining structural and content features yields most accurate predictions.

Keywords: • Social Media • Election Prediction • Network Feature • Content Feature • Meta-Analytic Review •

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1 Introduction

In recent years, the use of social media as a "social sensor" has been observed in many recent studies for predicting public opinion and election results. A rising proportion of everyday social interactions are happening in a digitally mediated context, making it easy to capture, store, process and analyze such data and use it as an always-on, unobtrusive spatiotemporal monitor of human thought and behavior. As compared to traditional methods of user data collection, social media analytics potentially offer a new kind of insight, through the ability to "listen in" to casual conversations, understand networks of friendship and influence, and assess their impact on public opinion.

This study presents a meta-analysis aimed at assessing the potential of different social media signals to correctly predict election results. It supports a fact-based understanding of the importance of social media to understanding public opinion by synthesizing the results from 45 published, peer-reviewed studies. We anticipate that our findings will address many of the concerns raised in recent work decrying the use of social media for electoral prediction. For instance, Jungherr et al. (2017) have raised the concern that measurement of political support through Twitter could instead be measuring "attention towards politics", and as such its relationship with political support is correlational but in need of further validation. Furthermore, Beauchamp (2017) suggests that many studies using social media to predict elections lack rigorous statistical testing, comparison against reasonable benchmarks and out-sample evaluations. Indeed, instead of predicting the future, many studies have usually predicted known outcomes in the present (Varian and Choi 2009) or the past (e.g., post-hoc predictions) and have rarely assessed the validity of their predictions through comparisons against other sources of data.

2 Background: Social Media and Public Opinion

The advent of social media-based opinion mining has challenged the two fundamental assumptions of survey research—namely, probability-based sampling and structured, solicited participant responses. First, probability-based sampling — employed by most quality surveys — assumes that all opinions have the same value and should be equally weighted (Bourdieu 1979), and can, therefore, be understood as "a possible compromise to measure the climate of public opinion" (Lazarsfeld 1957, p. 45). However, this approach ignores the dynamics of individual influence in forming public opinion (Katz 1957; Katz and Lazarsfeld 1955). Second, the survey-interview situation might produce a biased measure of public opinion skewed toward social desirability (Espeland and Sauder 2007).

Social media data differs from the structured, self-reported survey data in three main ways. First, it provides a large volume of user-generated content from organic, non-reactive expressions, generally avoiding social desirability biases and non-opinions, although self-censorship of political expressions has also been noted (Kwan, Moon, and Stefanone 2015). Second, social media data can be used to profile not only the active users but also "lurkers" who may not openly volunteer an opinion, by examining the interactional connections and network attributes of their accounts. Third, by looking at social media posts over time, we can examine opinion dynamics, public sentiment and information diffusion within a population (Jaidka, Ahmed, Skoric, & Hilbert 2018).

Still, social media data is criticized for not being representative of the general population, as it typically comes from the ranks of early adopters, teens, and better-educated citizens (e.g., Fox 2010; Wei and Hindman 2011). Political discussions on social media tend to be dominated by a small number of frequent users (Tumasjan et al. 2010). However, dismissing social media data as being invalid due to its inability to represent a population misses capturing the dynamics of opinion formation. As opinions held and debates conducted by certain politically active groups pre-empt those that develop in broader society (Zaller 1992) it is likely that social media conversations by active users play a stronger role in shaping public opinion.

2.1 Current Research

We identified several major methodological differences in how researchers approach the task of mining public support from social media data. The first important methodological choice made by researchers is which feature set – whether content features or network features – should be used to yield the most accurate predictions of election outcomes from social media. A similar "content vs. network" conceptualization is found in prior work by Livne (2011). Based on the Language Model of 687 candidates' tweets and documents cited and network features—i.e., number of retweets, replies, and hashtags, degree centrality, closeness centrality, HITS's Authority score (Kleinberg et al. 1999) and PageRank (Page et al. 1999) of candidates' "follow" networks, Livne (2011) built logistic regression models and correctly predicted the 49 out of 63 races' winner and loser during U.S. 2010 midterm elections.

Content features refer to the subjectivity and polarity convoyed in user-generated contents, i.e., social media users' direct expression of their attitude or opinion, which is often the form of texts, images or videos. There are many terms used to capture such automatic extraction of human attitude or sentiment from texts, among which sentiment analysis is the most widely used one. While apart from content features, political attitude/opinion could also be inferred from social media users' behaviors (e.g., follow, like, comment, share) with political candidates/parties, which constitutes a self-organizing and emergent network structure of the online communication flow. Within content features, sentiment analysis is further categorized into two sub-types: (1) lexicon-based, and (2) machine learning based. Prediction studies using lexicon-based sentiment analysis (González-Bailón et al. 2012; Ibrahim et al. 2015; Li, Ng, and Shiu 2013) adopt a given dictionary of words annotated with semantic orientation (polarity and strength) to classify the attitude/opinion conveyed by a piece of text toward a subject person or topic. The accuracy of such an automatic interpretation of semantic orientation is highly dependable on the quality and relevance of the lexical resources to the domain to which it is applied. Predictive studies using machine learning-based sentiment analysis (Contractor and Faruquie 2013a) learn from a set of (labeled or unlabeled) training data and then apply the learning model to classify the attitudes or opinions expressed in social media contents.

Studies using lexicon-based sentiment analysis yielded conflictive results in making political predictions. O'Connor et al. (2010) demonstrated that tweet sentiment correlated well with Obama's support rate during the 2008 presidential election and his job approval in surveys in 2009. While Chung and Mustafaraj (2011) and O'Connor et al. (2010) reported that sentiment analysis with lexica like Subjectivity Lexicon and SentiWordNet are not reliable for predictions due to the low coverage in their dataset. Studies which use machine-learning methods appear to have had better success (Beauchamp 2017; Dwi Prasetyo and Hauff 2015; González-Bailón et al. 2012; Kalampokis et al. 2017; Li et al. 2013; Monti et al. 2013; Sharma and Moh 2016; Huberty 2013; Xie et al. 2016). For instance, Contractor and Faruquie (2013) trained a regression model based on the bigram features from 37 million tweets to gauge Obama and Romney's approval rates in the 2012 U.S. Presidential election. Monti et al. (2013) trained a classification algorithm using Twitter Train Data and News Train Data and observed a strong correlation between offline inefficiency and online disaffection.

Network features encompass both centrality metrics (degree, betweenness, closeness, eigenvector centrality, etc.) used in social network analysis (Freeman 1979) and its non-normalized version—simple counts of edges of various network formed by social media users' interactions (mention, reply, retweet, share, follow, friend, etc.) with political candidates/parties. Network features are often interpreted as approval or support for a certain candidate or topic. For example, Mustafaraj et al. (2015) indicate that retweeting indicates not only interest in a message, but also trust in the message and the originator, and agreement with the message contents. Early studies focused mainly on simple counts of "mentions," e.g., the number of times political parties/candidate mentioned by social media users, as a proxy to predict political party/candidate's offline political support (Tumasjan et al. 2010). However, simple counts of "mentions" have largely been criticized because they fail robustness checks (Jungherr et al. 2012; Gayo-Avello et al. 2011a). Studies (Barclay et al. 2015; MacWilliams 2015; Vepsäläinen et al. 2017; Williams and Gulati 2008) have demonstrated that the "likes" recorded in candidates' Facebook Page/Fan pages could be used to predict electoral outcomes. MacWilliams (2015) use Facebook's PTAT ("People Talking About This") data to counting the interactions between the public and the candidates (e.g., liking a page, liking a post, commenting on a post, sharing a post, posting on the page's wall, etc.). Such "participation advantage" improved upon models that used only the Partisan Vote Index and incumbency as predictors. Cameron et al. (2016) found that the number of "friends" a candidate has in Facebook and number of "followers" they have on Twitter could be used the predict the candidates' vote share and the winner in 2011 New Zealand general election. Pimenta, Obradovic, and Den-gel (2013) predicted candidates' vote share in 2012 Republican primaries and opinion polls using the number of incoming links to blog posts, number of likes/repost a Facebook post received, number of retweet a tweet post received, the number of comments, likes/dislikes a YouTube video received and so on. Jaidka et al. (2018) used network features (counts of mentions, betweenness, PageRank of "mention" networks, etc.) and tweet sentiments to predict actual vote shares/opinion polls across three countries, finding that network features together with tweet sentiments are effective at predicting vote share, while machine learning based sentiment analysis yielded the most accurate predictors of election outcomes.

Since network features attempt to capture not only content but also the channels of opinion diffusion, it is hypothesized that:

H1: Studies using network features would outperform studies using content features in predicting public opinion and electoral outcomes.

H2: Studies using a combination of network and content features will outperform studies using any singular type of social media feature in predicting public opinion and electoral outcomes.

Given the relative sophistication of machine learning in extracting sentiment from texts, it is hypothesized that:

H3: Studies using machine learning-based sentiment analysis of social media contents would yield more accurate predictions of public opinion and electoral outcomes than studies using lexicon-based sentiment analysis.

3 Methods

3.1 Literature Search

The data collection was finalized in August 2018, using the following keywords—Twitter, Facebook, YouTube, microblog, blog, forum, social media, social networking site, online discussion or political sentiment, election, public opinion, protest, dissent or opinion mining, predict, measure, forecast, approximate—to search within the following databases: ACM Digital Library, IEEE Xplore, AAAI, ScienceDirect, Web of Science, EBSCO, JSTOR, SCOPUS, Taylor & Francis, Wiley Online Library, and ProQuest. After the initial search, a manual selection was performed to filter for relevance. Studies were included if they (a) utilized social media data to predict offline political behavior or opinion; and (b) measured one or more of the three criterion variables (i.e., political voting, protest, or public opinion) as a predicted variable. This resulted in a corpus of 61 articles published between 2007 and 2018, among which 45 studies predicted election results while 22 predicted opinion polls (6 predicted both). We only selected the studies which predicted election results directly and excluded those predicting opinion polls; the total number of studies included was 45, with the majority of studies analyzing Twitter data (above 75%).

3.2 Coding

Social media predictors are first categorized into two types: content features vs. net-work features. Content features are categorized into (1) lexicon-based and (2) machine learning-based sentiment analysis. While network features include (1) centrality metrics (degree, closeness, between-ness, etc.) which examines the individual nodes' (social accounts) position/importance in its social net-work, and (2) centrality metrics' non-normalized version —simple counts of the various type of edges, i.e., edges formed by the interactions among social media users and political candidates/parties. Such edges include social media users' interactions such as "follow"/"friend", "mention"/"tagging", "re-tweet"/"share", "reply", "comment", as well as "like" (a post or Fan page), which in the end constitute the network centrality. For blogs or forums, the edges are formed by incoming/outgoing links that a blog post has; for YouTube video, it includes setting videos as "favorites."

The present study focuses on electoral *results* alone, i.e.: (1) vote/seat share that political candi-dates or parties received during the election; (2) winning party or candidate in the election. This yielded 310 social media-based public opinion measures for our meta-analysis.

3.3 Results

Since each study may test more than one prediction, we ended up with 310 estimates in total, among which 161 estimates reported Mean Average Error (MAE) or other convertible forms (RMSE, Absolute Error, etc.) and 149 estimates reported R squared or coefficients.

As seen in Table 1, the best-performing feature set was a combination of content and network features, which yielded the lowest MAE (Mean=2.3, SD=4.17). Thus, Hypothesis 2 is supported. Studies which deployed structural features outperformed those with content features when measuring predictive power with R^2 (Mean=.60, SD=.32), but not with MAE (Mean=4.88, SD=4.55). Thus, Hypothesis 1 is partially supported.

Table 1 Predictive Power of Social Media Data with Different Predictors

	MAE (%)			R^2		
Predictors	Mean	SD	N	Mean	SD	N
Network features	4.88	4.55	83	.60	.33	96
Content features	4.27	3.83	69	.63	.26	33
Content & structural features	2.30	4.17	9	.58	.30	20
Total	4.47	4.17	161	.60	.31	149

To further assess whether machine learning produces better predictors of voting outcomes we compared (1) lexicon-based and (2) machine learning-based predictions, as shown in Table 2.

Table 2 Predictive Power of Social Media Data with Different Predictors (recoded)

	MAE (%)			R2		
Predictors	Mean	SD	N	Mean	SD	N
Network features	4.88	4.55	83	.60	.33	96
Lexicon-based content features	5.36	4.65	23	.77	.24	7
ML-based content features	3.73	3.28	46	.60	.26	26
ML-based content & network features	2.09	1.70	8	.82	.14	3
Lexicon-based content & network features	4.00		1	.54	.30	17
Total	4.47	4.17	161	.60	.31	149

Hypothesis 3 is thus supported. As seen in row 5, studies with a combination of structural features and machine-learning based content features report the most accurate prediction across both MAE (Mean=3.08, SD=1.55) and R2 (Mean=.91, no SD), landing further support to H2 and H3.

4 Discussion and Conclusion

In this meta-analysis, we compared the predictive power of social media analytics across different approaches, platforms, and contexts. In many of the cases, the results reported using MAE-based estimates and R^2 estimates were in agreement with each other, which is an encouraging sign of the robustness of our findings. While R^2 based measures showed the most stability and can be interpreted as higher recall or explainability of the data, MAE-based estimates can be used in cases where errors are symmetrical, e.g., in sentiment analyses, or in two-party races, where precision is of importance. Machine learning-based sentiment analysis tends to produce predictions with higher precision than lexicon-based approaches; however, they typically explain less variance.

The first important insight from our findings is the theoretical importance of interactions in the formation of public opinion. Combinations of network features and machine learning-based sentiment analysis of content features provide the most accurate predictions as compared to all the approaches considered. This means that content features work best when they are combined with network features to model the diffusion of opinion in a social network, regarding the reach of the authors, their interaction patterns, and their importance as influencers within their communities of followers. Still, most studies have relied on a simple count of interactional edges, which can be gamed by astroturfing or by heavy users, spammers, and propagandists (Metaxas and Mustafaraj 2012). In addition, they may also show attention spikes because of news cycles. Instead, we recommend that more sophisticated measures of author importance, e.g., network centrality measures, should be adopted to provide more accurate measures of online communication structures. Network features can capture the density of online discussions. More decentralized networks have more active users and thus wider outreach to a larger potential voter base (Jaidka et al. 2018). Network features have been found to be useful to dampen the estimation effects associated with national parties that are over-represented on social media or regional parties which may be popular online.

The second important insight is regarding the limitations of applying generic sentiment tools to mine political opinions, and applying dictionaries developed in the 1980s to analyze the present-day language of social media, which can falsely detect positive sentiment where there is sarcasm and hence can lead to erroneous predictions (O'Connor et al. 2010). Also, lexica are designed for Standard English, but many messages on Twitter are written in informal versions of English, which include alternatively spelled words and emoticons. Informal language cues are potentially useful signals, which are usually ignored in traditional methods of sentiment analysis. On the other hand, a supervised learning approach, which trains sentiment models on a small set of hand-annotated political messages yields much better predictions by inferring sentiment from otherwise neutral words used in context. Furthermore, studies have suggested that discarding negative posts and instead focusing on the positive tweets can help to filter out a large part of the noise from election-related content on social media (Jaidka et al. 2018).

Although this study is one of the first systematic reviews of social media-based predictions, it is important to note several shortcomings. First, since social media-based predictions are still in the early stages, there insufficient data to produce reliable estimates across different analytical categories. Several studies did not report their data sizes (e.g., Franch 2013; Li et al. 2013), while the other studies reported a wide range of data sizes – ranging from thousands (e.g., Gayo-Avello et al. 2011b) to hundreds of millions (e.g., Gaurav et al. 2013), making examination of effect of data sizes on social media data's predictive power of public opinion difficult. Fourth, the predictive power is reported in a range of formats – MAE, RMSE, correlation coefficients, regression beta, R^2, offset error, race-based percentage, making a systematic comparison difficult. We thus need a more standardized way of reporting data collection methods and statistical estimates of predictive power. Lastly, we were unable to systematically explore the temporal dimension in opinion mining, which is one of the key advantages of social media data and has been shown to affect the quality of election forecasts (Jaidka et al. 2018).

Social media data has many potential advantages – most importantly, it can bring the temporal and interactive dimensions of public opinion formation and change back to the forefront of research. We are optimistic that social media-based computational research, with more refined data collection and analytical methods, will be able to provide improved insights into the dynamics of public opinion and political behavior. Understanding political contagion on social media is also the first step towards countering problems such as disinformation, filter bubbles and hate speech, which are of growing concern in an increasingly polarized online community. Policymakers would also need to understand the real world correlates of online discourse to order to determine the future availability of social media data in ways that satisfactorily address the concerns regarding the key issues of privacy, freedom of expression, and public safety.

Note: Studies marked with an asterisk in the reference section were included in the meta-analysis.

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Digital Support to Guide Physical Activity - Augmented Daily Routines for Young Elderly

CHRISTER CARLSSON & PIRKKO WALDEN

Abstract New EU-level studies show that EU is "turning increasingly grey" and the old-age de-pendency ratio increases steadily during the next three decades. There is a growing, serious problem – people live longer lives but they are in worse shape during their final years and need growing support from health care resources. There is need for a new focus on prevention and on turning the development. The "young elderly" (the 60-75 years old age group) should adopt physical activity (PA) programs and make them part of their everyday routines. The learning processes get started through interventions with digital wellness services. DigitalWells is a research and development program to acti-vate 1000 young elderly to select and use PA programs. The goal is to keep the young elderly in better shape for their senior years (75+) and to contribute to significant reduc-tions in the growth of elderly health and social care costs.

Keywords: • Ageing • Physical Activity Programs • Digital Wellness Services • Multi-sensor Platforms • Smartphone Applications •

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1 Introduction

We have a growing awareness in many EU countries – to which we and the eBled conference may have contributed [6], [7], [8], [9], [10] – that something should be done to keep the ageing population in much better physical shape than now is the state of affairs in 2019.

This appears to be a simple insight and everybody agrees that it is in line with European values that elderly people should enjoy their lives after contributing to the wealth of their society during 30-40 years of work and paying their taxes. For some reason, this simple insight appears to be hard to turn into practical activity programs and to make real contributions to the wellness of the elderly. This despite the fact that the year 2012 was the "European Year for Active Ageing" and "Solidarity between Generations" [12].

One reason appears to be that the challenges are larger and more complex than the intuitive understanding of the slogans. The ageing population is large and growing for the next 20-30 years in most EU countries at the same time as the population of working age decreases both in absolute and relative terms. The elderly lives longer but they are in worse physical shape during their last few years, which requires a large and effective health care infrastructure to take care of them. This again translates to large and growing health care costs, which will start to be untenable for the working age population around 2030 [13].

In *The 2018 Ageing Report* [13] the European Commission projects a number of trends that will affect an EU that is "turning increasingly grey" in the words of the EC. The total population in EU will grow from 511 million in 2016 to 520 million in 2070, but the working age population will decrease from 333 million to 292 million in the same period. The old-age dependency ratio (people 65+ relative to working-age population (15-64)) will increase from 29.6% in 2016 to 51.2% in 2070; the EU will change from 3.3 working-age people for each 65+ person to only about 2.0. Much of the old-age dependency ratio change comes from people 80+ that will increase their impact on the ratio from 8.3% to 22.3% over the projected horizon.

The EC finds that the fiscal impact of ageing will be a significant challenge in almost all EU member states in 2020-2030. In the baseline scenario (there are two other scenarios with more challenges) the total cost of ageing is 25% of GDP in 2016 and will rise to 32-35% of GDP by 2070 [13].

There is growing political pressure to find long-term strategies for the ageing population [12] but decision makers have difficulties to agree on strategies and programs. The problems they should solve are complex and not separable from the infrastructure and value systems of a modern society [13], [23]. The macroeconomic theory and models that could offer understanding, the decision makers do not know nor understand sufficiently well. The strategic thinking appears to be more reactive than proactive, to focus more on handling the health and social care costs of ailing senior citizens than on preventive programs to keep ageing citizens in better health all the way to advanced years.

The ageing population will require annual budgeting for health and social care costs in several hundred billion euros. Rough estimates (worked out from Finnish statistics [29]) show that the annual benchmark cost for health and social care for the ageing population could be around 320-350 B€ in the EU countries, (there will be variations between countries). It makes sense to find out if some proactive, preventive program could help reduce the annual cost increases.

We have worked out a simple proposal for Finland: *get the young elderly [the 60-75 years old age group] involved in proactive programs to change their daily routines to improve their probability to have a healthy life into advanced age.*

A proactive program, which builds digital wellness services for the young elderly, is interesting for the digital services industry as the young elderly represent very large and growing markets (given the income levels and accumulated wealth of the young elderly in many EU countries).

The focus on the young elderly is a new approach for digital services, a market for which there has not been much interest to develop mobile value services ([5, 11]).

There is another, more important reason - society needs to have a strategy for the young elderly, which needs to be different from the health and social care strategy for the senior age group. A majority of the young elderly are reasonably healthy, active and socially interactive and do not require much intervention or support from the public health and social care systems. Consequently, the various programs for the ageing population ([12], [13]) do not focus on the young elderly and miss possibilities to build proactive and preventive programs. The reason is simple, they do not have diagnosed medical problems that require interventions. National health resources are not assigned to factors that could possibly generate health care issues after 15-20 years.

We have started a large, 2-year research and development program called *Digital Wellness Services for Young Elderly* (*DigitalWells*) that aims to get 1000 young elderly to build sustainable routines for including physical activity programs in their daily lives. *DigitalWells* cooperates with two unions of retired people's associations with a total of 100 000 members.

The program builds on a series of pilot studies [7], [8], [9] that served to produce first insight of what building sustainable routines for physical activity programs will require.

We developed a *storyline*: digital wellness services should build on methods and tools to form and support interventions in daily routines that introduce and sustain physical activity programs. Physical activity programs will improve the probability for better health in senior years. Better health for the senior population contributes to better quality of life – and to reduced and decreasing costs for senior health care. As the numbers are very large (the young elderly are 1.2 million in Finland), a significant improvement in health for the senior (75+) population – "*staying healthy for 5 more years*" – will significantly reduce the fiscal cost of the old-age dependency ratio [13].

The pilot studies produced a series of results. A first result we found was that wellness services are needed and useful – and wanted - for individual young elderly; a <u>second</u> result was that wellness services need to be digital to make them accessible efficiently and cost-effectively – the preferred way of distribution is through smartphones. A <u>third</u> result emphasized the need for an ecosystem of designers, developers, builders and maintainers of the digital services as there needs to be enough resources available to service 100 000 users that may be activated in Finland. This again, as a <u>fourth</u> result, requires an industry and university collaboration network. A fifth result is that there is potential for building a young elderly EU market, which may both grow very fast and be very large [7], [8], [9].

The *research problem* that drives *DigitalWells* and is the focus of this paper is *to identify design requirements and challenges for physical activity programs that will contribute to long-term physical wellness among young elderly*.

A reasonable way to tackle this research problem is through *action design research* [28] which we use to work out the *DigitalWells* and to structure the storyline of this paper. The *action design research (ADR)* method follows four stages [28]: (i) problem formulation, (ii) building, intervention and evaluation, (iii) reflection and learning and (iv) formalization of learning.

The rest of the paper works out the storyline. Section 2 addresses the designs of physical activity programs for young elderly. In section 3, we introduce digital wellness services and technology platforms to implement them. Section 4 introduces a research program to validate and verify that the activity programs, the technology and the digital wellness services get adopted for sustained use by the young elderly. Section 5 is a summary with some conclusions.

2 Physical Activity and Digital Wellness Services for Young Elderly

The WHO defines *wellness* as "the complete mental, physical as well as social well-being of a person or groups of persons in achieving the best satisfying or fulfilling life and not merely the absence of disease or any form of infirmity [33]. "Well-being" is imprecise as it builds on anything from systematic action to random events. We decided on *wellness* as the WHO definition builds on the physical and social elements we want to employ for the design of digital wellness services. In addition, *wellness* gets changing meanings from different angles [1], [25] in various contexts, and is an active research area [25], [30]. For work with young elderly user groups, we adopted a practical definition: *wellness – to be in sufficiently good shape of mind and body to be successful with all everyday requirements*.

The understanding and definition of wellness follow insights we have collected from the young elderly themselves: "*it is nicer to get old if you are in good shape*" or a more sober version: "*to get good remaining years*". These insights also neatly captures the strong motivation we have found among the young elderly to get in better physical shape [6]. *Physical wellness* comes from physical exercise to build stamina, muscle strength and balance and to ward off age-related serious illness; sustained physical exercise helps to meet everyday requirements and contributes to better quality of life.

Physical wellness is also the first wellness approach that comes to mind (*to be in good shape*) as it is easy to understand and to work out. Studies show [22], [31] that physical exercise is something of a corner stone for getting and sustaining a good quality of life in senior years. The young elderly themselves report that as they turned 60 they noticed that their bodies start to impose functional limitations on them and realized that some active measures will be required to improve on things. Karolinska Institutet [31] shows in a report, in which a synthesis of several studies over several years of physical wellness routines of 2500 elderly Swedes (the age group 65-84; there are 2 million people in this group), shows some interesting results. The findings are that 12% of the female and 14% of the male show no activity to improve their physical wellness. There are 69% of the female and 64% of the male, who show regular physical wellness activity at low or medium intensity (the minimum recommendation is 150 minutes at medium intensity per week). The remaining about 20% show regular physical wellness activity at medium or high intensity. The ATH 2010-2017 study in Finland [34] shows that in the 75+ age group, 31% have significant difficulties to walk 500 m and 41% report that they have challenges to cope with their everyday routines. Another worrying finding is that only 7% of the 75+ age group meet the recommendation of 150 minutes of physical activity every week; the 55-74 age group showed 15% that meet the recommendation, which health care professionals already should note and start active counter measures (not much happens as a matter of fact).

For young elderly the questions are *what* exercises and *how* to get health effects (and sometimes *at what cost* and even *why*). There are good answers to the *why* - research shows that work on physical wellness will have positive effects also on intellectual, emotional and social wellness and will reduce the probability to get serious (often age-related) illnesses [31]. The *what*, *how* and *at what cost* is the arena for digital wellness services.

So far, we have now covered ADR (i); we started with a research problem formulation, which helped us to identify a research opportunity (*proactive programs for digital wellness services for young elderly*) in a context of organizational commitment (*major, large organizations of retired people*).

In the *DigitalWells* program, we quickly realized that we are going to need a pragmatic approach to digital wellness services to change daily routines to include enough physical activity for health effects both in the short and long term.

We decided to select 28 activities that would fit young elderly and form meaningful weekly programs of physical activity. The programs need to be both manageable for young elderly and challenging enough to produce improved physical wellness that they could note and feel.

The 2011 Compendium of Physical Activity (CPA) [2] offers a standard for designing weekly programs. The CPA enhances the comparability of results across studies using self-report physical activity (PA) and quantifies the energy cost of 821 specific PA activities. There are other approaches to find the energy cost of PA activities [20] which are critical of the self-report results and want to build on measurements with multi-sensor systems. Then again, there is debate about what measurements are accurate enough to give meaningful guidance to the actual intensity and effects of different PA activities [4].

The MET is an objective measure of the intensity in carrying out a physical activity. MET is the metabolic equivalent and is measured as the ratio of the rate at which a person expends energy, relative to the mass of that person, while performing some specific physical activity compared to a reference, set by convention at 3.5 ml of oxygen per kilogram per minute, which is equivalent to the energy expended when sitting quietly [20].

The CPA offered a base standard for the following 28 physical activities [2]:

- Walking (individual, group), 5 km/h, 10 000 (12 000) steps, 3.5 (3.8) MET
- Nordic walking (individual, group), 6 km/h, 10 000 (12 000) steps, 4.8 (5.0) MET

- Jogging (individual, group), 7 km/h, 7.0 MET
- Running (individual, group), 10 km/h, 10.1 MET
- Treadmill running (1% angle), 10 km/h, 10.1 MET
- XC skiing (individual; classic, free style), 7 km/h, 10 (15) km, 7.0, (9.0) MET
- Aerobic (group, individual), 60 min, 7.3 MET
- Orienteering, 90 min, 9.0 MET
- Indoor ball sports (floor-, basket-, hand- and volleyball), 60 (90) min, 6.5 (8.0) MET
- Outdoor ball sports (football, Finnish baseball), 60 (90) min, 7.0 (8.5) MET
- Bicycle, 15 km/h, 7.5 MET
- Stationary bicycle, 15 km/h, 7.0 MET
- Senior dancing, 60 min, 5.0 MET
- Gymnastics (group, individual), 60 min, 3.8 MET
- Swimming (pool, open water; individual, group), 60 (90) min, 6.0 (7.5) MET
- Water running/walking, medium program, 4.5 MET
- Water gymnastics, medium program, 5.5 MET
- Rowing, normal stroke frequency, 3.5 MET
- Rowing machine, normal stroke frequency, medium load 4.8 MET
- Strength training (gym program 1), 60 min, 3.5 MET
- Strength training (gym program 2), 60 min, 5.0 MET
- Strength training (gym program 3), 60 min, 6.0 MET
- Group exercise, 60 min, 4.3 MET
- Stretching, light, 2.3 MET
- Yoga Hatha, light, 2.5 MET
- Functional training, 60 (90) min, 4.5 (6.0) MET
- Yard and forest work, 60 (90) (120) min, 3.8 (4.5) (5.5) MET
- Golf, 1 round, walking, 4.8 MET

The young elderly *DigitalWells* participants normally have two pointed questions ([7], [8]): "*what* exercises are good and useful for me and *how to* get health effects from these exercises". The recommendation offered from the CPA community "in one week spend at least 2.5 hours over 3 or more days at *medium* MET or 75 minutes at *vigorous* MET to get 495 MET minutes/week or 525 MET minutes/week". The colour codes classify the two lists of 28 activities (light MET is in black). They are also not absolute truths but average standards. The MET material comes from controlled experiments with adults 18-65 years old (only partially relevant for young elderly) [2]. We will at some point have to recalibrate the MET standards for our target population. In *DigitalWells* there will be 35 groups of 25-30 participants, a total sample of about 1000 participants, which will give us a basis for statistical analysis. Of course, there will be imprecision and variation as the participants will be in different physical shape. If we use the results in [30], 12-14% will have no previous history of physical activity programs, 64-69% will show regular physical wellness activity at light or medium intensity, and 20% will show regular physical activity at medium or vigorous intensity. Nevertheless, the process needs to get started.

If we want to get things correct, we should find the individual MET for each participant just before an activity program starts, again measure the MET before each moment of the activity and then get the MET-minutes at the end of the activity program. There will probably be some multi-sensor bracelet available in a few years to carry this out.

The *DigitalWells* needs a base and a standard that subsequently can be tested, verified and validated in actual use among the young elderly. We propose a simple approach, which is useful for fieldwork with existing technology.

Activity/day = minutes a_i * light MET + minutes a_i * medium MET + minutes a_i * vigorous MET, i = 1, 27
Activity/week = sum_j (activity/day), j = 1, 7

<u>Recommendation</u>: 3 or more days, ≥ 2.5 hours at medium MET or ≥ 75 minutes at vigorous MET to get 495 MET minutes/week or 525 MET minutes/week
<u>Norm I [*basic*]:</u> 5 or more days at medium MET and/or walking ≥ 30 minutes/day, 495 MET minutes/week
<u>Norm II [*active*]:</u> 5 or more days at medium MET (any combination of programs) or vigorous MET ≥ 45 minutes/day, 600 MET minutes/week
<u>Norm III [*senior athlete*]:</u> 3 or more days at vigorous MET ≥ 60 minutes/day, 1500 MET minutes/week

Then wse have to return to the reservation [2]: *CPA MET values are relevant for use in able-bodied adults who are 18–65 year old and do not reflect the energy cost of children and youth, older adults, and persons with disabilities.*

This initiated work to find corresponding CPA MET values for older adults [17], which produced the following formula:

Men: BMR = 66.5 + (13.75 × weight in kg) + (5.003 × height in cm) – (6.755 × age in years)
Women: BMR = 655.1 + (9.563 × weight in kg) + (1.850 × height in cm) – (4.676 × age in years)

We realized that the young elderly actually form five age groups, 60/65/70/75/75+, which also have different characteristics for males and females. This motivated us to introduce several levels of recommendations for the MET minutes/week:

Male [56-60]	576	Female [56-60]	468
Male [61-65]	540	Female [61-65]	432
Male [66-70]	498	Female [66-70]	390
Male [71-75]	450	Female [71-75]	348
Male [75+]	444	Female [75+]	342

These recommendations are only indicative – we will among our participants find 75+ aged marathon runners that easily train at 1200-1500 MET minutes/week and 55+ people who have never spent any time on physical activity programs and will find it challenging to reach 440 MET minutes/week [31].
The intensity at which an individual carries out an activity program is crucial but not well defined [2]. In laboratory based experiments a walking pace at 60 steps/minute for at least 10 minutes is *aerobic*, i.e. generates MET-minutes. Then, *light* would be < 60/steps/minute, *medium* 60-70 steps/minute and *vigorous* > 70 steps/minute. Another way to define the steps standard: *light*, aerobic steps for 10-30 minutes; *medium*, aerobic steps for 20-60 minutes; *vigorous*, aerobic steps for > 60 minutes.

Wew have now added to ADR (i) with contributing theoretical bases and an overview of possible contributions from existing measurement technology; next we will sketch some general requirements for the design and launch of digital wellness services.

The observation that (systematic) physical activity contributes to improved health and wellness starts to be verified and validated [22]. This supports a vision that physical activity programs and digital wellness services can produce sustainable health effects for young elderly. If large groups of young elderly (thousands, tens of thousand) adopt physical activity programs we can get sustainable health effects with an impact on national health care budgets.

The *first* observation is then that we are going to need and use digital wellness services for 10-15 years; macro-economic changes form slowly and reduced health care costs from improved health among young elderly need at least 5 years to materialize. In the digital service market, where applications typically need to be improved and relaunched every 6-12 months, this means that there will be dozens of generations of digital services. A *second* observation follows; an ecosystem of about 100 SMEs should develop, sustain and innovate the generations of digital services – it will be hard for any monolithic giant of the digital economy to build the flexible, renewable and adaptive services the young elderly will adopt, pay for and use for 10-15 years. A *third* observation is that the young elderly is a demanding user group; digital wellness services need to be intuitive, easy to use (probably voice activated), user and context adaptive (probably omnivore). The services will apply advanced technology that should incorporate technology innovations as they emerge. A *fourth* observation is that even with reasonable success the digital wellness services will have hundreds of thousands of users in the Nordic countries only. Software should be advanced enough and adaptable to the users to fit the requirements of young elderly [18], [19]. Development, maintenance and distribution of digital wellness services will need an ecosystem.

3 Digital Wellness Services and Technology Platforms

The technology should offer multi-purpose, viable platforms for multiple digital wellness services to support multiple activity programs of the type we worked out in section 2.

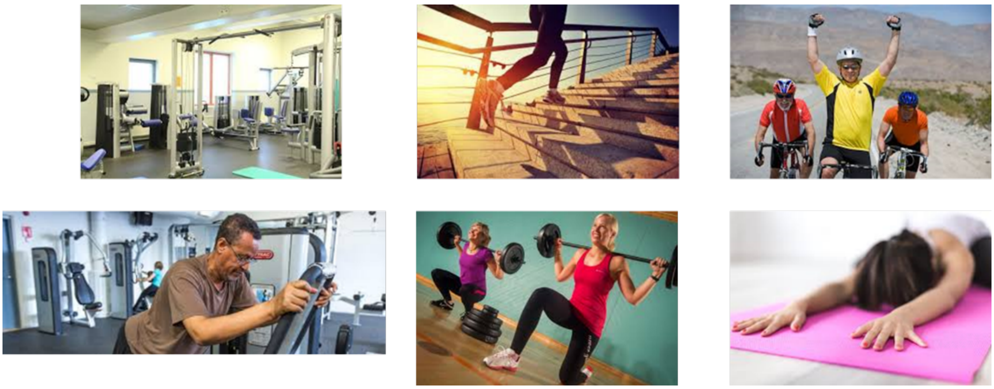

Fig.1 Multiple activity programs

There are dozens of wellness apps available for the leading brands of smart phones (Samsung, Apple, Huawei, Xiaomi, LG, etc. [35]). Tens of vendors offer fitness trackers that support wellness routines (Fitbit, Garmin, Xiaomi, Polar, Apple, etc. [36]). The fitness trackers normally come with supporting apps to summarize and interpret the data collected with sensors. Fitness trackers typically come with multiple sensors and the sensor technology shows fast and significant development.

In support of the activity programs to give participants individual feedback on the intensity and duration of their activities [24] a typical fitness tracker (Fitbit Charge 3 used as an example) collects data on and reports (i) 24/7 heart rate, (ii) VO2 Max, (iii) step tracking, (iv) SpO2 blood oxygen, (v) swim tracking and (vi) sleep stages (to collect data on sleep patterns). Another fitness tracker (Garmin Vivosmart 4) offers rep counting for gym sessions and crossfit, which probably will become a standard feature as the sensor combination becomes available for leading fitness trackers.

In the *DigitalWells* program, we decided to use available platforms and to build the DW-app(s) on top of existing apps for smartphones. This choice builds on the observation that members of the target group own and use fitness trackers and have wellness apps available on their smartphones. In tgerms of ADR (ii) we build the alpha and beta versions of the DW-app(s) on available platforms.

The preliminary choice is to use Wellmo and Exsed2 as platforms as they build on different sensor technologies (fig. 2).

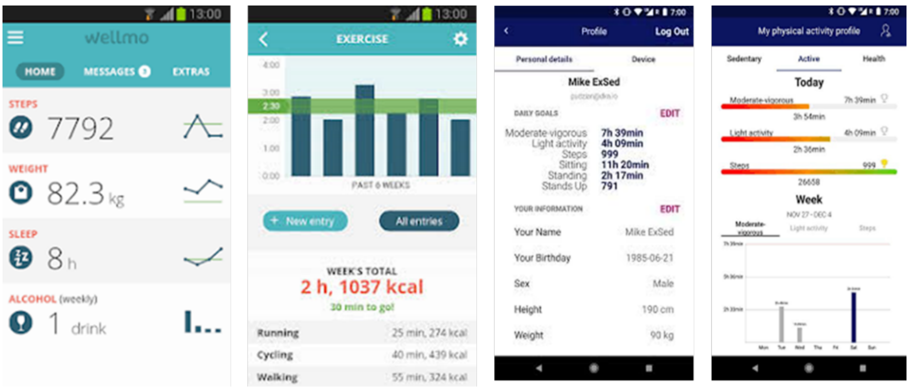

Fig. 2 Wellmo and Exsed2 wellness platforms

The differences between the two platforms come from the sensor technology used to measure the intensity and duration of the activities. The Exsed2 uses the Movesense (by Suunto) multisensory technology and Wellmo collects data from the most common fitness trackers (fig. 3).

Fig. 3 Movesense and Fitbit Charge 3

In the literature, there is some controversy about the correct way to measure and assess the medium to vigorous physical activity. In [20] hip-worn accelerometers collected data to find the threshold values for medium and vigorous activity. The technique builds on tri-axial acceleration data and the mean amplitude deviation (MAD) of the acceleration signal. The MAD values convert to metabolic equivalents (MET) through empirically derived and validated algorithms. The most frequently used method in fitness trackers measure VO2 max to trace intensity and duration of physical activity. Firstbeat [14] developed a series of algorithms that now gain growing acceptance among the fitness tracker vendors. Firstbeat claims to automatically detect the VO2max fitness levels during walking and running activities. This builds on proprietary software, which has been tested and validated in laboratory experiments and shown to give 95% accuracy. The hip-worn accelerometer supporters express scepticism about the accuracy and precision of the wrist-worn sensor measurements. Nevertheless, there is growing evidence [27] that the precision is sufficient for the intended use we have in the *DigitalWells* program. For the ADR (ii) technology artefacts we have singled out two main principles – the MAD and the VO2 max. The rest of the design needs to transform the measurements to meaningful expressions of light or medium or vigorous physical activity.

The beta design of the DigitalWells app (DW-app) introduces the following functionality (fig. 4)

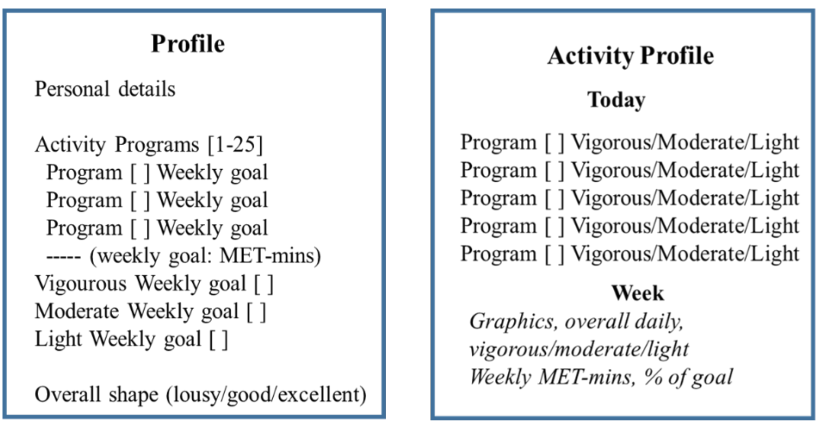

Fig. 4 DigitalWells app design

The user starts with background information to calculate an individual BMI, answers a questionnaire on personal history of physical activity and a subjective estimate of physical shape ("lousy/good/excellent"). He/she then selects 3-5 activity programs and defines weekly activity goals for each one and a weekly goal of MET minutes. The DW-app then follows up on the actual activity programs and the intensity (vigorous/medium/light) at which the user has carried them out. The activities summarize weekly as MET minutes relative to the goal set and as daily activity levels (with intensity levels) of each activity program. The DW-app protects user data with encryption and stores it under pseudonym on the *Kanta PHR* database, which the Social Insurance Institute operates over its cloud server. The user can select to use more features from the underlying platforms, for instance, to form peer groups that compare their activities and share best practices to get health effects.

The *DigitalWells* database will serve as a basis for cross-sectional and longitudinal studies of the effects of physical activity programs on wellness and health among the young elderly.

The crucial part is how easily the intended users will adopt the DW-app and the activity programs. This enters the ADR (iii) reflection and learning stage. We apply iterative design processes as part of guided emergence [28].

We carried out a number of pilot studies, which gave some insight to build on [7], [9]: (i) daily routines are a good choice for focus; (ii) wellness routines should be important parts of daily routines; (iii) digital wellness services should be usable without assistance; and (iv) smartphone users have sufficient skills to learn digital services. We have also tested the idea that relations between socio-economic characteristics, attitudes toward the use of mobile applications and perceptions about wellness could help identify potential users (see details in [8], [9], [10]). To introduce digital wellness services for young elderly, we should start with young elderly, who are,

- Active in full time/part time/volunteer work & advanced users of mobile apps & < 70 years
- Experienced users of mobile apps & more educated
- Males with good physical health & income > 30 k€ per year

- More educated & find mobile apps good value for the price

The findings make sense – active people will be early movers [26] and more educated people younger than 70 are experienced users of smartphones and mobile apps. Males, who are more educated and have good income, find mobile apps good value for the price (and would be willing to pay for digital wellness services).

4 The DigitalWells Research Program

Then we enter the ADR (iv), formalization of learning. The conceptual basis for building and sustaining physical wellness among the young elderly is *gerontologic prevention* [16] but we use the design and intervention of digital wellness services as tools (artefacts) to operationalize the insight and understanding gerontologists have of physical activity programs for ageing people.

We expect to get rich data collected from the 1000 young elderly recruited for and active in the program: (i) daily physical activities with a selection of activity programs on a variety of intensity levels, (ii) follow up on subjective wellness and (iii) how well they are doing in relation to individual goals. The data should help us to find, verify and validate answers to the following specifications of the research problem:

- What are the best activity programs for young elderly? What activity programs give the most effective, sustainable health effects? Will there be significant differences between young elderly – in terms of M/F, age groups (60, 65, 70, 75, 75+), history of physical activity, work history?
- What are the "correct" MET minutes/week levels for young elderly?
- What MET values are (more) correct for young elderly – hip- or wrist measured? Can we show systematic differences in multi-sensor system measurements in the set of physical activity programs?
- We have 35 groups – will there be significant differences between the groups in adoption of physical activity programs? Can we find reasonable explanations for the differences? Can we explain differences with digital services adoption theory or models?

- We will determine the base level of physical activity prowess and experience with the IPAQ Short form [21]. Can we find similarities or differences for the groups in international comparison?
- The groups will work with the physical activity programs and the DW-app for 4-5 months. Using the UTAUT2 framework [32], can we find similarities or differences in how the groups adopt the digital wellness services in international comparison?

The *DigitalWells* findings and results describe and start to explain *general trends of exercise and health*, which are relevant for the themes of the EU *2018 Ageing Report* [13]. The results will also show possibilities to validation and generalization with different theoretical frameworks (cf. ADR (iv) general outcomes [28]).

The field work with 35 groups of young elderly (each one with 25-30 participants) builds on research on *group work to develop activity programs for young elderly*, which develops and enhances living labs methods [3].

The work with young elderly to select physical activity programs and to compose a weekly portfolio of programs contributes to *co-creation of digital wellness services*, which develops and enhances the pioneer work of Grönroos [15].

It is probably unavoidable that after the first year with the digital services users (probably a majority) start to ask for a higher level of automation and more intelligent support to get advice on how to build effective combinations of activity programs. The answers are in three interrelated research themes, (i) *digital coaching principles adapted to activity programs for young elderly*, (ii) *multi-agent systems for digital coaching of digital wellness services* and (iii) *key activities to make digital coaching work with young elderly*. There are some preliminary results to build on [6], [8] but digital coaching offers a number of challenges that need to be worked out.

We made an initial observation that large-scale health effects will require large numbers of *DigitalWells* participants and/or users of physical activity programs. The relevant research themes will address *ecosystems of digital service stakeholders to build activity programs for thousands of users*. It is almost a truism that large structural changes require large ecosystems of stakeholders to get real change in reasonable time.

SME:s are a crucial part of the ecosystem to build, change, enhance and improve digital wellness services both as part of smartphone applications and as designers and developers of platforms for multisensory systems. For the SME:s, the ADR research themes include *business models for digital wellness services* and *business models for remote digital rehabilitation services*. The foundations and conceptual frameworks for these research themes are in the H2020 ENVISION research and development program [37].

5 Summary and Conclusions

The *DigitalWells* implements a simple logic: get the young elderly to change their daily routines in ways, which will improve their probability to have a healthy life into advanced age [90+]. This focus on *prevention* will help to reduce significantly the need to react to with advanced health care services to the needs of large, growing numbers of ageing people. Services that [13] shows will require resources that most EU countries cannot afford beyond 2030.

We have argued that *physical activity programs* is a viable approach to achieve changes towards better health scenarios by using digital wellness services as interventions in daily routines. We worked this out with a selection of 28 physical activity programs that we will support with smartphone apps and multi-sensor platforms.
The data *DigitalWells* collects from about 1000 users of the digital wellness services and the technology offers material for several research themes, which will have significant impact on methods and theory development for digital services in general and digital wellness services in particular.

The *DigitalWells* program aims at several contributions. First, it addresses a user group – the young elderly – that does not get much attention in research on digital services. Second, it develops digital services in an area where the macroeconomic impact of the services will be significant. Third, young elderly has other and new requirements on digital services than the young adults and the teenagers (the standard target groups). The young elderly wants and needs are new requirements for developers of digital technology and services, but young elderly is also a potentially very large market (about 97 million EU citizens are young elderly) that has so far been ignored.

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The Data-Driven Business Value Matrix - A Classification Scheme for Data-Driven Business Models

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Abstract Increasing digitization is generating more and more data in all areas of business. Modern analytical methods open up these large amounts of data for business value creation. Expected business value ranges from process optimization such as reduction of maintenance work and strategic decision support to business model innovation. In the development of a data-driven business model, it is useful to conceptualise elements of data-driven business models in order to differentiate and compare between examples of a data-driven business model and to think of opportunities for using data to innovate an existing or design a new business model. The goal of this paper is to identify a conceptual tool that supports data-driven business model innovation in a similar manner: We applied three existing classification schemes to differentiate between data-driven business models based on 30 examples for data-driven business model innovations. Subsequently, we present the strength and weaknesses of every scheme to identify possible blind spots for gaining business value out of data-driven activities. Following this discussion, we outline a new classification scheme. The newly developed scheme combines all positive aspects from the three analysed classification models and resolves the identified weaknesses.

Keywords: • Business Model Innovation • Data Analytics • Data-Driven Business Model • Classification • Business Value Matrix •

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1 Introduction

The subject of business models (BM) has gained steadily increasing attention in the last 20 years both in the academic field and also in the entrepreneurial practice. By Business Model (BM) we understand a description or model that represents a firm's logic to create, provide and capture value from and for its stakeholders (Bouwman et al. 2008). According to Osterwalder et al. (2005), a business model is a "blueprint" for how to run a business. Concerning Business Model Innovation (BMI) there is a heterogeneous understanding in the literature (Wirtz et al. 2016). The definitions reaching from modifications or introduction of a new set of BM key components that enable the firm to create and capture value (Hartmann et al. 2016) to the reinvention of a BM by a fundamental rethinking of the existing customer value proposition (Johnson et al. 2008).

Nevertheless, the topic of business model innovation is more relevant than ever due to increasing awareness about the potential and possibilities of digitization and the use of (big) data as a key resource. In the area of digitization and Industry 4.0 data became the new strategic resource for business model development. Data can be utilized in every element of a business model starting from value creation processes (e.g. improving production processes), enriching the value proposition (e.g. enhancing products with data-driven add-on services) up to value capturing (e.g. selling data or data generated information). The development of data-driven business models (DDBM) requires expertise in several fields, like technology, data science, business strategy or ethics.

Although much BMI research has been done, there is limited knowledge on how data function as a business resource and how to support data-driven business model innovation with adequate, hands-on and easy to use tools and methods. Therefore, our main research objective is to identify, and if necessary develop, a classification scheme which is useful to differentiate and compare between examples of a data-driven business model, and to think of opportunities for using data to innovate an existing or design a new business model.
Specifically, we seek to answer the following research questions:

RQ 1: What are the characteristics of the applied classification schemes in terms of being able to differentiate and compare between examples for data-driven business model innovation?

RQ 2: Which parameters should a classification scheme contain that maintain the strength and overcome the weaknesses and how does it look like?

The paper is structured as follows: In section 2, we will outline the theoretical framework by describing different classification approaches and the selected three which are applied in the study. Section 3 explains the methodological procedure including criteria for data selection, an overview of the project. The analysis results and a proposition for a new classification scheme are outlined in section 4 and 5. Finally, a conclusion chapter presents a summary of the findings, limitations and ideas for further research.

2 Background and Related Work

In recent years, BMI research has already begun to develop taxonomies and classification schemes for DDBM. Below, we will briefly outline the most important classification schemes and some relevant literature in the field of DDBM. Based on defined selection criteria, three approaches were selected for the classification of the data-driven innovation projects (see chapter 4).

Hartmann et al. (2016) proposed a data-driven business model framework with six dimensions (data sources, key activities, offering, target customer, revenue model and specific cost advantage) and up to three sublayers based on information systems and business model literature. The sample was limited to 100 start-ups in the category of "big data" or "big data analytics. The analysed companies can be characterised as "born-online" as the majority of the companies offer digital products and services since the foundation. Wixom and Ross (2017) distinguished between three approaches to transform data into business value, by improving internal processes, wrapping information around products and finally, selling data or information offerings.

Engelbrecht et al. (2016) developed a taxonomy for data-driven business models with three dimensions (data sources, target audience and technological effort) from a sample of 33 data-driven start-ups. Schüritz et al. (2016) described five "Data In-fused" BM patterns where data and analytics are directly impacting the core components of a business model (value creation, value capturing and value proposition). The analyzed sample use cases (115 companies) are mainly industry companies, which can be characterized as "born-offline" (established without digital products and services). Zolnowski et al. (2016) analysed how data and analytics transformed business models of established enterprises (20 cases from seven "born-offline" industries). A BITKOM study (2015) analysed 42 industry use cases using a four strategic dimension matrix (existing/new business, existing/new data) and described four main business model patterns.

Schmidt et al. (2018) revealed distinct patterns of DDBMs from start-ups and fin-techs respectively. Hunke et al. (2017) proposed a prototypical process model for data-driven business innovation with six process steps (mobilization, initiation, ideation, integration, realization, administration) following the model from Bonakdar and Gassmann (2016) and three process content layers (business, data, and ecosystem). Brownlow et al. (2015), Schröder (2016) and Schüritz et al. (2017) analysed barriers and challenges organizations face during data-driven business model innovation.

As present literature offers already plenty of different classification schemes, we applied the following selection criteria in order to support the identified research gap. The selected classification schemes should have a low level of complexity (easy to use, easy to understand). As our sample projects are mainly established enterprises (see chapter 3.1), we use as selection criteria "born online" (digital or data-driven start-ups) and "born-offline" (company founded without digital products and services).

Table 1: DDBM classification literature

Author	Sample mainly "born online"	Sample mainly "born offline"	Degree of complexity (ease of use)
Hartmann et al. (2016)	✓		high
Wixom and Ross (2017)		✓	low
Engelbrecht et al. (2016)	✓		middle
Schüritz et al. (2016)		✓	low
Zolnowski et al. (2016)		✓	high
BITKOM (2015)		✓	low

By applying the above-mentioned selection criteria, we selected classification schemes which matching “born offline” and low complexity to classify the data-driven innovation projects regarding business model implications. Hereafter the three selected classification schemes are described in detail.

(1) The strategic managerial approach is based on Ansoff’s product-market framework (Ansoff 1965) adapted by BITKOM (2015). Big Data initiatives or projects are classified into four categories illustrated in Fig. 1

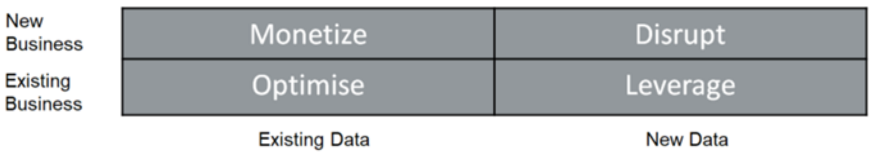

Figure 1: Strategic classification matrix based on Ansoff (1965) and BITKOM (2013).

Data-driven activities in the “Optimise” quadrant represent utilizing existing data sources for the current business. This could lead to improvements in many areas of the existing business model reaching from product quality topics to valuable insights into sales figures. The “Monetize” area aims to develop new products and/or services using existing data. Using new data could “Leverage” the existing business by enriching products and services. New product or service developments based on new data sets are positioned in the “Disrupt” quadrant.

(2) The data infused business model perspective: Schüritz et al. (2016) described five “Data In-fused” BM patterns (see Table 2) where data and analytics are directly impacting the core components of a business model (value creation, value capturing and value proposition). Schüritz et al. (2016) arguing conclusively that data may have a beneficial influence on each core building block of a business model, on two or all three simultaneously. The concept has been tested and evaluated based on 115 publicly available cases.

Table 2: Data-Infusion Patterns (Schüritz et al. 2016)

No.	Category / Pattern	Short description
I	Data-Infused Value Creation	Using existing or new data sources for optimizing value creation
II	Data-Infused Value Capturing	Identifying new customer segments or utilizing new revenue models based on data and/or data analytics
III	Data-Infused Value Proposition via Creation	Offering data-driven enhancements for existing products and services or entirely new data-driven services
IV	Data-Infused Value Proposition via Capturing	Using data to improve the value proposition and concurrently changing the way the BM captures value
V	New Data-Infused Business Model (DiBM)	Using data and analytics to developing an entirely new data-driven service by changing all three parts of a BM

(3) The specific value proposition view: As the value proposition is seen as a central part by many business model ontologies (Osterwalder & Pigneur 2010; Gassmann et al. 2013, Johnson et al. 2008) it is plausible to study how and to what extent data and data analytics influence the value offering. Based on recent research on data-driven business model pattern (Hartman et al. 2016; Schroeder 2016; Schüritz et al. 2017; Wixom & Ross 2017) five distinctive pattern based on a specific value proposition views were identified (see Table 3). The first two categories are similar to the previously described Data Infused BM pattern I (Data Infused Value Creation and III (Data Infused Value Proposition via Creation). In the third category, companies develop new services based on data, independently from the core offering (product or service) in order to generate additional revenues.

The data-as-a-service category offers the possibility to sell data which were generated by their core business processes or aggregated from third-party data providers (Otto & Aier, 2013) to customers, like any other good. Data is usually not modified, but pre-processed, analyzed and anonymized to be turned into a sellable product. Finally, companies can offer data-driven services, like analytics-as-a-service, infrastructure-as-a-service, software-as-a-service and consulting services (Schroeder, 2016). These activities were summarized in a fifth category named auxiliary big data services.

Table 3: Patterns focused on Value Proposition

Category/ Pattern	Short description	Value Proposition
Data-enabled Improvements	Leveraging data and analytics for company internal (process) optimization.	Value proposition is not affected
Data-enriched products and services	Existing products and services are enhanced with data and data analytics to provide additional value	Product/service with data/ information as an add-on
Data-enabled Services	Stand-alone data-driven services based on internal data or data from third parties are provided	Information, knowledge or answers
Data-as-a-Service	Data is sold like a common good. Activities in this pattern also include data aggregation, storage and broking.	Data
Auxiliary “big-data” services	Supporting data and analytics activities, when organizations do not have the core competencies in this field (e.g. Analytics as a Service, IaaS, SaaS, consulting services)	Non-data product or service

3 Method

3.1 Data Selection

We base our analysis on innovation projects carried out at a European applied research institution. The research centre’s mission is to carry out excellent research in the fields of data-driven business and big data analytics, to enable innovation in national and European companies, and to support qualification of professionals and organizations in these fields.

The projects we selected come out of a pool of 56 innovation projects executed at the institution in the years 2015-2017. All projects we analysed were research and innovation-oriented and were carried out always by at least two participating organizations, i.e. the institute and at least one non-research organization (the organization who intended to explore data analytics with the goal to create business value). In addition, we selected only projects were at least 2/3 of the project volume was assigned to data analytics related activities, such as data acquisition, data pre-processing, data analytics, data visualization, etc.
As a result, we worked on the following 30 projects listed in Table 4.

Table 4: Overview of selected projects

Number	Project Topic	Type of Business	Industry
1	Enhanced and new services through new data	Start-up	Services
2	Add on services based on new data insights	SME	Retail
3	Demand forecasting based on historical market/ sales data	LE	Retail
4	Increase security at major events through monitoring and data analytics	Public	Mobility
5	Intra-Logistics optimization	LE	Automotive
6	Social media analysis for traffic prediction	LE	Mobility
7	Guiding through data-intensive work processes	LE	Automotive
8	New services using biodata analysis	SME	Life Science
9	Increase work safety through data analytics	LE	Automotive
10	Interactive production data visualizations	LE	Manufacturing
11	Predictive maintenance	LE	Manufacturing
12	Pattern detection in big (measurement) data	LE	Automotive
13	Early detection of production errors	LE	Automotive
14	New services using biodata analysis	Start-up	Life Science
15	Data-driven coaching	Start-up	Life Science
16	Optimizations in intra-logistics	LE	Manufacturing
17	Guiding through data-intensive processes	SME	Life Science
18	Guiding through data-intensive processes	SME	Services
19	Strategic Intelligence	SME	Services
20	Process support	Start-up	Retail
21	Potential analysis of sensor data	LE	Manufacturing
22	New services using data-driven recommendation algorithms	Start-up	Retail
23	Developing new services using data-driven recommendation algorithms	SME	Services
24	Interactive data visualizations	LE	Automotive
25	Early detection of production errors	LE	Manufacturing
26	Semantic Search Support	LE	Services
27	Utilizing Mobility Data	SME	Mobility
28	New services based on machine data	LE	Manufacturing
29	Quality improvements through data analytics	LE	Manufacturing
30	Product enhancements through data analytics	SME	Life Science

The sample is characterized as follows:

- Type of projects: 88% funded research projects, 12% not funded research projects.
- Industry: 24% Retail, 24% Automotive, 16% Life Sciences, 12% Mobility, 12% Manufacturing, 12% Service Sector (consulting, public administration).

- Type of business: 52% Large Enterprises (LE), 16% Small and Medium Enterprises (SME), 16% Start-Up, 8% public administration.

3.2 Analysis

For analysing the thirty selected projects, we applied a multi-case study research (Yin, 2014) which allows the investigation of complex real-world phenomena. Case study research is the preferred approach to study data-driven innovations and related business models and has been used by different authors (Schüritz et al. 2016, Engelbrecht et al. 2016, Otto and Aier 2013). The goals of the analysis were to understand the business value that was created within these innovation projects and to identify the characteristics of the three classification schemes 1) Strategic managerial approach (BITKOM matrix) 2) Data-infused Business Model perspective and 3) Specific value proposition view.

In a first step, we analysed the available project documents (reports, presentations, and prototypes) to ensure a deep understanding of the project content as well as the applied data analytics methods and the reached project goals. This approach provides a solid basis for the subsequent classification process. Hereafter, all projects were classified by two independent researchers. Any disagreements have been resolved by consultation of the respective project manager at the research institution and joint discussions. After completion of the classification of each scheme, the researchers documented the results (see chapter 4.1, 4.2 and 4.3) and evaluated each scheme regarding support of data-driven business model innovation. Based on these results described in form of strength and weaknesses (see chapter 4.4), a proposition for a holistic classification scheme have been developed and outlined as "Data-Driven Business Value Matrix" in chapter 5.

4 Results

4.1 Strategic and managerial classification (BITKOM Matrix)

As shown in Table 5, more than half of the projects (57%) are located in the Optimization quadrant (project example: improving the demand forecasting process by taking historical market and sales data into account). Most of these are well-established companies (mainly LE) that using existing data as a starting point, focusing primarily on process improvements e.g. lead time reduction and increasing product quality. A small percentage of the analysed company projects followed the strategic approach of "Monetization" in order to develop new products and/or services using existing data (project example: enriching already provided inventory and shop management solutions with new additional data-driven insight services). The main topics here were data-driven additional services in the field of maintenance and service.

Projects related to the "Leverage" quadrant focused on improved services through new data (e.g., social media data or other external data sources) at the centre of business model considerations (project example: using social media data for traffic analysis and prediction). The two associated projects in the "Breakthrough" quadrant are start-ups looking out for completely new products/ services or business models (project example: using data from wearables and mobile sensors for emotion-based services).

Table 5: Strategic and managerial classification

Category / Pattern	**Projects**	**%**	**No.**
Optimise	3,5,7,8,9,11,13,16,17,18,20,21 24,25,26,29,30	57%	
Monetize	2,10,12,15,27,28	20%	6
Leverage	4,6,19,22,23	17%	5
Disrupt	1,14	6%	2

4.2 Data-infused business model classification

The majority of the projects (57%) were assigned to one business model category, the "data infused value creation" pattern (project example: analysis of internal log data for optimization of logistics processes). This is due to the high number of projects based on production data aiming for detection of process improvement potential. More than one-third of the projects (37%) heading for enhancements to the offered product or services via utilization of data out of the "creation" process (project example: monitoring and analysis of movement data for increasing security services at major public events). This category offers a wide range of activities starting with small digital add-on's to product/service up to completely new service offerings based on own "creation" data.

Two projects were mapped to the "New Data-Infused Business Modell" because in these projects changes were made in all three main segments of a business model (value creation, value proposition, value capturing). Project example: building up a common data-infrastructure for aggregated data sharing and analysis. None of the analysed projects was classified to "Data-Infused Value Capturing" and "Data-Infused Value Proposition via Capturing" pattern.

Table 6: Generic business model classification

Category / Pattern	Projects	%	No.
Data-Infused Value Creation	3,5,7,8,9,11,13,16,17,18,19,20,21,24,25,26,29	57%	17
Data-Infused Value Capturing		0%	
Data-Infused Value Proposition via Creation	2,4,6,10,12,15, 22,23,27,28, 30	37%	11
Data-Infused Value Proposition via Capturing		0%	
New Data-Infused Business Model (DiBM)	1,14	6%	2

4.3 Data-infused business model classification

17 projects were mapped into the "Data-enabled Improvement" pattern (project example: providing preventive maintenance functionality for production lines). Projects in this category did not lead to a change in the value proposition, but created value to the company in form of internal process optimisation. This category corresponds to the category optimization pattern from the BITKOM matrix; and the same projects were assigned to the Data Infused Value Creation cluster according to Schüritz. 11 projects were assigned to the "Data-enriched products and services" pattern (project example: using hybrid recommender engines for proposing suitable hotels). The additional value created out of this category is usually considered as a unique selling feature and is in most cases not charged.

The "Data-enabled Services" pattern matched for two projects which relate to the stand-alone characteristics (not related to the existing product/service) of the developed data-driven service. One project was mapped to the "Auxiliary Big-Data Services" category (project example: providing pattern search and detection for huge amounts of measurement data). No project was targeted towards direct data sales; hence we classified no project into "Data-as-a-service" category.

Table 7: Specific value proposition classification

Category / Pattern	Projects	%	No.
Data-enabled Improvements	3,5,7,8,9,11,13,16,17 ,18,19, 20,21,24,25,26,29	57%	17
Data-enriched products and services	2,4,6,10,15,22,23,27, 28,30	33%	10
Data-enabled Services	1,14	7%	2
Data-as-a-Service		0%	
Auxiliary "big-data" services	12	3%	1

4.4 Discussion of Results

Regarding RQ 1 (*What are the characteristics of the three applied classification schemes in terms of being able to differentiate and compare between examples for data-driven business model innovation?*) it can be stated that all three applied classification models do have certain pro's and con's in use for classification and evaluation of data-driven innovation projects regarding business model development.

The strengths of the BITKOM matrix lie in the area of strategic orientation. Considerations along the four quadrants could help to find the right gateway for further data-driven activities. Based on the experience of us, the matrix is less suitable for analysis and support of data-driven business model innovation processes. Nevertheless, it is an easy to use approach and a good starting point for reflections using data (existing/own or third party data) as a resource for creating (new) business value. Moreover, the BITKOM matrix visualizes three levels of increasing degree of innovation and increasing level of uncertainty

(Optimization →low uncertainty; Monetization and Leverage → middle uncertainty, Disrupt → high uncertainty) which could give an implication of the effort needed for implementation.

The data-infused business model classification based on Schüritz et al. (2016) requires a deep understanding of business model ontologies in order to apply the provided scheme. The outlined statements in chapter 4.2 reveal a deficit in utilizing data in the core business model component "value capturing", in other words how the value proposition is turned into (monetary) remuneration for the company. Our analysis shows that data and/or data analytics are barely used for identifying new customer segments or changing/adapting the revenue models. The classification results of Schüritz et al. (2016) displays a similar distribution into the five patterns as illustrated in Table 6. The analyses show a low use of data analytics in the marketing area.

The specific value proposition classification (see Table 7) illustrates the various uses of data in the central part of a business model. Similar to the other schemes there is a focus in the area of improvements and enriched products and services through data recognizable. Since there were just three projects assigned to "Data-enabled services" and "Auxiliary big-data services" a lot of data-driven business potential can be raised in these areas. This also applies to the pattern "Data-as-a-Service" which means selling data as common good including activities in data aggregation, storage and broking. Throughout the detailed breakdown of business value possibilities, this scheme can be used well for idea generation of data-driven use cases.

The weakness of the latter two schemes lies in the lack of data reference e.g. use of internal/external or existing/new data. All three models lack a meaningful demarcation between data-driven improvements or innovation (regarding processes and or services) and real data-driven business model innovations.

5 Synthesis: Data-Driven Business Value Matrix

In order to improve the above-mentioned classification models, we outlined a new classification scheme with regard to RQ 2 (*Which parameters should a classification scheme contain that maintain the strength and overcome the weaknesses and how* *does it look like?*). The new classification scheme depicted in figure 2 combines all positive aspects from the three analyzed classification models and resolves the identified weaknesses.

DDBM Improvement → DDBM Innovation

		Data-enabled Improvements (processes)	Data-enriched Products & Services	Data-enabled Services (stand alone)	Auxiliary (big) Data Services (AaaS/PaaS/DaaS)
DDBM Improvement ↓	Existing Data (internal/external)	Proj. 5	Proj. 10	Proj. 1	
	New Data (internal/external)		Proj. 10	Proj. 1	
DDBM Innovation	New Revenue Model (Pricing Model)			Proj. 1	
	New Customer Segments (Customer Group)			Proj. 1	

Figure 2: Data-Driven Business Value Matrix

The horizontally arranged parameters focus the value proposition aspects. The separate category "Data-as-a-Service" (see table 7) was assigned to the category "Auxiliary (big) Data Services" due to better affiliation. Analytics-as-a-Service (AaaS) and Platform-as-a-Service (PaaS) are also summarised in this category. The vertical axis covers data sources (existing, new, internal, external), value capturing aspect (new revenue model) and the customer perspective "new customer segments".

The latter two aspects are important for developing business model innovations. The introduced separation line between DDBM Improvement and DDBM Innovation should help to indicate if an existing or new use case or project (see classified project examples from analysed data set in Figure 2) belongs to the respective area. This demarcation should be seen only as an indication. As shown in Figure 2, project 1 (enhanced and new services through new data) is assigned to all four categories of a data-enabled service, which can be identified as an example for a data-driven business model innovation. In contrast, projects 5 and 10 (see Table 4) in Figure 2 are assigned to data-driven business model improvements due to not touching the DDBM innovation parameters.

The new classification scheme can be used for analyses and evaluation purposes of past and existing use cases/projects as well as for supporting the development process (exploration and design phase) of new data-driven business ideas.

DDBM Improvement → / DDBM Innovation	Data-enabled Improvements (processes)	Data-enriched Products & Services	Data-enabled Services (stand alone)	Auxiliary (big) Data Services (AaaS/PaaS/DaaS)
Existing Data (internal/external)	16	10	2	1
New Data (internal/external)	1	4	2	
DDBM Innovation: New Revenue Model (Pricing Model)			2	1
New Customer Segments (Customer Group)			2	1

Figure 3: Classified 30 data set projects into Data-Driven Business Value Matrix

In Figure 3, we assigned the 30 data set projects into the Data-Driven Business Value Matrix by summing up the projects which belong to each category. As projects can be assigned to more than one box, the overall sum exceeds the total number of projects. We also colour coded the matrix in form of a heat map.

The classification results support in principle the same statements described in the results chapter (see 4.1, 4.2 and 4.3) which points out that the majority of projects are realised in the "Improvement Section". The new classification scheme visualizes and demonstrates in more detail (value proposition, customer view and value capturing aspect) the widespread potential of data as a central resource for business model development.

6 Conclusion

The economic opportunities that promise the use of the resource "data" (own, existing and third-party data), are recognized by most companies and some are already gaining value out of it. Unfortunately, the potential of data-driven business is still underutilized, except for the area of optimization and incremental improvements. A fundamental reason for this inequality refers to the limited knowledge regarding the development process of data-driven business models.

The development of a new business model is generally challenging and especially when new data-driven technologies (machine learning, artificial intelligence, etc.) and capabilities (data analytics, data management, etc.) are needed and so far not established in organizations. Furthermore, the use of data for new products and/or services usually has a great influence on a large number of (also external) business processes or business model areas associated with e.g. new customer segments (new markets), new distribution channels, sources of revenue, etc. These changes are fraught with many uncertainties that are particularly challenging for established companies. The aim of the Data-Driven Business Value Matrix is to make a valuable contribution to the development process of data-driven business model innovation.

Limitations and Future Research

Overall, the selection of the projects and the relatively small number of analyzed projects implicates certain limitations. The broad spectrum of company sizes (LE, SME, Start-ups) and different domains impede concrete and general statements. Although the new classification scheme has already been used in business model workshops, a detailed evaluation of the scheme needs to be done.

Future research projects could address various sub-aspects of a data-driven business models such as specific competencies (data analytics, data management), technical infrastructure (server, cluster) or organizational challenges (integration of data scientists, set up of internal competence center). Furthermore, there is a need for "hands-on" field-tested DDBM frameworks, tools and methods, especially for companies with a well-established business model e.g. SMEs and large enterprises. If possible using the BMI path and tool approach (Heikkilä 2016) as a "blueprint" for developing a DDBM framework.

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Customer Attitudes Towards Participation and Health Data Sharing in the Digital Transformation of Finnish Insurance

MICHAEL PERSSON, CASANDRA GRUNDSTROM & GUIDO GIUNTI

Abstract The contemporary insurance ecosystem is digitally transforming to meet a myriad of emergent conditions pressured by an increase in available data. A paradigm shift necessitates new business models, digital practices, and customer relationships. To begin to understand the attitudes of customers within the digital transformation context, we conducted a large survey of Finnish insurance organization customers (N = 452). The survey gathered customer attitudes towards three factors of digital transformation: Participation in service development, visions and values of the service provider, and health data sharing. The results of the study offer a descriptive statistical snapshot of the attitudes of insurance customers in the Finnish case context relating to these topics; finding a lack of knowledge about the company digital strategy, a low perceived possibility to participate in the creation of services, a high level of trust, and a reluctance to share health data.

Keywords: • Digital Transformation • Insurance • Customer Participation • Health Data • Descriptive Statistics •

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1 Introduction

The European Commission (2018) considers digital transformation (DT) to be the key to unlocking future growth in Europe. To centralize the DT progress in Europe, the Commission proposed the Digital Europe programme, outlining a budget of €9.2 billion (projected through 2027) towards the transformation of Europe's society and economy. DT aims to describe the gradual alignment of the societal and organizational contexts— that is, a fundamental shift of business models, infrastructure, practices, and culture, towards the facilitation of digital factors in improving social and business outcomes. In the context of insurance, a DT process can involve modernizing digital infrastructure such as decentralized blockchain-driven alternatives (Gatteschi et al., 2018). While many of these solutions are currently in a nascent state, and far from market implementation, a significant amount of research and development is reshaping the insurance sector, and the ramifications of its DT are difficult to predict. Notwithstanding, there has been limited empirical research on digitalization in the insurance sector (Eling & Lehmann, 2017), and business leaders are struggling to implement effective digital strategies to leverage digital platforms with their customers (Probst et al., 2018).

The traversal of a successful DT represents a necessity for insurance businesses, and over the last decade has spurred a significant increase in the prevalence of digital strategies in the insurance sector. The expression of digital agendas has been shown to be positively correlated with business success (Bohnert, Fritzsche, & Gregor, 2019). Understanding how the digital strategy is received by customers and stakeholders may be a key factor of success for DT. Eling & Lehmann (2017) identified four major areas of improvement for the DT of the insurance industry: the customer experience, the business processes, the innovation of services and products, and the readiness for competition with other business sectors. Only one of these areas is explicitly concerned with customers, indicating that there may exist a lack of consideration towards understanding the role of the customer in the DT of insurance (Persson, Grundstrom, & Väyrynen, 2018). Tangentially, health data is an evergreen issue in the realm of healthcare insurance, acting as a key commodity and building block of digital service provision, but are heavily legislated and demand a high level of trust and transparency (Grundstrom & Karampela, 2018).

1.1 Objective

The focus of this study is contributing to research on DT by gathering data on customer attitudes towards factors of DT. To this end, we undertake a large customer survey as a part of a case study of Alpha, a Finnish insurance organization undertaking DT, expressed by a renewal of their digital strategy and their service offerings (Persson et al., 2018). Through a survey study of their customers, we investigate customer attitudes and perceptions towards health data sharing, the communication and evolution of digital strategy, and customer participation in service development, factors that may represent significant factors in informing the practices and processes of successful DT. As such, the objective of this descriptive statistical paper is to present and describe the data collected through the aforementioned survey of the insurance customers of Alpha.

2 Literature Review

In this section, we review aspects of customer participation of DT as well as particulars related to health data sharing.

2.1 Culture and Customer Participation in Digital Transformation

Moving towards a digital paradigm is often facilitated through the proliferation of digital development practices and cultural aspects found in the context of software development and service design (Calabretta et al., 2016; Kettunen & Laanti, 2017). These digital practices are commonly derived from the field of human-computer interaction (HCI) and characterized by ideals of democratic and user-centric rationales and a high focus on user experience. While HCI scholars are likely to argue that customer experience is an outcome that can only be derived from participation (Sanders, 2002), focusing on customer experience appears insufficient to properly outline the particulars of a high level of customer participation.

Tangential to the HCI context, service-dominant logic and value co-creation have been explored as a driver of DT in insurance (Weiß et al., 2016). Value co-creation has a strong focus on the roles of customers as active participants in the value creation process, and consider them resource integrators (Prahalad &

Ramaswamy, 2004; Vargo & Lusch, 2004). Customer participation in insurance contexts studied through the lens of value co-creation, has been shown to have a short-term positive effect on brand satisfaction and brand loyalty (Apenes Solem, 2016). Leading to positive effects on the motivation on employees, establishing that *"... understanding how companies can harness the benefits of customer participation is of great importance."* (Chen, Chen, & Lin, 2016, p. 493) Customer participation has also been found to increase the perceived process value of a service through new knowledge, developing relationships, and pleasurable experiences (Nguyen Hau & Thuy, 2016). Ethical issues around co-creation and organizational performance have also been explored, where exploitative practices are not necessarily rejected because they are explicitly illegal, but because co-creating stakeholders consider them morally reprehensive (Vial, 2019).

The mechanisms and practices which facilitate customer participation in innovation practices have been explored, but the effects of digitally enabled infrastructures on designs and participation is still unclear, and requires more research (Nambisan et al., 2017), although co-creation scholars remain optimistic about virtual or mixed platforms being suitable for co-creative and participatory practices in the future (Sanders & Stappers, 2008).

2.2 Health Data Sharing

The efficacy of traditional insurance models are diminished by the predictive power of big data in preventative healthcare services (Pikkarainen et al., 2018; Raghupathi & Raghupathi, 2014). Access to personal data to power preventative services is crucial for organizations towards facilitating DT (Huhtala, Pikkarainen, & Saraniemi, 2015). However, organizations face barriers to accessing personal and health data (Grundstrom & Karampela, 2018; Grundstrom et al., 2018). Notably, there are three key barriers acting both internally and externally to insurance organizations: institutional, legislation, and use and participation (Grundstrom et al., 2018). Legislation as a barrier addresses how insurance organizations are heavily regulated by both national and international regulations such as the *General Data Protection Regulation* (GDPR) (Grundstrom et al., 2019). The willingness of the customer to share data is affected by two of the barriers: Institutional, through a conflicting understanding of customer propensity towards data sharing and use and participation, through a lack of customer incentives. (Grundstrom et al., 2018). Willingness to share health data is influenced by perceived levels of trust with different stakeholders (King, Brankovic, & Gillard, 2012). Negative perceptions towards insurance companies arise from a lack of understanding of how data will be used, as concern of discrimination against individuals who share data is a highly prevalent stigma towards insurance organizations, where data may be used to prevent insurance coverage (Grundstrom & Karampela, 2018; Weitzman et al., 2012). As data are the driving force behind organizations during DT (Huhtala et al., 2015), understanding the customer's attitudes through metrics of trust and willingness to share health data may prove critical for DT in an organization moving towards a healthcare paradigm.

3 Method

In this section, we elaborate on the case study context, the survey and its creation, outline the selection criteria and the channels of distribution, and describe the collection, cleaning, and analysis process of the survey data.

3.1 Case Study Context

The survey is part of a larger exploratory case study (Yin, 2014) of Finnish insurance organization Alpha, summarized in Table 1. The Finnish context is appropriate for this study, considering its advanced position in the International Digital Economy and Society Index (DESI) as having the third most advanced digital economy in Europe (European Commission, 2018). The digital economy is considered a prerequisite factor in DT by the European Commission and Finland is ranked second in the Digital Transformation Enablers' Index (DTEI) suggesting the conditions within Finland support DT (Probst et al., 2018).

Table 1: Case description

Case	*Alpha*
Core business	Insurance
Size (2018)	Employees: ~3600 Customers: ~1.3 million
Market focus	Finland and Åland
Digital transformation overview	Alpha is undertaking a DT through the implementation of an overarching digital strategy, summarized and translated to "holistic life security", in which they aim to renew their service offerings through a shift towards the healthcare and wellness sector, and a more intrinsic and proactive involvement of the customer base towards their own wellbeing.

3.2 Survey Rationale

The topics of the survey were derived from a set of interviews carried out at an earlier stage of the case study, interviews intended to outline the perspectives of the insurance development managers within Alpha towards the role of health data and other contemporary challenges in the evolution of the company (Persson et al, 2018). Based on the notions of the insurance professionals, we decided that a customer survey would be an useful counterpart to the interviews for understanding the customer perspective of the DT of Alpha.

3.2.1 Survey Creation and Structure

The survey was designed to gather customer attitudes and perceptions of company values and visions, customer participation in the service design processes of the company, and health data sharing. Furthermore, the survey has sections relating to demographic data, current services with Alpha, how the survey was accessed, and social media usage. As the purpose of the survey was to gather perceptions of a large number of customers, we opted to formulate a collection of Likert-type statements (Likert, 1932). A Likert-type response format is used when *"the primary interest of the researcher is not to synthesize the stance of the participants per se but to capture feelings, actions and pragmatic opinion of the participants about mutually exclusive issues around phenomenon/s under study"* (Joshi et al., 2015, p. 398). While Likert-type questions normally have 5 or 7 response levels, we chose to use a symmetrical 6-point version. The omission of a neutral response option mitigates social desirability bias (Garland, 1991).

3.3 Survey Implementation

During the planning period, we collaborated with insurance organization professionals that presided over the customer channels and the Webropol survey distribution channel. A decision was made to generate interest for the study on social media, and as such the survey saw a one-time posting to the Alpha Facebook page.

3.3.1 Selection and Distribution

The selection sampling decisions were made in collaboration with insurance professionals at Alpha, and together we reached a consensus that distributing the survey to 5000 active customers (roughly 0,45% of their reported customer base) would give us a good chance of emerging out of the process with a statistically valid number of responses amounting to ~7% of the total surveys distributed, or a sample size of N=385. This targeted sample size would allow us a 5% margin of error with a 95% confidence.

The criteria for being selected are as follows:

- Active service with Alpha
- Registered email address with Alpha
- Over 18 years of age
- Given consent to automated marketing

These criteria were met by a vast majority of the Alpha customer base, although the customer database from which the population was selected may have had certain instances of anomalous data. With no explicit exclusionary criteria, the survey was distributed to a fully random selection of the target population. The distribution of the survey started on January 30th, 2018 and lasted until March 6th, 2018.

3.3.2 Collection and Cleaning

As the survey process concluded, our total tally of responses amounted to N = 513, a significantly higher sample than our projected N = 385 — a response rate of roughly 10%. A survey was determined ineligible if the participant was not an active Alpha customer or had reached the survey through social media. The final sample size was counted to N = 452, a larger sample size than required for the projected confidence level, with a narrower margin of error (4,6%). Through an internal validation process with Alpha, we ascertained that the demographics of our study sample are representative of the customer base of Alpha.

Given the randomness in the selection process, the number of respondents, the narrow margin of error, and the overlap of the selected sample with the full population, we conclude that the dataset is statistically valid.

3.3.3 Visualization of Survey Data

The visualization of the data was performed through use of IBM SPSS Statistics version 25. The Likert-type items were grouped into stacked bar charts based on their overall topic, with their frequencies divided into percentages of the entire population. The health data sharing sensitivity items were collated into a Likert scale towards determining a general attitude, through finding the mean of all the items and rounding them to the closest integer, and presenting the negative group (score of <=3) to the positive group (score of >=4) in a pie chart. In line with descriptive statistics (Rendón-Macías, Villasís-Keever, & Miranda-Novales, 2016), the results of this study are presented as-is, primarily through representations of frequency, and does not attempt to show strong statistical inferences or reach statistically validated conclusions in this stage.

4 Results

In this section, we outline the results of the study. Unless otherwise noted, the data presented in this section represents the full participant group (N = 452). Positive responses are coded in blue, and negative responses are coded in gray, and the Likert items are presented as gradients from **1** (Strongly disagree) to **6** (Strongly agree), left to right.

4.1 Demographics

Table 2: Demographics of survey participants

Gender	*Frequency*	*%*	**Age**	*Frequency*	*%*	**Education**	*Frequency*	*%*
Male	224	49,6	18-24	11	2,4	Primary school	32	7,1
Female	227	50,2	25-34	43	9,5	High school	145	32,1
Other	1	0,2	35-44	87	19,2	Some college credit	30	6,6
			45-54	99	21,9	Bachelor's degree	146	32,3
			55-64	104	23,0	Master's degree	98	21,7
			65-74	86	19,0	Doctorate degree	1	0,2
			75 +	22	4,9			
Total	452	100,0	**Total**	452	100,0	**Total**	452	100,0

The demographics of the survey participants can be viewed in Table 2. Some outliers in the data are Gender: “Other”, N = 1; Education: “Doctorate degree”, N = 1. Respondent age groups appear to follow a normal distribution, with fewer respondents on either extreme than in the middle, and the gender divide is near-equal “Male”: N = 224, “Female”: N = 227.

4.2 Customer Attitudes Towards Participation and Culture

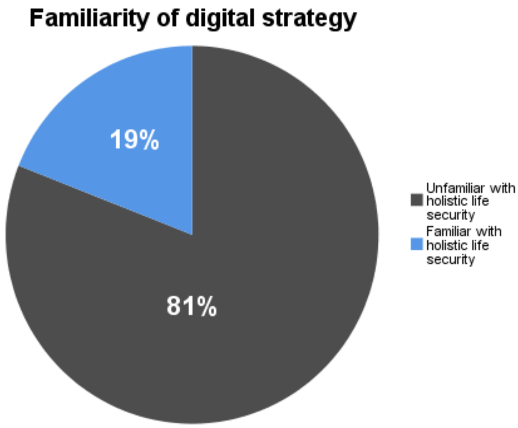

Figure 2: Familiary of digital strategy

We asked the participants how familiar they were with "holistic life security", the moniker given to the digital strategy enacted by Alpha. The question was formulated through the Likert-type statement and seen in Figure 1. We refactored the negative responses (Strongly disagree, disagree, and slightly disagree) into "Unfamiliar with holistic life security", and the positive responses (Strongly agree, agree, slightly agree) into "Familiar with holistic life security". This refactoring was done for clarity of presentation, justified through the fact that the percentage of "Strongly disagree" alone was twice as large as the sum of the positive responses (38% to 19%). As we can read from the Figure 1, over 80% of their customers reported being unfamiliar with the digital strategy of Alpha. The development of their new digital strategy and its intrinsic concern with the customer (Persson et al, 2018) as well as the expression of digital strategies having positive correlations with business success (Bohnert et al, 2019), makes this question relevant to understanding certain facets of Alpha's DT processes.

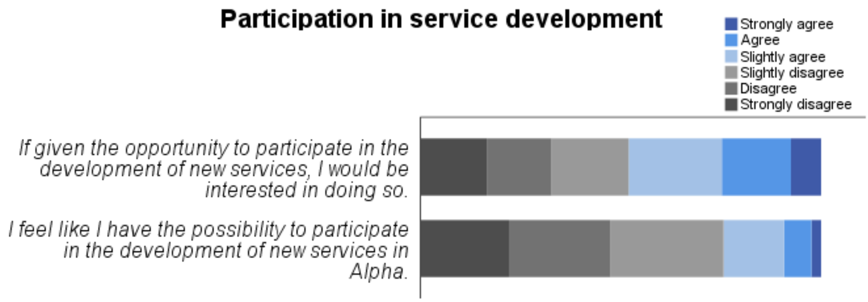

Figure 3: Participation in service development

Regarding participation in service development, we asked about two key concepts — whether the customer would be interested in participation, and whether the customer perceives a possibility to participate in the development of new services with Alpha (Figure 2). Roughly half of the respondents were positive towards participation given the opportunity, while only a quarter of them perceived the possibility of participation.

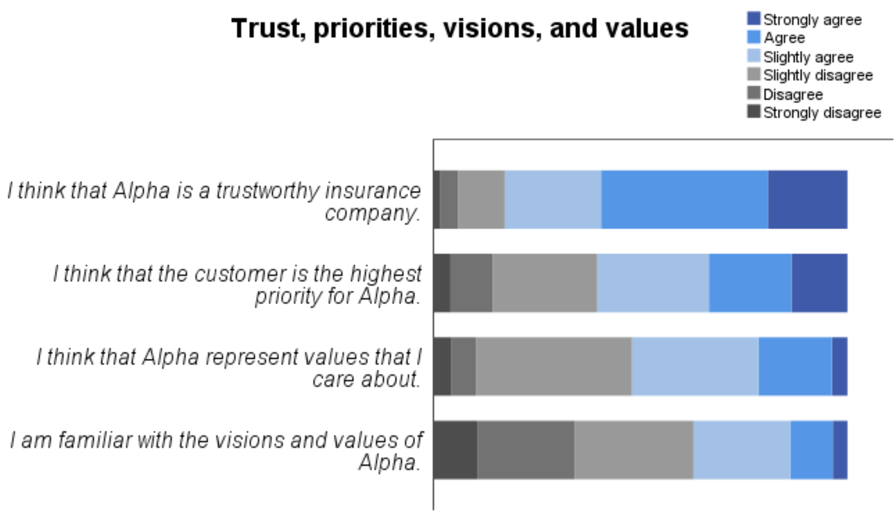

Figure 4: Trust, priorities, visions, and values

Towards measuring the customer perception of the organizational culture and values of Alpha, we presented the survey participants with four Likert-type statements (Figure 3). Despite being relatively unfamiliar with the visions and values of Alpha, and neutral in the belief that Alpha represents values that they care about, a large majority of the customers held Alpha to be a trustworthy insurance organization, and a slightly smaller majority agreed that the customer base is the highest priority for Alpha.

4.3 Customer Attitudes Towards Health Data Use, Sharing, and National Rights

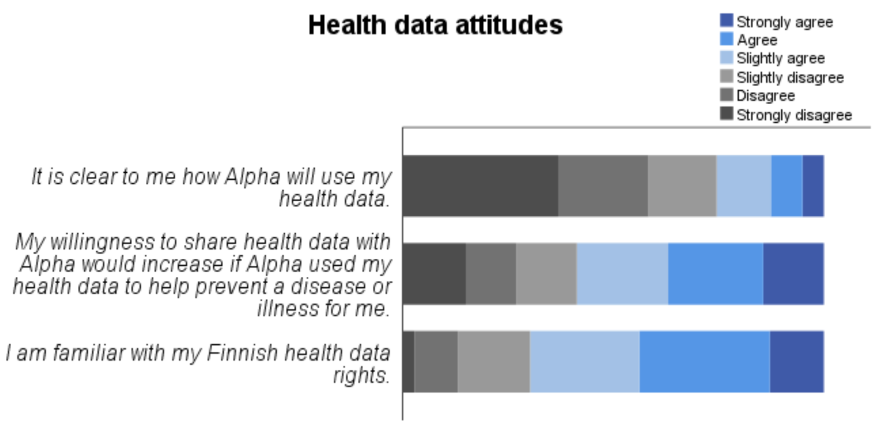

Figure 5: Health data attitudes

Statements regarding the use, the sharing, and national rights of health data were presented to customers in the form of the Likert-type items shown in Figure 4. First, clarity of use, intended to find how transparent Alpha was in communicating health data use, which a large majority of customers indicated to be poorly understood. Second, the willingness of customers towards health data sharing with Alpha assuming their data would be leveraged to create positive health outcomes for the customer, was examined. Under this caveat, around 60% of the customers were positive towards the sharing of their health data with Alpha. Lastly, we asked the customers to gauge their awareness of their Finnish health data rights, which roughly 70% of the customers considered themselves familiar with.

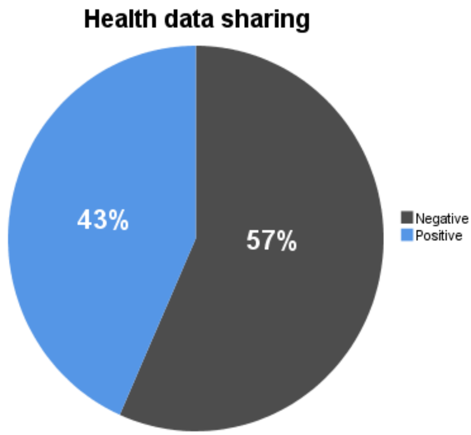

Figure 6: Willingness to share health data (mean)

Within the health data section of the study, we also asked the customers to evaluate 12 different types of health data to be shared. These categories of data were aggregated from other health data sharing sensitivity types from mixed methodology research in survey and questionnaires (King et al., 2012; Weitzman et al., 2012) and combined into a scale of general customer health data sharing attitudes (Figure 5). The customer attitudes towards health data sharing are skewed towards the negative.

5 Discussion

In this section, we will summarize the descriptive statistical results of the study and outline possible implications for research and practice for DT.

5.1 Customer Participation

The significant difference we can see between the perceived ability for a customer to participate and their reported willingness to participate is an interesting venue for further exploration. If customer participation is more limited by the customers feeling that participation is not possible than it is by their willingness to participate, it suggests that the onus is on Alpha to transform their company culture and digital practices towards leveraging customer participation in their

DT process in general, and service design processes in particular, in line with the notion. Engaging their customers with their digital strategy may be a good first step towards this objective, as the survey revealed that a significant majority of customers lacked familiarity with the aforementioned strategy. As the value networks of an organization grow increasingly complex during a DT process, adopting agile customer-inclusive practices (Kettunen & Laanti, 2017) and developing ways to sustain the advantages of co-creation (Apenes Solem, 2016) may be critical to the success of a DT process. We believe that the customer perspective is a dimension of DT that stands to benefit the managerial practices and understanding of the field going forward.

5.2 Trust and Knowledge about Organizational Values

Examining the organizational culture is an important factor towards understanding the relationship between an organization and their customers. Studying the interplay between factors of participation, data sharing, and trust, some cursory patterns appear. For instance, there appears to exist an inherent trust in Alpha, despite a limited understanding of their visions and values, and an even more restricted understanding of their digital strategy. This suggests either that knowledge of Alpha's visions and values is not of strict importance for customer trust, or that customers trust Alpha despite not being having insight into their organizational culture. Since potential feedback loops between organizational DT and customer behavior and expectations are under-researched (Vial, 2019), more customer/stakeholder-focused research is required to move towards an understanding of these relationships and their impact on the DT process.

5.3 Health Data Sharing

The survey focused on different areas of health data, including sharing and use of health data, and familiarity of health data rights. Access to data is crucial for organizations and therefore understanding the customers' attitudes towards health data sharing in the context of private insurance organizations is crucial for DT (Huhtala et al., 2015). Minimal acts of transparency for intended health data use by Alpha is a central component of establishing trust between individuals and private organizations (Grundstrom & Karampela, 2018; Weitzman et al., 2012). The overall attitude towards sharing different types of health data, such as past medical history, is slightly more negative (57%) than positive (43%). However, this aggregate is not as negatively inclined as other studies have shown. Examining the results of a Canadian study, 67% of patients did not want private insurance organizations to have access to health data (Perera et al., 2011). Willingness to share health data was reported by customers as likely to increase on the contingency that Alpha would personalize preventative actions for diseases in the customer's lifetime. Finally, the reported familiarity of health data rights for customers was very high, which could potentially be explained by the survey being contemporary with the heavy publicization of the upcoming GDPR.

5.4 Conclusions and Future Research

In this process, we set out to contribute to the theories of early stage DT, which represents not only something of a renaissance of service provision but also a shift in the relationships between customers and service providers. The customer survey offers a snapshot of customer perceptions related to potentially impactful factors for successful DT in the Finnish insurance service context: customer participation, trust, knowledge regarding organizational values and digital strategy, and health data sharing.

The resultant data of this survey study are planned to be juxtaposed with the qualitative interview studies of the service developers and managers gathered as a part of the case study of Alpha. Furthermore, the Likert-type items found in the survey will be subject to statistical interpretation and validation in a future study.

Towards a more holistic understanding of the practices and processes of DT, further customer-based studies are required, in a wide variety of digital ecosystems. We strongly encourage contributions to an explicit customer perspective of DT through research and collaboration with insurance companies and other service ecosystems. More actionable customer research is needed to be able to create a better understanding of the impact of customer attitudes towards participation and data sharing as factors of digitally transforming an organization.

5.5 Limitations

As this survey was carried out as a part of a case study of a single insurance organization in a single context, the results cannot be easily generalized to a wider geographical scope. The survey data is also not subject to statistical interpretation within the scope of this paper, which makes the contribution less actionable. Finland is similar to other Nordic countries in its high prevalence of social policy compared to many non-Scandinavian contexts, which may be reflected in the levels of trust its citizens appear to hold towards the insurance sector.

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Understanding the Creation of Trust in Cryptocurrencies: Bitcoin

VENKATA MARELLA, BIKESH UPERTI & JANI MERIKIVI

Abstract Compared to traditional financial services, cryptocurrencies lack any kind of institutional, monetary, or legal backing. Yet, the popularity of the cryptocurrencies remains intact despite several adversaries. In the context of lacking basic premises as a financial tool, these cryptocurrencies provide security and earn users' trust via under-lying technologies. Despite the presence of a plethora of research in both trust and cryptocurrencies, there is a clear lack of research on what factors of the underlying technology drive trust. To uncover the factors contrib-uting to building trust, we analyzed 1.97 million discussion posts related to Bitcoin, the oldest and most widely used cryptocurrency. From the theory, we found out that functionality, reliability, and helpfulness are the con-structs to evaluate the trust in technology. Based on our analysis, we discovered 11 different factors related to three constructs of technology garnering users' trust in Bitcoins. Our results highlight factors that require atten-tion to developing new technologies that users can trust.

Keywords: • Cryptocurrency • Trust • Functionality • Reliability • Helpfulness • Bitcoin •

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1 Introduction

Trust has been and still remains a core component of financial transactions and payments. Individuals need assurance that the transactions they make are processed and completed fair and safe, a requirement that puts financial intermediaries (e.g., commercial banks) and central banks in the business of trust (Nelms, et al., 2017). These financial intermediaries guarantee the security of the customer's account and financial transactions. Customers trust these financial intermediaries and pay some amount of money as a transaction fee for their services. Unfortunately, such a trust was recently put to test due to failures in accountability and transparency due to events like the collapse of Lehman Brothers (Marella, 2017). This led individuals to look elsewhere for new alternatives, such as cryptocurrencies, which at the advent of Bitcoin in 2009, gained slow yet enduring popularity.

Cryptocurrencies (e.g., Bitcoin, Ethereum, and Ripple) are defined as digital cash where cryptography is used to ensure the security of the transactions, and to govern the supply of digital coins in circulation (Davidson & Naveed, 2014). There are three key drivers that set cryptocurrencies apart from paper monies. First, they have no central authority, and, hence they are claimed immune to government interference and manipulation. This makes them a viable alternative especially in countries with volatile currencies and unstable economies (Brett, 2016). Second, and perhaps even more importantly, cryptocurrencies draw on blockchain technology (i.e., distributed and consensus-based database with a high cryptography and transparency), which enables the use of a distributed and immutable ledger, making every transaction tamperproof – thus eliminating the requirement of a trusted third party (Zheng, et al., 2017). Third, due to their digital nature cryptocurrencies can be easily used across international borders.

While technology sets individuals free from the business of trust, cryptocurrencies do not exist without evil. Further, compared to other financial tools cryptocurrencies suffer four shortcomings. First, since they are not backed up by any institution or legislation, and while this takes out the transaction fee, it also makes cryptocurrencies unpredictable, volatile, and risky (Brezo & Bringas, 2012). Second, cryptocurrencies are typically pseudonymous, meaning that users are identified by their public key address (a 32-bit string with a combination of characters and numbers), rather than their name and social security.

Consequently, this makes cryptocurrencies an easy tool for money laundering, tax evasion, and illegal trade in drugs and weapons (Brezo & Bringas, 2012). Third, Bitcoin and all other cryptocurrencies do not have legal status as an investment option in many countries yet. Therefore, buying or selling Bitcoins from these countries would be extremely difficult. Hence, there are several uncertainties and barriers involved with cryptocurrencies. Finally, the value of cryptocurrencies is extremely volatile for a wide variety of reasons including the cyber-attacks on the wallet (i.e., software that stores your private and public keys one needs to send and receive cryptocurrency), and exchanges (i.e., online intermediaries that help buy, sell, or exchange cryptocurrencies for other currencies).

Both the online financial services and cryptocurrencies rely on underlying technologies to secure transactions, except cryptocurrencies lacking institutional backing of central authority. The use of cryptography is driven by trust in technology in cryptocurrencies whereas traditional financial services benefit from an extra layer of trust from the institution. In the absence of basic legal and institutional premise, cryptocurrencies demand trust, not in people but in technology (Jarvenpaa & Teigland, 2017) (Ostern, 2018) as the security of financial transaction depends upon the underlying technology. The soaring popularity of cryptocurrencies implies that there are still millions of enthusiasts willing to trust in the underlying technology and try out cryptocurrencies.

Despite the wealth and diversity of research on cryptocurrencies and trust in technology (Lankton, McKnight and Thatcher, 2014), only a few studies have so far examined trust and technologies within the cryptocurrency domain ((Ostern, 2018); (Walton & Dhillon, 2017)). What is still lacking is knowledge of the attributes that add to individuals' trust in technologies (e.g., blockchain, cryptocurrency wallet, and exchanges) when they apply them for a particular purpose. That is, **what attributes of a set of technologies foster trust in a cryptocurrency domain?** Bridging this gap is of crucial importance since locus of trust is shifting from people to technology (Jarvenpaa & Teigland, 2017) (Lindman, et al., 2017). In addition, using technologies fostering the transactions of cryptocurrencies must come with low risk and uncertainty (Xin, et al., 2008). Understanding what specific attributes of technology increase trust comes thus with a managerial implication: technology designers and business professionals learn what technology attributes are most relevant to existing and potential users.

The findings are also beneficial for other domains like governance (e.g., voting and taxing) or healthcare (e.g., incorruptible medical data) where reliable technology is a must (Beck et al., 2017).

The paper unfolds as follows. First, we offer a brief introduction to cryptocurrencies and the underlying technology. We then adopt a theoretical framework, which links trust in technology to three constructs: functionality, helpfulness, and reliability (Lankton & McKnight, 2014). We use these constructs to better understand what develops trust around cryptocurrencies. As for empirical evidence, we focus on Bitcoin, as it is the most popular and widely used cryptocurrency (Lindman, et al., 2017). To understand how trust links to technology, we analyze 1.97 million posts extracted from a popular cryptocurrency forum (Bitcointalk.org). Our analysis of the bitcoins related posts builds on text content model employing *doc2vec,* a deep learning model for text data, proposed by Le and Mikolov (Le & Mikolov, 2014). The results report the technological features semantically closest to each of these three trust constructs. We will conclude the paper with a discussion.

2 Background

2.1 Underlying technology

Cryptocurrencies rely on three technological elements: blockchain, cryptocurrency wallets, and exchange platforms. Of these, blockchain technology is the backbone cryptocurrencies. It can be defined as a decentralized and distributed database that is shared across a network of computers called nodes (Narayanan, et al., 2016). Each node in the network has access to the data on the blockchain. Each block contains the unique identifier termed hash, which is determined by the content of a block and is inputted to the next new block. A new block, which is created every ten minutes, contains the hash value of the previous block and content of its block. Backdating, revising, tampering, or deleting any of the blocks will also change the hash value, which then creates a mismatch between the blocks in the blockchain. This property of the blockchain makes it a trusted network, since changing block data would require changing the hash value of every subsequent block and this must be computed faster than other nodes in the network can add new blocks to the chain. The following simplified diagram represents the data structure of the blockchain.

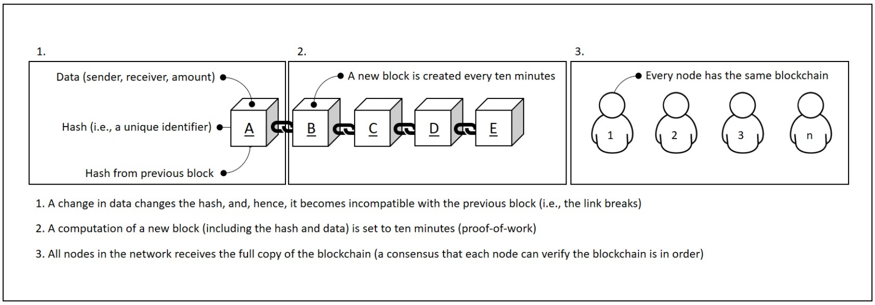

Figure 1: A simplified representation of a blockchain data structure

A Cryptocurrency wallet is a software program that stores public and private keys of the account and can interact with blockchain to enable to manage the account. These wallets make the transfer of cryptocurrencies easier (Anon., 2017). However, they are vulnerable to cyber-attacks and which cause a loss of value to the cryptocurrencies. A cryptocurrency exchange is a web-service that provides its customer's services for the exchange of cryptocurrencies into various assets such as fiat or other digital currencies (Anon., n.d.). Exchanges buy the cryptocurrencies from sellers and sell to the buyers. Some of the reputed exchanges include in Coinbase, Kraken, Bitstamp, etc. Cryptocurrency Wallets can be either stored on a hardware device, or a wallet software that can be saved either on the computer or with an exchange.

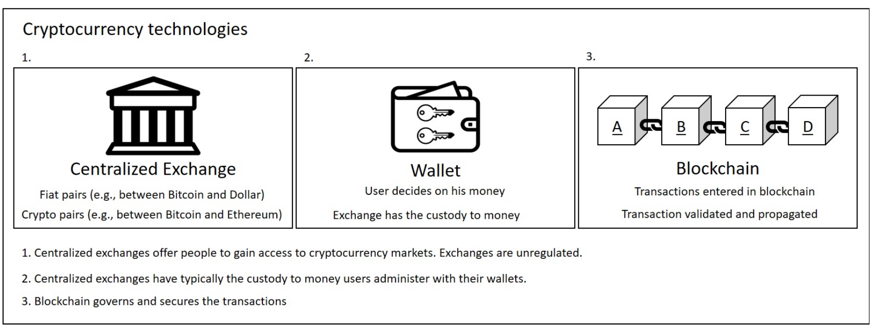

Figure 2: Cryptocurrency Technologies

2.2 Trust in Technology

Trust refers to the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other party will perform an action important to the trustor, irrespective of the ability to monitor or control that other party (Mayer & Davis, 1995). Trust is a dynamic concept that develops over time. Trust is an individual's reliance on another person under conditions of dependence and risk (Roderick & Tom, 1996). Reliance allows the fate of one person to be determined by another. Trustor is a person who holds certain expectations about the other party, while the trustee is a person or an entity that is assessed by the trustor (Beerra & Gupta, 2018).

While trust is studied extensively and with varying perspectives (McAllister, 1995) (Ruyter, et al., 2001), also in IS research (S. Jarvenpaa, 1997) (P.A. Pavlou, 2004), research on trust in technology is still in its infancy, yet very much demanded. McKnight et al. (McKnight, et al., 2011), for example, note that besides building trust in other actors (e.g., sellers and buyers) and agents (e.g., operators and intermediaries), users tend to also trust in technology. While trust in technology excludes moral volition since technology has typically left moral conduct and decision-making to its users it seems to hold especially true when technologies, such as blockchain or other self-sufficient artifacts, eliminate the third parties. With these technologies, users have no option but to make themselves vulnerable to the capacity of technology to help achieve their goals (e.g., A smartphone user trusts that it connects well to the internet). Therefore, the question goes: "what is it about technologies that make individuals find them trustworthy?"

The current trust in technology literature employs two different types of trust constructs in technology. The first one is the human-like trust constructs, such as benevolence, integrity, and ability. The second set of constructs are system-like constructs, such as helpfulness, reliability, and functionality (Lankton et al., 2014). While benevolence, integrity, and ability are the trusting constructs in humans, these characters would translate into helpfulness, reliability, and functionality when it comes to trusting the features of the technology. The underlying idea behind associating these trust constructs to technology is that they reveal what specific features add value (McKnight, et al., 2011). That is, if a user believes that blockchain survives from malicious attacks due to decentralization, then it is likely that the user perceives this feature trustworthy, and, hence, valuable (Thatcher, et al., 2011).

Concerning the three trust constructs proposed by McKnight et al. (Mcknight *et al.*, 2011) and empirically validated by Lankton et al. (Lankton et al., 2014) , ability refers to the belief that the trustee has skills that help the trustor achieve the desired function (e.g., a translator with an ability to translate texts from one language to another language). Functionality is conceptual very similar to ability or competence. It refers to the belief that the specific technology has the capability, functions, and features, to do the required task (e.g., software that translates texts from one language to another language). Integrity is the belief that a trustee would associate with a set of principles that are acceptable to the trustor (e.g., a translator that translates texts from one language to another language during office hours). Reliability is like integrity and can be defined as the feature that technology operates consistently over a period (e.g., software that translates texts from one language to another language at all times). Benevolence is the belief that trustee has a motivation to do something good to the trustor besides being profitable (e.g., a translator who besides translating texts from one language to another language during office hours advice where to take the texts that needs be translated outside office hours). Helpfulness is like benevolence and described as the belief that technology provides adequate and responsive assistance for users via their help features (e.g., software that besides translating texts from one language to another language at all times guides on how to enable the speech recognition feature). See Table 1 for the three constructs.

Table 1: Constructs of Trust in Technology (Lankton et al., 2015)

Constructs	**Human-like comparison**	**Description**	**Operations**
Functionality	Ability	Functions needed to accomplish the expected tasks	Performs a function for the user, provides system features the user needs to do a task, provides the user with the appropriate functionality
Reliability	Integrity	Continually operating properly or in a flawless manner	Performs functions reliably, does what the function says it will do, gives accurate and unbiased facts and information, calculates correctly, does not crash
Helpfulness	Benevolence	Providing adequate and responsive aid	Provides help, understands and caters to needs, does not cause harm, is responsive to user needs and requests

In this study, we adopt the above three constructs and anchor them to the underlying cryptocurrency technologies (i.e., the blockchain, cryptocurrency wallet, and exchanges) described earlier in this chapter. We acknowledge that individuals intending to use or already using cryptocurrencies may have different expectations about these technologies than those using them for other purposes (i.e., features that cryptocurrency users trust in these technologies may not be the same features that actors in the music industry, who care about intellectual rights, trust in them). That is, the features these trust constructs a link to are context-dependent and this is because the uncertainty technology arises among users depend on their goals. To tap into this contextuality, we seek to identify the key trusted features with user-generated data over the years, which helps us uncover trust characterized as persistent.

3 Method

In this section, we will talk about our data collection process from the popular online Bitcoin forum. Later, we end the section by describing our model in detail.

3.1 Data Collection

Our objective is to understand how the Bitcoin earned trust from its users' despite being faceless and devoid of any legal and institutional backing. In this context, discussion forums have played a crucial role in the growth of Bitcoin, as the users engage in the discussion and interaction to share knowledge and information. Among various online discussion forums, "Bitcointalk.org" is the most popular and the oldest online forum with a large user base. We base our analysis on the bitcoin-related discussion posts collected from "Bitcointalk.org" for two important reasons. First, compared to other data sources, online discussion platform acts as a good alternative to source data as the discussions, interactions, opinion and the flow of information can be accessed on an unprecedented scale. Second, discussion data do not condition the study or experiment to be conducted but rather generated naturally by the users. This allows us to infer the technology attributes related to trust in Bitcoin from the users' own statements and words that were used to address the users' concerns or sharing information within the Bitcoin community.

To collect data from the discussion forum, we wrote a web scraping script using python package "beautifulsoup[1]". As our objective is confined to Bitcoins only, we limit our analysis to general discussions on Bitcoins covering 3 subtopics, such as legal, press release and legal. We downloaded about 2 million discussion posts, from March 1, 2012, to September 21, 2018 that included original posts, replies, date of the post, and the details about the users who posted.

3.2 Text modeling

Our approach requires us to identify the factors that contributed to creating trust among Bitcoin users. The first step in this direction requires us to identify the posts that relate to trust. A naïve approach would be to use a simple keyword

[1] https://pypi.org/project/beautifulsoup4/

search to retrieve trust related posts. However, such an approach entails two fundamental issues. First, discussion posts are user-generated data where users are not obliged to adhere to the grammatical form and correctness in writing. Further, users can use all different combination of words to mean trust. Second, a keyword-based search for trust returned us over 10000 posts. With this large amount of search results, identify relevant posts requires manually reading all the posts which are both time and resource consuming. Moreover, ordering the post on the trust scale is a difficult task considering it requires developing a consistent and reliable rating method and overcoming the variance among the ratters. To circumvent these issues, we rely on the vector representation of word and documents generated using paragraph vector, also known as doc2vec, proposed by Le & Mikolov, 2014 (Le & Mikolov, 2014). In learning the semantic similarities, doc2vec methods have shown superior performance to competing methods ((Dai et al., 2015), (Le & Mikolov, 2014)). The root of paragraph vector method lies in the usage of the neural network to predict the word near the word. In this neural network-based method, a vector of weights is trained to maximize the prediction of the nearest word for a word in a given context. Like a classification problem, the model learns the network weight to maximize prediction of the nearest word. However, unlike the classification problem, these networks output the learned weight as a vector as a semantic representation of text rather than the final prediction from the model. These vectors, word embeddings, are considered as the good representation of the text as they capture semantic similarities by contributing to the nearest word prediction task. Mikolov et. al, 2013 reported state-of-art performance in learning semantic similarities and relationship. For instance, the word vector method could produce a relationship such as "Paris – France + Italy = Rome" (Mikolov et al., 2013). Later this idea was extended by Le & Mikolov, 2014 (Le & Mikolov, 2014) as a paragraph vector, also known as doc2vec that could learn the semantic representation for both the words and documents in same vector space. Their approach involved important improvements such as this method was the ability to retain word order, unlike methods like Bag of words and also allowed the text of variable length.

To train doc2vec model, we relied on implementation provided by python package "Gensim" (Rehurek & Sojka, 2010). Among available models, we trained three different variants of doc2vec model, paragraph vector with a Distributed bag of words (PV-DBOW) with doc vectors only, PV-DBOW in a skip-gram mode with word vectors trained with document vectors and PV- with distributed memory (PV-DM) using sum. Due to the huge resource requirement in estimation PV-DM with concatenation, we omitted it from our potential model alternatives. In training models, for all three doc2vec models, we set same model parameters; the size of the vector to 300 dimensions, context window size of 10, minimum word frequency to 5, and epochs to 50. Here, vector size refers to the dimension of vector outputs for both word and document vectors. Similarly, context window size refers to the length (number of words) that is considered as a context. In our model, while learning the semantic relationship, our model considers 10 words at a time in a sliding fashion for each document. Given that the post can be of varying length, we consider the context window size of 10 to be a reasonable choice. Similarly, epoch refers to the number of training iteration and we train our models with 50 iterations, well above the practice of 10 iterations. After training models, we manually evaluated the word and document similarity in randomly selected 20 words. The results showed that Paragraph vector with a distributed bag of words with documents and words trained together performed better in comparison to other models and thus was our preferred choice.

Figure 3 summarizes the methodological approach used in the analysis of discussion posts collected from our 'Bitcointalk.org". Our methodology involves cleaning and pre-processing of text followed by training doc2vec model. Once the model is trained and preferred model is selected, we analyzed data building upon two sets of output from doc2vec model; a) word vectors, semantic representation of words in the collection of posts b) document vectors, semantic representation of the actual posts. To analyze the data, we first extracted fifty posts closet to the keywords related to the constructs, "reliability, functionality, and helpfulness". Given a word, the doc2vec model can return similar documents, words with similarity score using cosine similarity. The cosine similarity is computed over the vector representation of the given words and the closest word or document vectors with the highest cosine similarity score is returned. Since these vectors are learned from data exclusive to bitcoin discussions using several context windows with the given words, we deem it's as a suitable method to extract relevant posts.

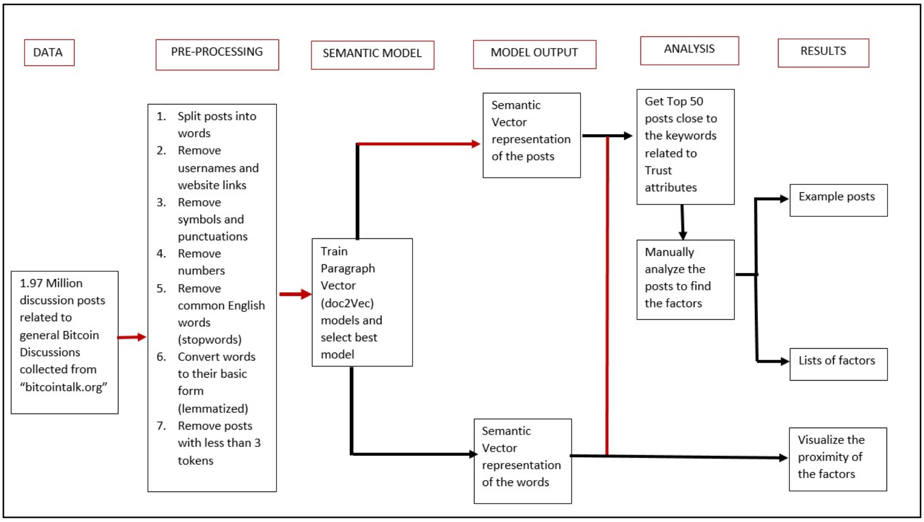

Figure 3: The Methodological approach used in the analysis of data

Once the posts are collected, we read through the posts to identify the factors from the posts. Based on identified factors we present our results in terms of a description of these factors with example posts. Additionally, we also visualize the proximity of these factors, to trust, based on the word vectors learned from the data. Since the word vectors are in 300-dimensional space, we visualize these word vectors in two-dimensional space reduced using Multi-dimensional scaling (Buja et al., 2008). The 2-dimensional plot visualizes the semantic closeness of the semantic vectors of identified factors and the semantic vector of trust.

4 Results

Our analysis is built on the output from doc2vec model of discussion posts. To identify the factors related to trust, we first extracted fifty most similar posts to the keywords related to the trust-related constructs; "Functionality", "Reliability" and "Helpfulness". The most similar posts are based on the similarity score between the word vector of the constructs and the posts. To search for the constructs, we listed our keywords that are often used about the existing technology and institutions in financial transactions. For instance, to represent the functionality, we searched for keywords such as Performance, Quick Transfer, Purchases, and Payments. Similarly, in identifying reliability related posts, we searched for posts closest to the keywords like Stability, Regulations and knowledge. Finally, we used keywords words like Investments, Profits, and, Alternative Currency as words associated with Helpfulness construct. In total, we searched for posts related to constructs using seventeen keywords (four related to functionalities, nine for reliability and four for helpfulness) and extracted the top fifty posts for each keyword. We read through and analyzed these eight hundred fifty posts and found eleven factors relate to three constructs functionality, reliability, and helpfulness. Table 2 lists the factors as features with the description and similarity scores. Additionally, the table also links Trust factors related to functionality and reliability, to the technology/technologies that are exclusive to bitcoins and cryptocurrencies. The table links three technologies such as Blockchain technology, Cryptocurrency Wallet, and Cryptocurrency exchange to Trust related factors. Finally, we mentioned the similarity with the given keywords and the content of the post with a similarity value mentioned next to the post. Similarity value one refers that the post is completely like the keywords and a similarity value zero refers that post is not like the given keywords.

Table 2: Constructs of Trust in Technology * Similarity value expresses how semantically sim-ilar the feature (keyword) is to the words the given post contains. The closer the value is to one (1), the higher the similarity; ** B = blockchain, W = wallet, and E = exchange

Constructs	Example post [similarity value]*	B**	W**	E**
Functionality				
Transfer (ease and affordability of transactions)	*"Bitcoin is better than cash because it can be transferred easily." [0.64]*		X	
Decentralization (shared ledger)	*"I believe, bitcoin is more valuable. Because it is trusted, decentralized, our interest and our investment in bitcoin which makes it valuable." [0.65]*	X		
Immutability (tamperproof ledger)	*"Bitcoin will never end or will never be destroyed. The system is secure and the blockchain is*	X		

	immutable and more and more people are joining the network to make it better." [0.54]			
Openness (Public Ledger)	*"The openness is striking. This is the kind of thing we need in this economy. Security and transparency. Thanks for sharing this." [0.54]*	X		
Reliability				
Stability (high volatility)	*"The main factor that scares people from investing in it is the risk factor. People find it risky because Bitcoin's price is not steady…."[0.63]*		X	X
Regulation (regulations posed cryptocurrencies promotes trust and reliability)	*"Bitcoin can never die regulation can only make it to be strong and trusted by many people." [0.63]*	X		
Security (hacking, stealing, and fraudulence)	*"[…] My BTC address from Zebpay account having almost 0.01550 BTC has been hacked and the amount has been stolen just few days ago….." [0.61]*		X	X
Knowledge (simplicity/complexity of cryptocurrencies)	*"Knowledge and understanding will keep people in getting into cryptocurrency because definitely he can understand analyse….." [0.61]*	X	X	X
Helpfulness				
Investment (value expectations)	*"I mainly use bitcoin as investment for future and sometimes I purchase goods with bitcoins." [0.66]*			

Profits (Earn profits in a short period)	*"The main advantage for me-with the help of investments in bitcoin, you can earn quite a large amount of money."[0.59]*
Alternative Currency (to fiat currency	*"This is the great news for iran and uzbekistan. as they are consider as third world country. they are mainly suffering from currency .." [0.58]*

Our research findings suggest that Coin Transfers, Immutability, Openness, and Decentralization are the functional factors of Bitcoin that created Trust among the users. Many users felt that transferring Bitcoins is much easier and quicker than transferring fiat money. Immutability in Bitcoin means the transaction histories recorded on Bitcoin Blockchain cannot be manipulated, deleted, or revised (Low & Teo, 2017). Similarly, openness refers to the property that the information on the blockchain is available to the public. The feature of having a robust publicly available distributed blockchain creates trust among Bitcoin users (Berke, 2017). The Decentralized structure, Openness, and Immutability are the unique features of the Blockchain technology and are major factors contributing to trust creation among Bitcoin users.

In reliability, we found that factors like stability, regulation, security, and knowledge of Bitcoin would make Bitcoin a reliable technology. Bitcoin is often criticized for its volatility (Bouoiyour & Selmi, 2016). Users expressed concerns about the volatility in the value of Bitcoin. They strongly felt that the stability in the value of Bitcoin would make it more reliable. Secondly, contrary to a certain segment of the user's beliefs, many users believed that the regulations would make Bitcoin more reliable and convince many others to use it. According to the article written by Kaplanov in Loyola Consumer Law Review (Kaplanov, 2012), Bitcoin would flourish under legal regulation. Thirdly, users were also worried about the security of the wallets and cryptocurrency exchanges due to the cyber-attacks on various wallets and exchanges. During the first half of 2018, cryptocurrencies worth 1.1 Billion dollars were lost in cyber-attacks (Rooney, 2018). Improved security measures by exchanges and individual wallet holders will make Bitcoin very reliable. Finally, users who had a better understanding of the technology behind Bitcoin felt more secure about it. They understood the situation better and were able to make a better investment decision to gain bigger profits.

With regards to the factors related to the helpfulness of Bitcoin, many users agreed that Bitcoin was a great investment tool to earn profits in the short term. The acceptance of Bitcoin as a payment system has not completely evolved yet (Pollock, 2018). Most users consider Bitcoin helpful as an investment option rather than a payment tool. Finally, Bitcoin turned out to be an alternative currency for people living in countries with volatile fiat currency. Though Bitcoin is highly volatile, the technology makes it possible to easily buy them. Hence, it serves as an alternative currency in those countries.

Once the factors related to trusts are identified from the posts, we also explored their semantic closeness to trust. For the purpose, we plotted word vectors of these factors with the word vector of trusts. Since the word vectors are learned from the actual data generated by the discussions among the users from the Bitcoin community, relative positions of these factors and trust help us to visualize how close or far these factors are in the actual discussion. Figure 4 plots the vector representation of the factors and trust in two-dimensional space vector space obtained by applying Multi-Dimensional Scaling (MDS) (Buja et al., 2008). The figure shows that openness and immutable, the unique functionality of bitcoin, are closer to the trust. This proximity implies that in the bitcoin-related discussions these unique functionalities, among all factors are closely associated with trust. Further, factors related to profit and transfers are close to each other whereas factors like regulation, security and stability are close to each other. Deviating from our expectation, the Decentralized structure as a factor of trust remain further away from all factors including trust.

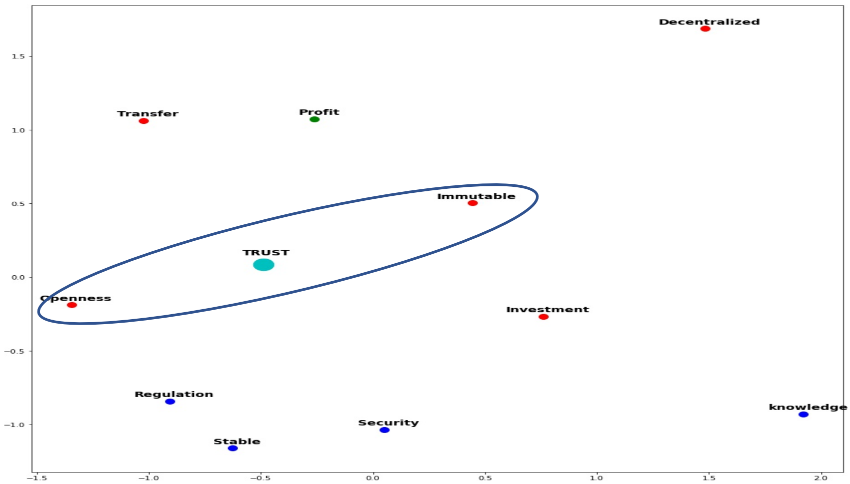

Figure 4: Semantic proximities among Trust and the associated factors

5 Discussions and Conclusion

In this study, we aimed at examining trust in technology within the cryptocurrency domain. To do this, we employed the technology trust model proposed by Lankton et al. (Lankton et al., 2014) and focused on three distinct trust constructs: functionality, reliability, and helpfulness. We then used them to identify the specific features, which contribute to trust in technologies (i.e., the blockchain, cryptocurrency wallet, and exchanges) that underlie cryptocurrencies. As for the empirical analysis, we decided to focus on Bitcoin, because it is currently the most widely used cryptocurrency in the market. To collect data, we extracted 1,97 million posts from a popular cryptocurrency forum 'Bitcointalk.org'. The analysis we performed draws on a paragraph vector model termed doc2vec (Le and Mikolov, 2014), which produces a semantical representation of words and posts. This allowed us to map the semantically most relevant features to the three trust constructs.

The results suggest that trust is semantically closest to the unique features offered by blockchain technology. The features raised in the posts are ledger immutability and openness, the former securing safe and fair transactions, and the latter making the transactions accessible to the public. Immutability refers that the transaction history provided on Bitcoin ledger cannot be manipulated, revised, or deleted by anyone. Openness refers to the availability of the data on the Bitcoin Blockchain to everyone and hence making the system completely transparent. Openness creates transparency while Immutability creates accountability. Transparency is considered as the key elements to create a trust (Grimmelikhuijsen, et al., 2013). These two functionalities are the unique features offered by cryptocurrencies using Blockchain technology. The degree of transparency and accountability offered by Bitcoin or other cryptocurrencies is unparalleled to any financial institution across the world including the investment banker Lehman Brothers. These unique technological attributes made the Bitcoin users to trust Bitcoin even without any backing or support from any institution.

Our research makes three important contributions to the literature related to Trust in cryptocurrencies. First, we add uniqueness of technology as a construct that contribute to the trust in technology model. Secondly, we combine large-scale data from the Bitcoin community with state-of-art textual analysis as-as research methodology for studying the factors that create trust in technology. Finally, the research results can be generalized to the literature related to building trust in new products that rely highly on technologies and automation. For example, the driverless car, to win users' trust.

Our data for the research is collected from Bitcointalk.org online forum, which is the oldest online forums on Bitcoin. However, the forum consists of a wide category of users, which includes users who are not Bitcoin users. Hence, the trust factors that we identified from the textual analysis is not exclusive to the opinions of the actual Bitcoin users. Further, Bitcoin users outside of this forum are not included in our analysis. The paper can be extended further by including the user-level analysis into the research.

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Digital Coaching among University Students with Low Levels of Physical Activity: A Quantitative Intervention Study on Exercise Self-efficacy

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Abstract University aged people have been found to be at a high risk of disengagement of physical activity. They also belong to a generation where technology is strongly integrated into most parts of their lives. Therefore, using technology also in physical activity promotion has potential. This exploratory study investigates the perceived effects of a sport and wellness technology digital coach among physically inactive university students during a 10-week intervention. The perspective for the research came from exercise psychology focusing on the effects of the use of a digital coach on self-efficacy related to physical activity and exercising. The results indicate that a digital coach can increase the user's self-efficacy and awareness regarding their own exercising. However, the results also show that further development could be done for digital coaching to reach its full potential. These results give more insight to sport technology companies as well as to coaches and trainers about the effects and possibilities of digital coaching among physically inactive people.

Keywords: • Digital wellness • Physical activity • Digital coach • Self-efficacy • Students • Sport and wellness technology • Intervention •

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1 Introduction

People who are of university age have been found to be at high risk of a sedentary lifestyle (Cocca et al., 2014, Downes, 2015). Physical inactivity is also significant problem around the world due its negative effects on overall health and wellbeing (WHO, 2017). In university students, a sedentary lifestyle has been linked to increased levels of anxiety, stress, and depression (Lee & Kim, 2019). As young people transit from secondary school to university, they are at heightened risk of decreased physical activity (Vella-Zarb & Elgar, 2009). Therefore, it is important to find a variety of methods to increase the level of physical activity and to prevent disengagement from physical activity.

Young people who are born between 1977 and 1997, are called the "Net Generation" by Comegys et al. (2006) meaning that they have had a chance to use information technology throughout their entire lives. Most of today's university students also fall into this category. By being familiar with technology and being used to integrate it in different parts of life, it is worth studying whether technology has potential to motivate this generation also towards more physically active lifestyle.

Since sport and wellness technology devices are becoming more popular and less expensive, not only athletes but also regular exercisers have started to combine technology into their training. According to previous research, feedback sources are considered more relevant and effective during the beginning of skill acquisition (Winstein and Schmidt, 1990). Therefore, sport and wellness technologies are suitable also for recreational exercisers who are in the initial level of skill acquisition and whose knowledge level regarding exercising has not reached its peak (Liebermann et al., 2002).

According to previous studies, sport and wellness technology has potential in increasing user's motivation by increasing the level of awareness regarding personal physical activity. (e.g., Chan et al., 2004; Faghri et al., 2008; Kang et al., 2009; Kari et al., 2017a; Wang et al., 2016). However, the increased awareness regarding one's physical activity alone may not lead to maintaining the use of sport and wellness technology (Miyamoto et al., 2016) This might subsequently also affect the overall maintenance of physical activity routines (Warraich, 2016). Adding personalized achievable goals, sufficient usage guidance, and clear and easy to understand information might increase adherence and help users to maintain their motivation and exercise routines. Receiving feedback on how to enhance or maintain overall wellness and physical activity can make users more goal oriented (e.g., Kari et al., 2016; Kari et al. 2017b), which can lead to increased motivation (Locke and Latham, 2002; Shilts et al., 2004).

Many current sport and wellness technology devices and applications concentrate on giving data and feedback related to past performance and do not provide personalized information or instructions on what to do next. This is problematic considering users who do not possess knowledge and experience about exercising and who would like to rely on instructions received from external sources.

One potential solution for this problem is digital coaching, which refers to a "service on a technological device that not only gives feedback but also offers advice, suggestions and future steps for a user to follow in the pursuit of their wellness and fitness goals" (Kettunen & Kari, 2018, p.3). While more traditional sport and wellness technology devices and applications focus on increasing awareness by giving feedback on performance data, a digital coach goes one step further by creating for the user an individualized training plan. A digital coach can potentially identify the strengths and weaknesses of a user, and also update the personalized training plan based on user's performance and development (Schmidt et al., 2015). The potential of a digital coach regarding physical activity and exercise has also been recognized in other previous research (Kranz et al., 2013; Kari & Rinne, 2018; Kettunen & Kari, 2018; Kettunen et al., 2018; Kettunen et al., 2019).

Since the commercial sport and wellness technology digital coaching devices and solutions are relatively new, there has not been many studies focusing on the effects or the usage experience of this technology. However, since interest towards digital coaching is growing it is worthwhile to continue studying further digital coaching solutions and their effects especially in a physical activity and wellness context.

This study continues the important investigation on the usage experiences of digital coaches focusing more closely on the exercise psychological perspective. More precisely the aim of this study is to find out whether the use of a sport and wellness technology digital coach has an effect on exercise self-efficacy of people who are physically inactive but interested in pursuing more physically active lifestyle. The main research question this study seeks to answer is: *Can the use of a digital coach affect self-efficacy related to physical activity and exercising within physically inactive people?*

The concept of self-efficacy was chosen for the study due to its significant relationship to physical activity performance affecting the choice of activity, effort expenditure, persistence level and vulnerability to stress and depression (Bandura, 1997).

The study included 59 participants who were all physically inactive university students but who were interested in increasing the level of their physical activity. The study lasted for 10 weeks and the participants were divided into intervention and control groups where the intervention group was given a sport and wellness technology digital coach. Online self-assessment surveys were sent to all participants in the beginning, middle and the end of the study period. The survey measured the participants' self-efficacy and opinions related to a digital coach. The findings of the study provide interesting first insights on the use of digital coaching solutions and aim to encourage future research on digital coaching especially from an exercise psychology perspective.

2 Theoretical Background

The theoretical background for this study comes from Alfred Bandura's (1977) theory of self-efficacy. Self-efficacy refers to a person's beliefs regarding his or her own capabilities of performing a specific task. People with high self-efficacy tend to view difficult tasks as opportunities to overcome a challenge, whereas those with lower self-efficacy may tend to avoid tasks that are perceived to be difficult. Motivation may also be affected by self-efficacy because it may affect the amount of effort a person is willing to put in, particularly in the face of obstacles. When there are moderately challenging tasks that can be overcome, people may experience satisfaction of accomplishment and therefore increased motivation, while motivation may decrease with tasks that are perceived as either too easy or too difficult relative to their own perceived skill level (Bandura, 1998).

Within self-efficacy theory, there are four sources of information that may affect self-efficacy: performance accomplishment, vicarious experience, verbal persuasion, and physiological states (Bandura, 1998). Performance accomplishments are based on positive past performances and are considered the most influential source of self-efficacy. Vicarious experiences are received when observing other people performing a skill. Verbal persuasion simply means receiving comments or feedback from others. Finally, physiological state relates to how a person perceives their physiological reactions to an experience, specifically their emotional arousal, such as their stress reactions from a particular situation. The self-efficacy construct is one aspect of Bandura's social cognitive theory (1986) which suggests that a person's actions, reactions, and social behavior are influenced by their observations of the actions of others. The social cognitive theory highlights the role of social experience and observational learning in personality development and has often been used as a framework theory for studies focusing on motivation and physical activity. Within the field of self-confidence in sports performance studies, the theory of self-efficacy is one of the most widely used.

In this study, the theoretical background of self-efficacy has been studied from the perspective of physical activity and exercise and therefore the focus can be said to be on exercise self-efficacy. Exercise self-efficacy is being studied from the point of view of a person who is not physically active enough but would like to become more physically active and start exercising. The concept of self-efficacy was chosen for the study since it has been demonstrated to have high influence in the adoption of physical activity (McAuley & Blissmer, 2000) and especially during the phase when physical activity has not yet become habitual (Bandura, 1986). Exercise self-efficacy has also been associated with the long-term maintenance of physical activity (McAuley et al., 2011).

People with a high level of self-efficacy will also participate more frequently, put in more effort and also persist longer, enhancing their performance (Bandura, 1986) for example in exercising. Therefore, self-efficacy has an important role in everyday life when trying to improve one's fitness and become more physically active. Self-efficacy is one of the most widely researched concepts in the field of health promotion (Kroll et al., 2007) and sports performance (Feltz, 1988).

3 Methodology

3.1 The Digital Coach Used in the Study

The device that provided the digital coaching in this study was the Suunto 3 Fitness, created by Suunto Oy (Suunto, 2019). The device is a fitness monitoring watch, which includes wrist-based heart rate detection, exercise timing and stopwatch features, 24/7 activity tracking including sleep monitoring, stress and recovery measurements, step and calorie counting, as well as additional features when pairing the device with Suunto's mobile phone app. The device may also receive speed and distance information from a phone's GPS information.

The Suunto 3 Fitness also includes a digital coaching feature, an adaptive training coach that can provide training instruction directly on the watch. The personalized training plan created in the watch is based on a user's estimated fitness level. The fitness level may be calculated using a guided fitness test, or the device may make an automatic fitness level calculation based on previous workout data. The user can also select a fitness goal, from three options, "maintain", "improve", and "boost", "boost" being a goal that aims to improve fitness level at a faster rate than in the "improve" program. The different goals will change the amount of training load that is recommended, and the goals may also be changed at any time.

Based on the user's fitness level, the device's digital coach will provide a recommendation for the next day's workout. It will also display a general presentation of what the next 7-days of the training program will be, as well as a text list of the workouts. The next workout recommendation may be a rest day, or may be some sort of training target, usually in a measure of time (in minutes), as well as a recommended intensity, usually in the form of "easy", "moderate", or "hard".

When the user performs the recommended workout, the device will provide real-time guidance. The guidance is based on staying within the designated heart rate zones. The watch will have visual indicators showing the user's heart rate and where it is within the target zone. It will also show a progress bar showing how much of the workout has been completed. If the user's heart rate leaves the recommended the target zone, there will be a visual notification, watch vibration, and the device will provide an audio notification, all of which will specifically tell the user to lower their heart rate (by slowing down), or raise their heart rate (by speeding up). The user will then be notified when the workout has been successfully completed.

The resultant data from the workouts may be used to adjust future workouts, being made harder or easier based on the changing fitness level of the user. This may also include if the user performed the workout and it appeared too easy or too hard. If the user does a completely different workout than the recommended workout, subsequent workouts will also be adjusted to maintain the training targets.

3.2 Data collection and analysis

The study was conducted as an intervention study using an intervention group and a control group. The target population was university students who reported being physically inactive in the sense of not meeting the physical activity recommendations but who wanted to have a more physically active lifestyle. The invitation to take part in the study was sent to all students studying in the authors' universities via student online magazine. The students were also recruited using snowball sampling method. In total, 67 students volunteered to take part in the study. Out of all the volunteers, 7 students did not meet the criteria of being physically inactive enough and were excluded from the study.

The study had two sub groups, an intervention group, including 30 participants and a control group with 29 participants. The control group originally also had 30 participants but one participant dropped out during the study. The first 30 students who expressed their interest in taking part in the study and training with a digital coach and whose background fit the requirements, were chosen for the intervention group. The reason for limiting the number of participants to 30 was due to the number of available digital coach devices. The other suitable students who expressed their interest to take part of the study but were not chosen for the intervention group, formed a control group. The recruitment process was stopped when 30 participants were found for each sub group.

The duration of the study was approximately 10 weeks. During that time the intervention group was using a digital coach along with their exercising whereas the control group participants did not receive a digital coach. At the beginning of the study, the participants in both groups were surveyed for the first time by using an online survey. After the first survey the intervention group was given the digital coach devices. The participants were asked to use the device in a way that was most suitable for them. Half way through the study, after 5 weeks, both intervention and control group received another online survey. The third and last survey was sent to them in the end of the 10-week intervention.

In the three online surveys, the measurements were conducted identically for both groups. The survey questionnaire contained an exercise self-efficacy scale by Kroll et al. (2007) using a four-point rating scale ranging from 1 = "Not at all true" 4 = "Exactly true". The questionnaires also had 13 items measuring the self-efficacy regarding overall beliefs about exercising in general and about using sport and exercise technology in training. The questions had a seven-point Likert scale ranging from 1 = "strongly disagree" to 7 = "strongly agree". These items were not, as such, intended as measures of specific broader constructs related to self-efficacy, although some of the items shared common themes. Therefore, the responses were examined on the item level instead of looking at them on the construct level. In addition, the survey questionnaire contained five items measuring the attitude towards digital coaching by using a seven-point semantic differential scale. In addition, the surveys contained five items measuring the attitude towards digital coaching by using a seven-point semantic differential scale. In all of the questions in the questionnaire the order of the items was randomized for each participant. Missing values were also possible since responding to the items was non-mandatory.

The participants' ages in the beginning of the study ranged from 20 to 61 years. Information was collected about the participants' physical activity by using a scale based on the Finnish National Sport Survey (FNSS) (Finnish Sports Federation, 2011), which consisted of seven categories. The categories in the order from the most active to the least active were competition athletes, fitness athletes, fitness participants, physically active for health, active in commuting and non-exercise, occasionally active, and inactive or sedentary. Table 1 reports the descriptive statistics of the sample.

Table 1. Descriptive statistics of the whole sample and the two sub-samples.

	Whole sample (N = 59)		Intervention group (N = 30)		Control group (N = 29)	
Gender						
Male	17	28.8	10	66.7	7	24.1
Female	42	71.2	20	33.3	22	75.9
Age						
< 25 years	14	23.7	8	26.7	6	20.1
25–30 years	18	30.5	8	26.7	10	34.5
31–35 years	11	18.6	6	20.0	5	17.2
36–40 years	7	11.9	5	16.7	2	6.9
40< years	10	16.9	3	10.0	7	24.1
Degree under study						
Bachelor's degree	16	27.1	8	26.7	8	27.6
Master's degree	39	66.1	20	66.7	19	65.5
Doctoral degree	4	6.8	2	6.7	2	6.9
Study mode						
full-time student	40	67.8	21	70.0	19	65.5
part-time student	15	25.4	7	23.3	8	27.6
other	4	6.8	2	6.7	2	6.9
Physical activity						
Fitness participants	8	13.6	0	0	8	27.6
Physically active for health	8	13.6	4	13.3	4	13.8
Active in commuting and non-exercise	24	40.7	17	56.7	7	24.1
Occasionally active	19	32.2	9	30.0	9	31.0
Sedentary	2	3.4	1	3.3	1	3.4

The collected data was analyzed with the IBM SPSS Statistics 24 software. Because of the non-normal distributions in some of the items and small sample size and, the statistical significance of the changes between the measurements were tested by using the non-parametric Wilcoxon (1945) signed-rank test instead of the parametric Student's paired-samples t-test. We used $p < 0.05$ as a threshold of statistical significance. The potential missing values were handled by excluding the responses of a particular participant to a particular item if he or she had not responded it in all the three surveys. That means that the exact number of respondents (N) may slightly vary per each item.

4 Results

The results are presented in three sub-sections, of which the first concentrates on the overall exercise self-efficacy. The second part focuses on self-efficacy related to improving physical activity and the perceptions about sport and wellness technology related to training. The third section focuses on the attitude about digital coaching. For each item, we report the results of the intervention group (in grey) and the results of the control group (in white) on separate rows. The reported results include the number of respondents (N), the mean and the standard deviation (SD) of the measurements at each of the three time-points, and the p-values of the Wilcoxon signed-rank tests that were used to examine the statistical significance of the change in mean between the first measurement and the second measurement as well as between the first measurement and the third measurement. We have also bolded the changes that are statistically significant at the level of $p < 0.05$.

4.1 Exercise Self-efficacy

Exercise self-efficacy was measured by using the Exercise self-efficacy scale by Kroll et al. (2007). The scale included 10 questions regarding personal abilities in performing physical activity which are presented in the table 2 below. As can be seen from the results the intervention group experienced statistically significant positive results related to many of the questions. This increased self-efficacy was seen for example in finding means to be physically active, in overcoming barriers related to exercising, being able to exercise when feeling depressed, being physically active without a support from friend family or trainer, and being able to continue physical activity after an inactive season. However, the control group experienced a decrease in self-efficacy in being able to meet the set exercise goals and in overcoming possible barriers. Whereas the intervention group also felt more confident in being motivated to exercise even if they were tired, the control group felt less confident about it. It is worth noting that most of the statistically significant changes occurred not within the first half of the study but only when comparing the change throughout the entire intervention.

Table 2. Changes in exercise self-efficacy

Statement	N	Time 1		Time 2		Time 3		p	p
		Mean	SD	Mean	SD	Mean	SD	(1 vs. 2)	(1 vs. 3)
I can overcome barriers and challenges with regard to physical activity and exercise if I try hard enough	30	3.3	0.7	3.3	0.8	3.5	0.8	1.000	0.275
	28	3.6	0.6	3.4	0.8	3.4	0.7	0.083	0.334
I can find means and ways to be physically active and exercise	30	2.6	0.8	2.6	0.9	3.2	0.8	1.000	**0.005**
	29	3.0	0.7	3.0	0.8	3.2	0.8	0.819	0.152
I can accomplish my physical activity and exercise goals that I set	30	2.5	0.8	2.6	0.9	2.6	0.9	0.532	0.449
	28	2.3	0.8	2.5	0.8	2.8	0.8	0.052	**0.001**
When I am confronted with a barrier to physical activity or exercise I can find several solutions to overcome this barrier	30	2.4	0.8	2.6	0.9	2.8	0.9	0.130	**0.022**
	27	2.4	0.8	2.5	0.8	2.8	0.7	0.819	**0.025**
I can be physically active or exercise even when I am tired	30	2.1	0.7	2.4	0.9	2.4	1.0	**0.039**	**0.025**
	28	2.6	1.0	2.2	0.7	2.4	0.8	**0.014**	0.251
I can be physically active or exercise even when I am feeling depressed	27	2.3	0.9	2.4	0.9	2.7	0.9	0.384	**0.022**
	23	2.3	0.9	2.4	0.9	2.7	1.0	0.527	0.054
I can be physically active or exercise even without the support of my family or friends	30	3.2	0.9	3.1	1.0	3.6	0.8	0.377	**0.035**
	26	3.3	0.8	3.2	0.9	3.4	0.6	0.248	0.642
I can be physically active or exercise without the help of a therapist or trainer	30	2.7	0.9	2.8	0.9	3.3	0.8	0.674	**0.004**
	27	3.4	0.7	3.3	0.5	3.6	0.6	0.366	0.356
I can motivate myself to start being physically active or exercising again after I've stopped for a while	29	2.4	0.8	2.7	0.7	3.0	0.8	0.077	**0.003**
	28	2.6	0.9	2.7	0.9	2.8	0.8	0.415	0.071
I can be physically active or exercise even if I had no access to a gym, exercise, training, or rehabilitation facility	30	3.2	0.9	3.2	1.0	3.2	1.0	0.523	0.564
	26	3.1	1.0	3.0	0.9	3.1	1.0	0.623	1.000

4.2 Self-efficacy Related to Improving Fitness and sport and exercise technology

The self-efficacy regarding participant's opinions about exercising and improving fitness in general was measured by a total of 13 items. Of them, six items concentrated on the role of sport and wellness technology regarding exercising and improving physical fitness. The results of these measurements are reported in Table 3.

As can be seen, statistically significant changes between the measurements were found in several items. First, the intervention group found it easier after the intervention to analyze their own aerobic fitness as well as felt more confident on knowing how to improve it. After the intervention the intervention group also felt on average more confident in being able to create for themselves an exercise program and were more confident in training independently without any guidance or coaching. Both groups found it easier in the end of the intervention to find out how to improve one's fitness. Secondly, when it comes to the beliefs about sport and exercise technology, the intervention group participants experienced a statistically significant decrease in their belief in reliability and accuracy of sport and wellness technology devices whereas the control group did not have any significant changes in their beliefs. The intervention group also had a statistically significant decrease in their beliefs regarding the usefulness of the data received from the technology and its ability to help in improving fitness. As can be seen form the results, this decrease took place already in the first five-week period during the intervention. Regardless of the decrease the average opinions regarding the above-mentioned statements still stayed more positive than negative.

Table 3. Changes in self-efficacy related to improving fitness and sport and wellness technology

Statement	N	Time 1		Time 2		Time 3		p (1 vs. 2)	p (1 vs. 3)
		Mean	SD	Mean	SD	Mean	SD		
I know how to create myself an exercising program	30	3.0	1.4	3.5	1.6	3.9	1.8	0.092	**0.002**
	29	3.8	1.7	4.0	1.6	4.0	1.6	0.444	0.463
I need help in creating myself a suitable exercising program	30	5.9	1.4	5.0	1.7	4.6	1.6	**0.002**	**< 0.001**
	28	4.6	2.0	4.4	1.5	4.2	1.7	0.591	**0.040**
I am able to train independently without any guidance or coaching	29	3.8	1.6	4.7	1.4	4.9	1.8	**0.003**	**0.001**
	29	5.2	1.4	5.3	1.4	5.4	1.3	0.505	0.313
Sport and wellness technology has an important role in my exercising	30	3.5	1.8	3.9	1.8	3.6	2.0	0.365	0.793
	29	3.3	2.1	3.1	1.8	3.0	1.6	0.473	0.182
Sport and wellness technology provides me with important information that I can use in my exercising	30	5.7	1.2	4.9	1.5	4.9	1.7	**0.027**	0.076
	26	5.4	1.1	5.0	1.5	5.2	1.3	0.310	0.334
I am able to improve my fitness with the help of sport and wellness technology	28	5.4	1.1	4.9	1.6	4.5	1.6	0.103	**0.004**
	24	4.8	1.6	4.8	1.1	4.6	1.5	0.672	0.659
I believe that sport and wellness technology provides me with reliable information regarding my own exercising	30	6.1	0.7	5.0	1.4	5.0	1.6	**0.001**	**0.001**
	28	5.2	1.4	5.3	1.4	5.5	1.2	0.542	0.187
I believe that sport and wellness technology provides me with accurate information regarding my own exercising	30	6.0	0.9	5.0	1.6	4.9	1.6	**0.002**	**0.002**
	27	5.6	1.3	5.1	1.4	5.3	1.1	0.106	0.425
I believe that sport and wellness technology provides me with truthful information regarding my own exercising	30	6.1	0.8	5.0	1.5	5.1	1.5	**0.001**	**0.003**
	29	5.2	1.6	52	1.4	52	1.2	0.814	0.869
It is hard for me to find out how to improve my aerobic fitness	29	3.2	1.9	2.7	1.7	2.4	1.6	0.123	**0.027**
	28	3.0	1.9	2.6	1.5	2.3	1.2	0.300	**0.022**
	30	2.9	1.5	2.5	1.6	2.4	1.5	0.174	0.085

I do not know how to increase the level of my aerobic fitness	28	2.3	1.7	2.2	1.3	2.3	1.2	0.912	0.831
It is hard for me to analyze my aerobic fitness	30	4.7	2.0	4.2	2.0	3.8	1.9	0.316	**0.005**
	28	3.9	1.8	3.8	1.7	3.9	1.4	1.000	1.000
I know how to improve my aerobic fitness	29	4.3	1.8	5.0	1.6	5.0	1.6	**0.047**	0.058
	29	5.6	1.5	5.3	1.3	5.3	1.3	0.330	0.469

4.3 Attitude towards digital coaching

The attitude towards digital coaching was measured by five items. These items concentrated on the overall attitude (bad vs. good) as well as on the experimental (unpleasant vs. pleasant and uncomfortable vs. comfortable) and the instrumental (useless vs. useful and foolish vs. sensible) aspects of attitudinal evaluations. The results of these measurements are reported in Table 4 below. When looking at the results it can be seen that the attitude in the intervention group experienced a statistically significant decrease when comparing the time throughout the entire intervention period. This change was not statistically lower when compared the results within the first five weeks, meaning that the more significant changes in attitude took place in the second five-week part of the intervention. There was no statistically significant change in the control group.

Table 4. Changes in attitude towards digital coach

Statement	N	Time 1		Time 2		Time 3		p	p
		Mean	SD	Mean	SD	Mean	SD	(1 vs. 2)	(1 vs. 3)
The thought of using a digital coach as a support for my training sounds: bad vs. good	30	6.4	0.8	5.9	1.1	5.2	1.7	0.078	**0.003**
	29	5.3	1.3	5.4	1.2	5.3	1.5	0.591	0.791
The thought of using a digital coach as a support for my training sounds: useless vs. useful	30	6.3	0.8	6.0	1.0	4.8	1.9	0.192	**0.002**
	29	5.5	1.5	5.6	1.4	5.4	1.5	0.630	0.783
The thought of using a digital coach as a support for my training sounds: foolish vs. sensible	30	6.4	0.8	6.2	1.0	5.5	1.5	0.361	**0.007**
	29	5.2	1.5	5.5	0.9	5.3	1.4	0.278	0.741
The thought of using a digital coach as a support for my training sounds: unpleasant vs. pleasant	30	5.9	1.1	5.6	1.3	5.1	1.7	0.398	0.053
	29	4.9	1.4	5.1	1.5	5.2	1.4	0.209	0.230
The thought of using a digital coach as a support for my training sounds: uncomfortable vs. comfortable	30	6.2	0.8	5.8	1.2	4.9	1.6	0.068	**0.002**
	29	5.1	1.2	5.2	1.3	5.1	1.5	0.519	0.957

5 Discussion

This study examined the changes in self-efficacy regarding physical activity and exercising within university students who were physically inactive and who felt they needed to increase their exercise level. The main research question of the study was: Can the use of a digital coach affect self-efficacy related to physical activity and exercising within physically inactive people? The study was conducted as an intervention study which contained 59 volunteer participants divided into intervention and control group. During the 10-week intervention the intervention group participants used a sport and wellness technology digital coach. The measures used in the study were based on psychological measurement of self-efficacy that consisted of three online surveys regarding participants' perceptions about their own skills and confidence and also about their attitude towards digital coaching.

According to the results, digital coaching has some potential in affecting the self-efficacy of its users. The intervention group participants seemed more confident at the end of the study in their abilities to overcome obstacles related to exercising as well as felt more confident in their ability to train independently without support from friends, family, or a trainer. In general, the self-efficacy towards exercising had increased, whereas the control group did not experience a significant increase in their self-efficacy.

Moreover, it also seemed that after the intervention, the intervention group participants felt more confident about their ability to analyze their own physical activity level, knowing how to improve their fitness, and on their skills to create themselves a training program. However, the results also showed that the intervention group experienced a decrease in trust towards the data they received from their digital coach. This was also apparent when measuring their attitude towards digital coaching. Control group participants did not have statistically significant changes in their attitude towards digital coaching nor in their trust towards sport and wellness technology data. Regardless of the decrease in all levels of attitude (experimental, instrumental, and overall) within the intervention group, the average attitude towards digital coaching still remained positive after the intervention in both groups.

From a theoretical perspective, the study suggests that digital coaching has potential in increasing self-efficacy related to physical activity and exercising. The results support the findings of previous studies (e.g., Kettunen et al., 2018, Feltz et al., 1988) which highlighted the role of performance-based information affecting self-efficacy positively. However, as most of the effects only occurred in the second half of the study, it indicates that it might take a while for the users to learn to train with a digital coach and to understand its potential for their own personal use and benefit. Further, it may be that 5 weeks is too short a time for significant behavioral change to occur while 10 weeks starts to be long enough for changes to be realized. Ensuring sufficient time for behavior change to occur may be an important consideration for both practitioners and researchers in future studies and physical activity interventions.

From a practical perspective, the results imply that when using digital coaches as part of interventions to promote physical activity, the length of the intervention should be long enough. And, when conducting research with such interventions, it would be good to have not just the start and end surveys but also surveys in the middle or at varied time points during the intervention period.

The finding that the trust towards the digital coach decreased during the intervention period sends a message to the developers of such solutions. They should pay increasing attention to their users' perceptions of the data and focus on improving the quality and trustworthiness of the presented data and subsequent coaching programs. And of course, base their suggestions on scientific research.

To summarize the contribution, from a theoretical perspective this study increases the understanding on how digital coaching solutions can influence physical activity related self-efficacy. From a practical standpoint, the presented practical implications can be utilized both within the sport and wellness technology industry and the society when working with digital coaching or different physical activity interventions.

6 Limitations and Future Research

The main notable limitation of this study is its relatively small sample size consisting of 59 participants divided into two sub groups. Regardless of this limitation, statistically significant differences were found in both groups. However, in the future it is worth doing a similar study with a larger group of participants. Having a large number of female participants compared to male participants could also be seen as a limitation.

As this study was combining exercise psychological perspective and digital coaching into physical activity intervention within physically inactive people, future studies could focus on using different types of digital coaches or different target groups and studying the effects within this setting.

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Global service platforms in local markets: case taxi services

JUKKA HEIKKILÄ & MARIKKA HEIKKILÄ

Abstract In this paper we discuss digital platform economy and use theory of Governance of Commons by Elinor Ostrom as a lens through which we look at related problems and social issues, such as tragedy of the commons. We discuss how communities can react to side effects and overgrazing of free, common resources by norms and rules. We illustrate the issue with the opening of taxi service markets to new entrants such as Uber.

Keywords: • Digital platform economy • Governance of Commons • Uber • Taxi • Common resources •

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1 Introduction

Digital Platform Economy has been aired for its efficiency, innovativeness, and disruption of the markets. In this article we discuss the relationship of platforms such as Uber and their national equivalents with the limitations of physical infrastructure and markets. Our article pinpoints that even though the platforms may hold their promise this may not be what the communities need, want or can sustain.

We illustrate the unprecedented side-effects of the disruption on the markets with Uber in Metropoles of the U.S. The side effects include doubts on safety, unfair pay and worsening working conditions, as well as congestion and pollution on streets. There after we analyze changing taxi markets in Finland.

The potential remedies to situations where new platform businesses threaten to disturb the markets range from privatization of assets, regulative mechanisms to local agreements (Ostrom, 1990).

This paper is structured as follows: First, we describe the benefits and arising concerns of platforms as experiences on their unforeseen effects are accumulating. In the next chapter we use the alternative theories to explain how to tackle the problems of externalities, socially undesirable behavior and overgrazing the common resources. In Chapter 4, we illustrate the situation with Ubers at New York and other metropoles in U.S. In Chapter 5 we analyze the impacts of opening of taxi market in Finland. The paper ends with discussion and conclusions in Chapter 6.

2 Benefits, complexity and concerns of platforms

Amazon, Facebook, Airbnb, Lyft and Uber are examples of digital platforms which have changed the way we work, socialize, create, and share value in the economy (Kenney & Zysman, 2016; Sundararajan, 2016). These digital platforms, defined here as sociotechnical assemblage of the technology, associated organisational processes and standards (de Reuver et al., 2018), have been praised for their new innovative business models that may even disrupt the current markets and create more consumer surplus with their innovative, technology-based business models facilitating multi-sided markets.

Multi-sided market is the core concept of platforms. Often the platforms match different groups of users, such as buyers and sellers, and can differentiate them for capturing better profits, growth prospects, and providing superior or cost-effective service for the customer. Instead of focusing on profit maximisation in a single market, platform owner's business model primarily aims at serving several user groups and tries to find balance between openness and lock-in of customers (Ballon & Van Heesvelde, 2011). The customer markets can be defined as separate markets for each customer group, or as single market to all customer groups with different set of products and services. To estimate the benefits to one party using the platform, the platform owner must consider the benefits (increase in efficiency and profit) on both sides of the market, i.e. towards the customers and partners/suppliers/producers. This is at the core of the superiority claims of platforms such as Uber and Airbnb.

Network externality is another important concept related to platforms. Positive network externalities mean that the larger number of users on the platform, the higher is the perceived or expected utility from using the platform (Katz & Shapiro, 1985). This fosters growth and innovation, but complicates the analysis of competitive markets, because the utility can vary substantially between the segments, depending on their valuation of the expected benefits in the future.

Even though the public discussion many times is about which of the platforms will win and dominate the markets, in reality the combination of multi-sided markets and positive network effects with risk-seeking venture capital can create situations where competitive, oligopolistic and monopolistic markets exist simultaneously. In addition, predicting the emergent side effects on the environment and vice versa (i.e., indirect externalities), and the dominant market structure becomes then almost impossible. It can lead towards *tipping markets,* where one platform dominates the market, either by indirect network effects of interdependencies of different customer and supplier groups, or by cross-subvention of the sub-markets by the platform. On the other hand, it can also lead to so-called *multi-homing* behavior, where customers are not connected with one platform of multi-sided markets only, but use other platforms, too.

The literature on platforms also points out the regulatory role of platforms, as they create markets of their own. Boudreau and Hagiu (2009), for instance, show by case examples, how setting the prices was not enough to assure proper functioning of the multisided platform ecosystem, but required regulation of access and interactions by contractual, technical and informational instruments.

3 Governance of Commons

Many of the problems explained in the Chapter 2 stem from self-interested behavior, negative externalities or from the changes on the use of resources, which the platforms exploit or affect in their business.

The solution usually offered to avoid negative externalities is privatization (Buck, 1992). We could make clear the property rights and liabilities by making the resources private. It is claimed that if one party can establish the property right, there will be a bargaining process leading to an agreement in which externalities are taken into account. Thereafter it is a matter of finding proper balance of regulation of markets and introduction of pricing.

However, in certain circumstances the above solution is not working, but rather creating the *tragedy of the commons*. tragedy of the commons is illustrated with an example originating from Hardin (1968): There is a common village pasture, which can support only a limited amount of cattle, but all the villagers are entitled to pasture their animals on the field. Each villager benefits from his own animals and suffers from the deterioration of the commons when his and others' cattle overgraze. In this situation each of them is tempted to add more and more animals because he is getting direct benefit from his own animals and bears only a share of the costs resulting from overgrazing.

The tragedy of commons is apparent in situations, where property rights cannot easily be established (such as with the air, sea, or roads). The usual claim is that rational, self-interested individuals will not act to achieve their common interests, unless the number of individuals is small or unless there is aforementioned enforcement of regulation taking place. The premise for such situations is that any person, who cannot be excluded from obtaining the benefits of a collective good has little incentive to contribute to the joint effort, but to free-ride on the effort of the others for self-interest. An extensive literature discusses the effect of free riders, concluding that common pool resources would inevitably be destroyed because of lack of care (Buck, 1992). To avoid such tragedies of the commons the central governments should control common pools of resources that cannot be appropriated (e.g. most natural resource systems). They can intervene in directly through taxes, or directly with controls and regulations, such as selling permits, licenses or limiting the use of the common resource pool.

Nobel-prize laureate Ostrom (1990), suggests an alternative solution to govern the commons. Continuing the example of the common village pasture, she notes that the herders, who use the same meadow year after year, have detailed and relatively accurate information about carrying capacity. Thus, they should have the best information required for making optimal decisions on the usage of the common pasture. The community members can *"make a binding contract to commit themselves to a cooperative strategy that they themselves will work out."* And, when they are herding their animals, they can observe the behavior of others and report contractual infractions.

The outcome of this is in strike contrast with the idea of self-interested behavior regulated by central authority: *"groups are capable of avoiding the tragedy of the commons without requiring top-down regulation"* (Ostrom 1990, 2009). Ostrom's main argument is that small, local communities establish rules overtime to avoid overusing common resources. Instead, these rules are both economically and ecologically sustainable, at least if core conditions listed in Table 1 are met (Ostrom 1990, 2009).

Table 1. Eight core design principles by Ostrom, 2009

1. **Clearly defined boundaries**; members know that they belong to a group and why do they belong exactly to that group, and what are the limits of the common resource.
2. **Proportional equivalence between benefits and costs**; there is a connection between earnings and effort, e.g., appropriation of rents is not enough.
3. **Collective choice arrangements**; i.e., agreements must be reached in consensus by those affected by the agreements.
4. **Monitoring users and condition of the resource**; Harmful self-interested, self-serving behavior can be detected.
5. **Graduated sanctions**; Repeated self-serving appropriators are assessed graduated sanctions according to seriousness and context of the violation by group members, or by officials accountable to these appropriators, or by both.
6. **Fast and fair conflict resolution**; Conflicts can be handled without excessive costs, locally, and without internal conflicts breaking the group.
7. **Local autonomy**; The group is autonomous to manage its own matters without external authorities intervening.
8. **Nested enterprises**: When the resource is closely connected to a larger social-ecological system, governance activities are organized in multiple nested layers. (Ostrom, 2009)

In conclusion, the literature proposes three remedies for the challenges arising from non- functioning markets: privatization, regulation or local commitment.

How is this then related with platforms? As the platforms are keen to disrupt markets, they exploit the common pool of resources without considering overgrazing or indirect negative externalities. Furthermore, they are also keen to expand, fueled by venture capital and IT, which means unprecedented spread of the services to the new areas, 'overgrazing' the local resource pools, and causing tragedies of commons. This is evident in metropole areas, where the increase of Airbnb is regulated by city councils. Similar challenges are with Uber and Lyft due to the increasing evidence on their unanticipated indirect external effects on congestion, pollution and diminishing use of public transportation (Erhardt et al, 2019).

As suggested by the theorists above, the outcome can be highly unpredictable, and hence other approaches than the standard means of regulation and introduction of pricing mechanisms are in need. This is especially true, when it involves the threat of overgrazing common pool resources, or changing the status quo of locally agreed and locally committed social arrangements. We illustrate the former with examples from metropoles in the U.S. and the latter from the deregulation of Finnish taxi markets.

4 Illustrative example of Taxi services in Metropoles of the U.S.

The success story of Uber platform tells about better access to taxi services, both in terms of availability of services and average decline in prices. For instance, safety and similarity are appreciated by globetrotters, who receive similar service in cities all over the world, and safety for the drivers is appreciated in some areas.

In Uber, each driver is expected to own a car used to render the service and the drivers are not employed by Uber, but the drivers get paid per gig. There is no centralized dispatch service-center, but service requests are automatically processed by Uber's algorithm; drivers can use their smart phones to receive and respond the service requests from users by an app. This application also allows customers to place orders through it, which also locates customers automatically for the driver. Furthermore, customers can follow in real time the location of the ordered driver such that they know when to expect the car to arrive. Payment is handled automatically through the smart phone app at the end of the ride, when also customers rate the service publicly with the application.

Impacts to markets are easily seen for instance in the New York: There are officially black taxis (limousine and premium for corporate customers), green and yellow taxi cabs (midrange, street hailed), and small livery companies for hire vehicles, which carry less than 10% of paid trips in Metropolitan New York. Uber services and other similar platforms offering ride services (PRS) have disrupted the prevalent market segmentation by changing pricing and increasing pre-arranged rides. As a consequence, the supply has increased, and segments are overlapping, thus in general meeting better user needs for transportation.

The new entrants have gained big market shares quickly. Figures vary, but Uber's market share of the US ride-hailing market is between 69% and 74% (Iqbal, 2018). For instance, in New York PRS now outnumber yellow taxis four to one (Wodinsky, 2018).

However, there are several negative impacts as well: The studies reveal that PRS has added billions of miles of driving in the largest metro areas in the US at the same time that car ownership grew more rapidly than the population (Schaller, 2018). Uber taxis actually use more mileage per trip, because they have to pick up the customer. And they prefer not to park but to drive around, because parking is expensive. Thus, 20-50 percent of miles are without passengers (Law, 2018). Importantly, PRS actually compete mainly with public transportation, walking and biking. In major U.S. cities, the popularity of FHV has *"reduced the use of buses by 6% and light rail by 3%"* (c.f. Law, 2018). Thus, it seems that the increased supply has lured people to switch from public transport to taxis making limited street space congested. These findings are confirmed in another assessment of the effects of uberization in San Francisco; it found that contrary to the vision of PRS, it is actually the biggest contributor to growing traffic congestion in San Francisco (Erhardt et al, 2019).

In 2018, two years after entry of the PRS, New York decided for limitations (New York City, 2016). The license's duration was shortened to 12 months, driver minimum wage and minimum fare price was introduced, number of PRS cars cannot grow, but in wheel-chair -accessible category, or where PRS service is in short supply (Wodinsky, 2018). Still, the taxi drivers consider not to be part of the deal and there has been recently strikes due to worsening income by drivers (Rapier, 2019).

One could also argue that it is a matter of time, when the markets will find the right balance between regulatory measures, pricing, demand and supply, but, for example Uber has been operating in San Francisco since 2010, and in New York since 2011, so the explanation is neither credible, or feasible. Hence there is a need for better, more local approaches, such as the one proposed by Ostrom's design principles.

5 Analysis of taxi services in Finland

In Finland, taxi markets have been highly regulated, authorities admitting taxi licenses on regional needs basis. However, the authority in charge of regulation, Finnish Ministry of traffic and communications, informed in Autumn 2016 that taxi business is to be deregulated. The expectation was that deregulation would result in more taxis, better service, cheaper prices and more taxable income for traffic investments. Since Autumn 2018, there is no more regulation on the amount of taxi cars, the taxi licenses are national (instead of regional), official requirements on vocational competence and local knowledge are omitted (passing a simplified test is sufficient), and pricing is liberated.

The Ministry is following the effects of the deregulation on taxi markets with surveys, which form the main data source for our analysis. The Ministry anticipated that the main effects are the opening of the taxi business to new entrants and boost in innovation in transportation services. This came true: there are new entrants and the total number of taxi-licenses grew in Finland: In Feb 2019, there are 2762 (29%) taxi licenses more on the market (of total 12249 licenses) than at the end of the regulation in the Summer of 2018. Consequently, the taxes paid by taxis should have increased. However, the most recent statistics shows opposite results – the taxes paid by taxis actually decreased by one third from the previous three years according to the tax authorities – this discrepancy is expected to be due to tax evasion (Konttinen, 2019).

However, a more detailed analysis reveals that the regional differences are significant – the increase of licenses takes place in the big cities. Uber is operating only in the capital area in Finland. As cities are becoming dominated by international taxi company subsidiaries, they are turning to oligopolistic leader-follower pricing: the price of taxi service increased by over 20% in the biggest cities. At the same time, sparsely populated areas suffer from increasing lack of taxi service, and this is causing severe problems for example to elderly country-side residents. The complaints about non-profitable business has increased (in public discussion a 25% decrease of income is regularly reported, with an increasing workload).

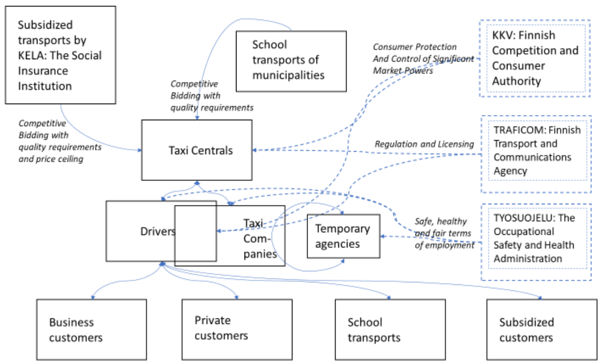

Figure 1. Taxi markets in Finland

After deregulation, the market changed as depicted in Figure 1. There are now clearly several distinctive markets for Taxis in Finland:

1. Business customers and private customers, who can negotiate the price when reserving transportation. The market *has turned to an oligopolistic supplier markets* in bigger cities, where a few international taxi companies dominate the market share and have been able to raise the price level recently. Typical price reduction of negotiating the price at the spot (taxi post) is -25% from the list price. On the other hand, during rush hours, or late-night hours the price can be many times the list price. In sparsely populated areas the situation varies. Small one car-one driver companies are not obliged to be on call, which means that the cars are not available as before, or at all. Bigger companies have no interest for the insignificant market.
2. School and daycare transportations are allocated through competitive biddings by municipalities. The prices are pushed down by combining

rides for the elderly and school kids. Typical winners are taxi companies of bigger size, who can guarantee regular, daily service. The market consists of *multiple monopsony-oligopoly structures.*

3. Subsidized KELA-transports[1], where a sole client determines a ceiling price and saves costs by requiring combined transports with minimum number of passengers. On the other hand, taxi centers act as proxies for small and big taxi companies and they are inspected by authorities for the quality of service. The political pressure for price reduction continues. Market has switched from *pure monopsony to monopsony-oligopolistic structure.* Half years after deregulation the studies show how service level and availability has deteriorated significantly in the special customer segment, such as elderly and people with wheel-chair.

In summary, the liberation of taxi markets has not moved towards perfectly competitive taxi market, but it has led to the growth of internationally funded big fleets of taxi companies, who can utilize the economies of scale. It is now clearly oligopolistic markets for private customers, and the previous oligopsonies (municipalities and KELA) are facing oligopolies in their negotiations (instead of association of taxi drivers). This is in line with the theory predicting tipping and unpredictable markets in an uncontrollable manner.

The outcome in densely populated areas is better availability, but lesser profitability for taxi drivers, because the big companies were able to exert predatory pricing in the beginning and later increasing prices. The prices rose +14% in the capital area and +7 % in the whole country. At the same time there are some hints for slightly diminishing use of other public transportation like buses, trams, trains and metro in bigger cities. However, in sparsely populated areas the capacity reduction in taxi services is clear, and in some places, there are no taxi service, as the drivers quitted or sold their companies to big players.

So, there are major problems with service quality, price levels, competitive bidding and obviously tax evasion – by the public, the taxi liberation is considered a failure, and the differences between market segments is significant. Majority of regular customers and subsidized specialty customer groups feel that the effects of deregulations are negative (Uusitalo et al., 2019). Hence there is also a need

[1] In Finland you can get reimbursement for your travel costs in connection with the treatment of an illness.

for alternative, probably market segment specific, more local solutions, as the central government is not capable to meet the objectives of the deregulation. One attempt for Ostromian solution is explained below.

Local adaptation of deregulated taxi service - ATaxi

We also analyzed in more detail the reactions of one incumbent taxi service provider, a taxi drivers' co-operative ATaxi, which had operated over hundred years in Northern Finland. With its high standards ATaxi had created over the years locally well-known brand image of quality, credibility and safety. It served customers in the rather sparsely populated region with a fleet of 600 cars equipped with proprietary technology that enabled the drivers to receive and accept orders and accept debit/credit payments among the first in the world. Customers could order ATaxi by calling centralized call-center, which forwarded request to nearest drivers, the fastest of whom then took the order, previously via radio, later via the mobile Internet. In practice, before deregulation, the ATaxi had a monopoly position in the local market for almost a century – the situation was basically the same in other regions in Finland. Legal consultants helped ATaxi to evaluate the kind of changes they can make, not abusing its significant market powers, which ATaxi still possess. ATaxi realized that its competitive edge was that it offers reliable, safe, and high-quality taxi services. In order to be able to keep this value proposition, the company balanced the number of cars to serve the market well and still provide sufficient earnings to the drivers. Thus, instead of competing with price, it aggregated regional taxi data and estimated the number of taxis required to meet its service proposition. The rules of ATaxi membership, including rules for determining the number of drivers were agreed and put openly available from their web pages. These rules are revisited biannually, or whenever members see it necessary. In addition, the co-operative saw as a necessity to introduce new brand, and new channels through which the customers can identify, order and interact with the service.

6 Discussion and conclusion

This paper discusses the side effects of platform economy: the unanticipated consequences and indirect externalities. The two identified unexpected effects on the community, based on theory and accumulating experiences of platforms in taxi business are the overgrazing of common resource pool and unanticipated changes of the market structure. The former is illustrated with an of Uber in the U.S., where uberlike platforms' indirectly diminishes use of public transportation, and consequently increase environmental pollution and congestion. The latter case is illustrated with taxi services in Finland, where deregulation of taxi services changed the market structure significantly and failed to meet the set targets of the change. However, a regional taxi company operating in Northern Finland designed a local solution for deregulated markets, that was able to maintain the present quality of service without deteriorating the income of taxi companies and prices.

Next, we discuss the three cases: Uber, Finnish taxi deregulation and the counter-measures to the deregulation by ATaxi against the backdrop of Ostrom's *Core Design Principles* for groups capable of avoiding the tragedy of the commons by:

9. *Clearly defined boundaries; members know that they belong to a group and why do they belong exactly to that group, and what are the limits of the common resource.* Taxi drivers formed a professional community, and license system set geographical limits to the common resources: space and customer base. Uber in N.Y.C and deregulation threatened the status quo and served as an incentive to limit the overgrazing of street space (N.Y.C).The limited customer base of ATaxi in Northern Finland, who nurtured their professionalism despite the regulation in a limited geographical area and are (so far) able to avoid the complications of changing market structure elsewhere in Finland
10. *Proportional equivalence between benefits and costs; there is a connection between earnings and effort, e.g., appropriation of rents is not enough.* Disruption of the market and falling profits (N.Y.C), or threat of future decline (ATaxi) created an incentive to re-regulate the market by the community, so that the drivers can earn a living from their profession. This actually was the boost to renew the rules for ATaxi which returned the balance between earning and effort. In metropoles of the U.S. the taxi drivers started demonstrating, because of unfair share of income.
11. *Collective choice arrangements; i.e., agreements must be reached in consensus by those affected by the agreements.* Taxi drivers' unions were formerly negotiating for different markets in N.Y.C (black, green, yellow, livery markets); or serving all market segments in Finland (private, business, subsidized rides) with obligation to being on call and providing service in sparsely

populated regions. As the markets were deregulated, the consensus disappeared. Sparsely populated areas are suffering from no-access to taxi services and in N.Y.C., there was no respect to the upper limit of taxi cars, which drove the prices down and congested the streets. ATaxi maintained the on-call responsibility.

12. *Monitoring users and condition of the resource; Harmful self-interested, self-serving behavior can be detected.* As the agreed use of common resource could not be, or was not allowed to be monitored, due to liberalization of terms of conditions, the situation promoted self-interested and self-serving behavior. In essence, the negative externalities (for drivers non-sufficient wages), and negative indirect externalities (congestion in N.Y.C, lack of service in sparsely populated areas, oligopoly price-hikes in densely populated areas) could be detected only afterwards, leading to unintended consequences. The local communities responded by re-regulating the market, or by establishing mutual consensus agreements and self-monitoring and -reporting by rules (see also 3. and 5.) and applications available to the customers, too. However, in Finland there is evidence of increasing tax evasion beyond the control of tax office.
13. *Graduated sanctions; Repeated self-serving appropriators are assessed graduated sanctions according to seriousness and context of the violation by group members, or by officials accountable to these appropriators, or by both.* It appears that both the platforms (N.Y.C.) and deregulation set centrally strict sanctions for the drivers. This differs from the past where sanctions were graduated, proportional, and maintained by the community, which is still the case with ATaxi.
14. *Fast and fair conflict resolution; Conflicts can be handled without excessive costs, locally, and without internal conflicts breaking the group.* Disappearance of taxi inspectors in Finland has led to situations, in e.g. big events, where there is no impartial authority over all taxi drivers for queuing, unloading, etc., or reconciliating non-satisfactory service, or pricing has lead to fist fights for customer in waiting areas (TS xxx), which lead to local conciliation between taxi companies and municipality. The conflict resolution by the authorities is simply too slow and non-proportional demoralizing the profession.
15. *Local autonomy; The group is autonomous to manage its own matters without external authorities intervening.* Platforms and authorities have moved in the territory of self-regulated drivers and companies, with un-intended

consequences on availability (in restless areas of N.Y.C.; sparsely populated areas in Finland), quality of service (subsidized rides in Finland), and on pricing (greater Helsinki area in Finland, rush-hours in N.Y.C). The central authorities are not able to solve the problems in our cases despite their attempts.

16. *Nested enterprises: When the resource is closely connected to a larger social-ecological system, governance activities are organized in multiple nested layers.* There is an indication that ways to enhance the situation is not by redistributing the resources (N.Y.C., Cities in Finland), or by pushing for harder competition and setting price ceilings in competitive bidding in subsidized rides in Finland. Instead, the parties should come together and acknowledge the limitations of market mechanisms and utilize platforms and re-regulation to give a try the Ostrom Core Design Principles to avoid over grazing of common-resources, or distortions on the distinct markets. This remains to be seen.

The examples in previous chapters show how the taxi services quality and supply increased in big cities, but on the other hand caused overgrazing of common resources, the street areas. Therefore, In US the communities were soon forced to restrain Uber by establishing new rules regarding number of cars and length of license periods. In Finland, the deregulation of the markets in the whole country did not work as anticipated by liberators. The emergent properties were many and hard to predict. Instead of perfect markets, the market was divided in several distinctive markets: the markets in big cities concentrated and is now dominated by international players. There are now more taxi cars driving around in the cities, but contrary to expectations, the prices rise. In special customer segments and sparsely populated areas the quality reduction in service level is clear. As a response to the above a local ATaxi community in a limited geographical area established rules to balance the number of taxi cars to serve the market well and still provide sufficient earnings to the drivers. Ministry is currently evaluating impacts of the deregulation in Finland and might be forced to take actions similar to New York and set restrictions to the taxi service markets, or alternatively, allow the local communities to establish their own rules for guaranteeing available, safe, and reliable taxi rides.

In the illustrative cases it becomes evident that there are no simple solutions, but the solutions are actually adaptations to the dynamic situations, which are hard to meet by the standard means of privatization, i.e., by appropriating resources and introducing pricing mechanisms, Assuming multi-sided perfectly competitive markets is not true in the markets that can vary from monopsonies of customers to oligopolies of big taxi companies, or call centers, operating on limited common resources in terms of space or population.. This is further complicated, if the common pool resources are not taken into account. Nevertheless, the avoidance of the tragedy of the comments builds on social norms and characteristics of the community and adapting the platforms to their situations on an on-going basis.

More sensitive solutions to the situation could be provided by alternative approaches such as Ostrom's Core Design Principles. Combined with the power of multisided markets, it could be worth trying to achieve sustainable and better suited markets for the needs of the segments, both producers, aggregators and customers.

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Representing Precarious Work in the Sharing Economy through (De)motivations of Uber Contractors

ANNE-MARIE TUIKKA, ABAYOMI BAIYERE & KAI K. KIMPPA

Abstract The potential contribution of sharing economy to the global economy is increasing. Despite this, there are unanswered questions related to corporate social responsibility in the sharing economy. In this article, we draw from a case study on Uber and its contractors to understand the precarious work entangled to their relationship in two contexts. By unpacking the motivating and demotivating dimensions of this relationship in two context, the United States and Finland, we explore the underlying phenomenon of precarious work in the context of sharing economy.

Keywords: • Sharing economy • Platform economy • Ride sharing • Precarious work • Uber •

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1 Introduction

Sharing economy[1] as used in this study, is a term that represents the collaborative utility of excess capacity in goods and services whose distribution, sharing and reuse is enabled by an underlying digital platform (Hamari, Sjöklint & Ukkonen 2016). In other words, it is a digitally enabled shared access which provides a required resource to someone while simultaneously creating value for the owner (Chasin et al. 2015). Popular innovations in this area are Uber and Lyft (transport sharing service akin to taxis), Airbnb (room sharing service akin to hotels) and Mechanical Turk (task sharing service akin to recruitment companies). While the sharing economy has been applauded for its potential contribution to the global economy, there are still questions left unanswered as to the appropriateness of work practices under this umbrella.

Digitalization has changed the environment where people work and the conditions of their work. The introduction of digital tools to various fields of business have changed the way people work (Vaast & Walsham 2005) and where they work (Kurland & Bailey 1999). At the same time, these tools have facilitated the surveillance of workers (Brey 1999) and diminished the need for human workers for certain jobs (Rifkin 1995). Digitalization has also created new forms of work. One of these is sharing economy, which seems to unveil a new set of work relationship issues related to disrupting regulatory frameworks, conventional employment relationships and traditional business models (Gonzalez-Padron 2017).

In this paper, we discuss, how companies operate in the sharing economy, and explore the precarity of work related to the way these companies orchestrate their work relationships. This topic area has already been studied by other scholars, who are interested in different interpretations of sharing in the sharing economy (Martin 2016; Kennedy 2016) and ideas for creating socially sustainable sharing economy innovations (Martin et al. 2015; Hawlitschek et al. 2017; Hendry et al. 2017). However, the empirical research on this phenomenon is still emerging and it has often been studied mainly from the user's (e.g. Bardhi & Eckhardt 2012; Gargiulo et al. 2015; Hamari et al. 2016) perspective. Research on people who get their daily income through sharing economy is still scarce, although some

[1] We acknowledge that our interpretation of the sharing economy does not cover all aspects of sharing economy which includes e.g. non-profit solutions such as Landshare (McArthur 2015).

empirical studies have been made about sharing economy in disadvantaged communities (Dillahunt & Malone 2015) and experiences among Uber contractors (Rosenblat & Stark 2016; Malin & Chandler 2017).

We draw on a case study of ride sharing platform offered by Uber since it is a widely acknowledged example of sharing economy in prior literature on (see e.g. Cannon & Summers 2014; Cusumano 2015) and is seen as lucrative business model by other companies (Rosenblat & Stark 2016). Besides the scientific literature, ride sharing platforms stand out among sharing economy platforms that have been plagued with legal issues and several lawsuits, as well as movements to boycott the service by the public media.

Similarly to many other platforms in the sharing economy, ride sharing platforms have employed peer-to-peer market structure which – according to their claims – enables sharing of rides between individual car owners and the passengers. Passengers pay to car owners on each trip while the ride sharing platform gets a pre-set commission for providing the service of connecting car owners with the passengers. Within this business model, car owners are typically considered as individual contractors rather than employees of the platform owner.

Following the suggestions of prior studies to examine the societal nature of driving for ride sharing platforms (Chen et al. 2015; Schor 2016) we wish to elaborate the discussion on people who work through ride sharing platforms and analyse the work related issues they face through the concept of precarious work. Precarious work is characterized by insecurity, uncertainty, and low income (Arnold & Bongiovi 2013). It is related to casualization of labor, which enables sift from regular employment to the use of workers in short-term employment arrangements (Standing 2008). In industrial societies, self-employment offers companies a legal way to find people to work without obligation to carry out the responsibilities of an employer. However, precarious work can also be done through zero hour contracts, which do not require the employer to give any specific amount of work to any employee. Such legal arrangements facilitate the existence of hyper flexible work, which is a form of non-standard work, where working conditions are not fixed by temporal, numerical or financial characteristics (Harvey et al. 2017). This definition also applies to the work conditions of the Uber contractors, who experience splintering precarity according to Malin and Chandler (2017).

In this study, we have employed inductive research approach which led us to study the precariousness of work in the context of ride sharing. We focus on people who are in contractual relationship with Uber to drive for it, and to whom we refer as Uber contractors or as drivers. From these premises, our research question is: *How do motivation and demotivation of Uber contractors reflect precarious work in the sharing economy*? The following sections aim to answer this question by presenting our research methods, empirical findings and our conclusion. We take a critical stance to construct the avenues through which the insights from the ride sharing can be of value for research in other emerging forms of precarious work, particularly in the sharing economy context.

2 Research Methods

We adopt a qualitative research approach involving semi-structured interviews (Myers & Newman 2007) to get an in-depth understanding of the work practices and the experiences among Uber's contractors. To get a deeper insight of the importance of the context, we conducted our study in two countries: the United States and Finland.

The interview questions were grouped under two main themes – the reasons for driving for Uber and the disadvantages of driving for Uber. As enabled by the semi-structured nature of the interviews, the questions were developed under these themes and expanded based on the flow of the interview. Emphasis was placed on understanding the relationship between the driver and Uber, and the drivers' personal perceptions and details of their individual experience. Additionally, the knowledge gathered from earlier interviews was tested and evaluated during subsequent interviews for confirmation to filter out the cross-location commonalities and differences as well as to establish the general attributes and the location specific attributes of the Uber–contractor relationship.

The participants were found by requesting an Uber ride. In the beginning of the ride, the researcher presented themselves and asked driver to give an interview for research purposes. To offer full anonymity to the drivers, their names and contact information was not stored. Hence, it was not possible to contact drivers for further investigations. Drivers were also asked a permission to record the interview. When a driver did not want to be recorded, thorough notes were taken during the interview. Some drivers declined the request to participate in the study and no data was recorded from the discussions with them.

Our study was conducted during years 2016 and 2017, when a total of 48 semi-structured interviews were collected. The interviews lasted for about 20 minutes each. In the United States, 23 interviews were done in Boston and 19 in San Diego. In Finland, 7 interviews were done in Helsinki. We chose these cities as the US cities are recognized for the high maturity adoption rate of Uber in both cities, while Helsinki provided us a context where the adoption and existence of Uber is relatively new and its presence has been fraught with resistance, which implies uncertainty for both the company and especially the workers. In Helsinki particularly, it was not possible to collect more data through our methods after August 2017, because Uber had to stop operating in Finland at that time.

All the interviews were transcribed using professional services. We analysed the interview data by using the process of hermeneutics to make sense of the emerging insights from the study. Adopting this approach involves utilizing the hermeneutic cycle, which is a process that facilitates the abstraction of meaning from a text as a whole relative to the interpretation of its parts in a continuous interaction. According to Myers (1997), the flow of understanding takes place from the whole to the parts and back from the parts to the whole and this happens continuously in a circular fashion. As required by the hermeneutic approach, this analysis process continued as we sought to get an understanding of how the insights noted from the parts formed a representation of the meaning derived from the whole. This approach provided clarification and helped in getting a deeper insight to the nature of the relationship between Uber and its drivers.

3 Findings

The results from the data collection are indicative of the work arrangement between Uber and its drivers and the associated work relationship that characterizes them. A noticeable aspect is the asymmetric nature of this relationship that could be observed from the data, for example, the capacity of Uber to change its operating principles (loosely translated as contract in traditional sense of work-relationships) when and how it so desires. We also notice the demography and various motivations of the drivers to work for Uber.

We specifically draw insights from those drivers who are particularly dependent on Uber and highlight the associated impact of the asymmetry in the relationship on the social and the economic well-being of these drivers.

The results from the United States and Finland are discussed in separate sections. In both of these contexts, the relationships between Uber and its drivers are discussed through two themes: the motivation and the demotivation.

3.1 Findings in the United States

In the United States, we identified four key motivations and demotivations for most people to decide to drive for Uber as a contractor. These are source of income, promotional incentives, self-employment and work-time liberty. The demotivations to drive for Uber are related to declining rates, withdrawn incentives, account deactivation and increasing work time requirement.

Source of income is a recurrent motivation for many of the respondents to join Uber as a driver. A clear distinction as identified between those that embarked on this relationship solely based on using this as a means of daily sustenance versus those that do it just for the purpose of getting some extra income. The former usually tend to be people who would have otherwise been unemployed or who consider that their earlier jobs did not provide as much income as they would obtain from driving for Uber. The latter are typically people with another job and chose to drive for Uber on their free time.

> *"Well, this is my part-time job. I have a full-time job. What I like is, whenever I [decide] I'm going home, I'm going home. And I don't have nobody to tell me what to do."*

Incentives as a motivation for the Uber-driver relationship are closely related to income as a source of motivation. The data revealed that the incentives offered by Uber have a particular allure that attracts many in the United States to decide to use their car and time to provide the driver service for Uber. It appears that the type of incentives vary from location to location. Some of the incentives could yield returns that are equivalent to double the income earned after meeting specified targets.

> *"[W]hen the [passenger] demand is high, demand for drivers is [also] high then they increase the price. It's called surge. Before this the highest (rate) was 2.2 but the surge can go as, big as 3.0 and yeah [I also get better payment if the price goes up]."*

Regular income from Uber with incentives is significant enough for many to quit their jobs and join Uber after possibly doing some calculations and comparing the job options. In some cases, the income motivation is sufficient to inspire some of the respondents to take a loan to get a new car, just for the purpose of taking advantage of the income opportunity opened up by Uber in this regard. The following quote captures this motivation:

> *"I'm doing [Uber] just because I need to pay my bills, and not live like animal in zoo park. Eat something, coffee and anything that is necessary in life. That's all. It's quite expensive country, and of course I still haven't won Lotto [lottery]. So, I must do something [to make income i.e drive for Uber].*

To some interviewees possibility to be self-employed is important reason to drive for Uber. It is also related to the liberty to use their time as they find fitting as described in following quote:

> *"I started to drive for Uber, based on its comfortability and, it's like you are boss of your own. You are not under pressure that somebody [is] controlling you, [you work] at your own pace, [and] you can choose to drive or choose not to drive."*

The work-time liberty is essential for drivers, who have care responsibilities (e.g. the need to take care of a terminally ill spouse) resticting their career options. For example, one of the respondents who is a single mother explains that driving for Uber provides her with the time to be with her child, while still offering her the much needed opportunity to earn an income. The freedom offered by the arrangement between Uber and its drivers was valued especially by those, who have caring responsibilities, because they can now fit their work schedule into their life schedule.

> *"I like how you can, only do one run a day you if you wanted to [or] you can do as many as you want. [If] you don't wanna drive for a week man you only gotta turn it off. Be your own boss."*

According to our data, one of the cherished features of driving for Uber is the liberty that the drivers have over the use and the distribution of their time. However, the data revealed that Uber has systematically been changing the rates it charges passengers as it becomes more popular in an area. The dissatisfaction for many drivers comes from the fact that, some have joined Uber based on the calculated income that is accruable by driving for Uber during a given amount of time. Since their income is dependent on the rate the passenger is billed, the reduction in the rates by Uber means the drivers can no longer meet up with the anticipated level of income by providing the driving service for the same time period.

Most of the drivers who have a second job, pointed out, albeit grudgingly, that they are still able to meet their needs with their other income, since driving for Uber is basically an exercise to get more. This is however not the case with those that are completely dependent on Uber and are driving full time for Uber. For this category of drivers, the drop in income has been a recurring theme in the interviews as a source of demotivation and dissatisfaction with the work relationship. However, we found out that for these drivers, despite the discontent, they consider Uber to still be the better alternative than their other options.

> *"Just, passing my time with [Uber] because I don't have any other job. So that's why I'm doing it. If I find another job I won't do it for a second."*

In addition to declining rates, another source of demotivation is the withdrawal of incentives. The responses to our interviews revealed a pattern, which Uber deploys to get more drivers, particularly when it is just launching in a new city. In each of the cities, where we collected data, the trend has been first a flurry of incentives during the early months of Uber in the location, after which it systematically begin to cut some incentives when a critical mass have been reached. Hence, all the drivers that have made their plans and calculations based on the incentives would find those plans in jeopardy after the slash of the incentives.

Prior dimensions of demotivation have focused on the income associated with the relationship between the driver and Uber, while account deactivation terminates the relationship. According to our respondents, Uber has the power to deactivate any of the drivers' account thereby denying them the option to continue driving for Uber. The essence of the demotivation due to this threat is driven by the fact that the drivers need to have a minimum score of 4.5 star rating out of a possible 5 star rating. The ratings are the mechanism through which Uber collects feedback from the passengers. The challenge with this, as described by the respondents, is that the measure is subjective and dependens on the personality of the passenger. Some passengers tend to give 5 stars while there are some that consider a 5 star rating to be a perfect score and hardly ever give such rating. The problem with this is that, since the rating is an aggregate of the passenger ratings, a driver can easily get less than 4.5 with a few ratings of 4 stars of less.

> *"So if everyone gives you a 4 it's bad actually. Even though 4 sounds good, 4-5 sounds good, but if your rating's below 4.5 then yeah they, don't let you drive anymore."*

For many, the appeal of Uber lies in the time that they have to accommodate other life activities in their schedule, while still benefiting from the revenue from driving for Uber. However, depending on Uber as a source of revenue seems to gradually require the drivers to do much more work because of the diminishing rates and incentives. Especially drivers, who have taken a loan for a new car to be able to drive for Uber, had very limited options but to remain with Uber. The availability of this group of people who are still in a better financial position with Uber, despite the reduction in income, appear to provide Uber with sufficient supply of drivers to maintain its business model.

3.2 Findings in Finland

A major difference between Finland and the United States is that offering a ride for payment requires an official taxi permission document. This requirement is part of Finnish legislation, and it is supervised by police. The differences in Finnish and American regulations are reflected in the motivations and especially in the demotivation of the Finnish drivers (see Table 1).

The source of income was the main motivation for drivers in Finland as it was also for drivers in the United States. This applied to drivers, whose main source of income came from driving for Uber, and to those drivers, who had another

job and drove for Uber to get extra income. One of the interviewees, who was a full-time driver said:
"Best thing is getting the money. Money is good motivation."
Those two drivers, for whom driving for Uber was their only source of income, were really disappointed by Uber's decision to leave Finland. They were not sure about how to support themselves when Uber would leave Finland. One of them had a plan to start a business even if he was not interested to be an entrepreneur:

> *"I'm thinking about, I thought about many, many times about my own company because, it's good business but it's not for me. I'm doing just because I need to pay my bills, and live".*

While the income was important motivation to Finnish drivers, they were not interested in the incentives. The topic was discussed only because researchers brought it up in the interviews. Some of the drivers remembered that they got incentives when they started to drive for Uber but they had almost disappeared at the time of the interviews as revealed in the following quote:

> *"[W]hat I had earlier and when it started, there were incentives. So when you go for about maybe some 25 or 50 trips, [you get some incentives] 200 euros is at next job, your commission. But now I think they have stopped and no incentives are given."*

For most of the interviewees money is not the only motivation to drive for Uber. They were generally satisfied with the platform and appreciated its accuracy to get payments in time. Many of them drive for pleasure. One of the part-time drivers explains:

> *"For me, in my case I also drive out of pleasure. A lot of people drive out of necessity. I need to go there, I have to drive. For me driving around it's something that I enjoy. So, and if you get to make some money on it, why not?"*

Unlike in United States, the self-employed aspect of driving for Uber does not motivate Finnish drivers. Finnish drivers are not satisfied for being contractors instead of employees. However, they do appreciate the work-time liberty offered to them through Uber platform. This was clearly stated by one of the interviewees:

> *"[O]ne can choose their own schedule. That's really important. You can drive when you want. If you don't want to drive, then you don't."*

While there are some similarities between motivational dimensions in Finland and in the United States, the demotivational dimensions differ significantly. In Finland, important demotivating factors are related to the relationship between the driver and Uber. As discussed earlier, Uber does not acknowledge drivers as its employees. Uber defines drivers as its contractors. The nature of the relationship is usually clear for Finnish drivers; however, they are usually not pleased for it. Some of them would prefer to be employed by Uber. They also complain about the heavy cost of maintaining the car.

> *"They [Uber] do not pay much because you have to pay for the gasoline and diesel yourself. Maintain the car."*

Because Uber regards its drivers as contractors instead of employees, drivers are personally responsible for respecting the Finnish law. This is problematic because most of them do not have a taxi permit hence they are engaged in unlawful acts while transporting passengers for Uber. Most experienced drivers explained that it used to be very unlikely that police would stop someone for driving for Uber. However, the situation has changed and drivers acknowledge that police might stop them for driving for Uber.

All drivers did not appear to think that the unlawfulness of the driving was a big problem. Non-European drivers assumed that they might be stopped by the police more easily than European drivers. While the amount of interviews was scarce, analysis of the interviews appears to support their perception. One of the non-European drivers had been stopped twice according to his interview, however European drivers did not bring up the topic of police harassment if it was not directly asked. When asked they did not report any problems.

4 Conclusion

Some of our findings reflect the results of Malin & Chandler (2017) on splintering precarity among drivers for Uber and for Lyft in the United States. They found out that most drivers, especially the once who drive to get extra income, consider driving as fun and flexible way to earn money. At the same time, they experience number of anxieties and risks. However, our study revealed new aspects of precarious work among Uber contractors. This was partly due to our focus on those drivers, who rely on driving for Uber as their main source of income, although we did not exclude those drivers, who drive Uber to get extra income. In addition, we expanded the data collection to Finland, which had many differences compared with the United States (see Table 1 for comparison).

Table 2: Motivations and demotivations in the United States and in Finland

	the United States	*Finland*
Motivations	source of income	source of income
	promotional incentives	pleasure of driving
	self-employment	good platform
	work-time liberty	work-time liberty
Demotivations	declining rates	lack of employee status
	withdrawn incentives	unlawfulness
	account deactivation	police harassment
	increasing work time requirement	

In the United States, precariousness increased especially among drivers, who were driving full time, when the incentives were lost and prices on rides were lowered due to saturation in a certain market area. This caused problems to drivers due to extended periods of driving needed to gather the expected income from the work, as this was clearly diminished. Many drivers had expected to be able to considerably enhance their income with relatively small amounts of work, at times suitable for them for a variety of reasons such as looking after sick or elderly relatives. Nonetheless, many of the drivers in our sample continued working for Uber even after the negatively perceived changes in working conditions due to their need to get some additional income on, more-or-less, their own terms.

In Finland, the biggest concern for the drivers was their legal status. None of the interviewed drivers had a taxi permission, hence they engaged in an unlawful activity while driving for Uber. In addition, Finnish drivers felt that they ought to be able to be employees of Uber rather than "partners" who still have no say in the partnership. Despite these concerns, those, who were driving full time, were worried about their future income because Uber had announced leaving Finland.

Our study is not without its limitations. Firstly, our research method led to a randomized sample of drivers within given geographical locations, however this sample cannot be seen as representative sample of drivers within those geographical locations. Secondly, we were able to offer full anonymity to the drivers participating in our study, but it is not possible for the researchers to intentionally contact the participants again. Future research on this topic should closely evaluate if it is more important to offer full anonymity to the participants or assure the possibility to interview participants multiple times by collecting their contact information. Thirdly, our data from Finland is limited. Future research in Finnish context would be necessary because the new Act on Transport Services come into effect in July 2018 and at the same time, Uber returned to Finnish market. While the taxi permission is still needed for transporting passengers, its price got cheaper and its requirements became more flexible. Hence, the experiences among Uber contractors can differ from the ones identified in this study.

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Personality-Based Content Engineering for Rich Digital Media

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Abstract Firms have increasingly turned to rich digital media, such as videos and photos, to attract attention and boost awareness. Although extant research may help firms promote these media more effectively, the marketing process truly begins with creation of the media. Thus, content creators may benefit from understanding what media is likely to achieve greater popularity, based on its content features. We develop a method to understand the effect of content on the consumption of online videos, and employ our method on a unique dataset including 16,414 videos from 363 YouTube channels. Our approach labels videos as high- or low-performing relative to comparable videos, and leverages random forests to identify content features associated with performance level. We test this method using the personality of speech-driven videos, employing NLP to estimate the extent to which video captions exhibit each of the "big five" personality traits. Our analysis uncovers predictive, economic, and prescriptive insights. We find that using just their personality, we can predict whether videos perform better than expectation with 72% accuracy. Furthermore, videos associated with high-performing personalities can expect a nearly 15% increase in consumption. Finally, we examine which personalities are associated with high consumption, offering prescriptive insights for content engineering.

Keywords: • Content engineering • Personality • Rich digital media• random forests • NLP •

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1 Introduction

As the Internet enhances users' ability to filter and search for information, it is imperative that firms "pull" in consumers using content marketing, rather than merely "pushing" their message through paid advertising. The effectiveness of "push" strategies has been recently questioned, due to consumer resistance to advertising (Baek and Morimoto 2013)[1] and rising adblocker adoption[2]. In response, firms have turned to rich digital media, such as videos, images, and whitepapers, to promote themselves online (Corcoran 2009). In doing so, firms can leverage their fan base to spread word-of-mout (WOM) about their media, which may boost brand perceptions before the point of sale (Järvinen and Taiminen 2016).

But although content marketing offers promotional opportunities for firms, it also presents unique challenges. While firms can use analytical tools to iteratively refine the targeting, budget, and messaging associated with their ads, digital media offer less opportunity for modification after the media are released. As such, the content design of these media is a key determinant of their success. Presently, the creation of digital media is largely driven by creativity and intuition, and often lacks empirical guidance. This is perhaps due to the perception that the spread of digital media is somewhat random and unmanageable (Bampo 2008), or that features of these media that lead to their popularity are hard to quantify or operationalize. In this paper, we will provide evidence that, in fact, the content features of digital media *can* predict their consumption, and that high-performing features can be *learned* through empirical analysis. We will introduce and test an approach to identifying these high-performing content features, and estimate the effectiveness of these features in boosting consumption of media.

While advances in machine learning (e.g., deep learning, NLP) present opportunities to capture the content features associated with digital media, it is unclear how to assess the effect of these features on media consumption. Thus, it remains uncertain whether the content of these media can inform more effective media design, and if so, how firms can identify content features that are

[1] For example, organic results on Google searches achieve over twenty times the clicks of paid results, despite occupying less than forty percent of screen real estate (source: https://sparktoro.com/blog/seo-opportunity-growing-shrinking/).
[2] https://www.emarketer.com/Article/Ad-Blocker-Use-Grows-Publishers-Face-New-Challenges/1016076

associated with high-performing media. In addition to uncovering effective content features, firms and content creators could benefit from understanding what rewards they can expect to reap by creating media that reflect these features. To address these issues, our study poses two questions: (1) How can the role of content features in consumption of media be learned, and (2) What increase in consumption is associated with media that exhibits high-performing features?

Our analysis of content of digital media focuses on the "Big Five" personality traits (Norman 1963). While our model can be extended to incorporate other content features (e.g., tone, visual elements), we focus on personality due to its demonstrated relevance to the spread of WOM (Adamopoulos et al. 2018; Devaraj et al. 2008; McElroy et al. 2007), which is a key driver of consumption for digital media (Susarla et al. 2011). The "Big Five" traits refer to a psycholinguistic framework which advocates that personality can be characterized by five dimensions: openness, conscientiousness, extroversion, agreeableness, and neuroticism. Individuals or collectives may exhibit varying degrees of each of these traits, which can be described as follows. The *openness* trait is associated with curiosity and willingness to try new experiences, while individuals with low openness tend to be more cautious and reserved. *Conscientiousness* refers to a preference for planning over spontaneity, and self-discipline over free-spiritedness. The trait of *extroversion* is marked by high levels of engagement with other individuals and the external world, whereas individuals who are less extroverted (i.e., introverted) are more introspective. *Agreeableness* suggests an attentiveness towards others, and a concern for social and interpersonal harmony. Finally, the *neuroticism* trait is associated with emotional volatility, and a tendency to get irritated easily. The degree to which this collection of traits is exhibited by an entity can be referred to as its "personality".

The extent to which each personality trait is exhibited can be inferred through behaviors or speech (Corr and Matthews 2009; Costa & McCrae 1992). Although personality may vary slightly over time or adapt to situational factors, there is evidence that personalities tend to be relatively stable, and even biologically-influenced (Briley and Tucker-Drob 2014). As such, personality has been shown to various outcomes, including brand evangelism (Doss & Karstens 2014), job performance (Barrick and Mount 1991), and marital stability (Kelly & Conley 1987).

While much of the psychological literature has considered outcomes associated with the personality of "real" individuals or collectives, personality can also be exhibited by entities created with human input (Aaker 1997; Corr and Matthews 2009). Accordingly, we propose that the characters, personas, or narrators (whether real or fictitious) within media may project discernable personalities. These personalities may reflect those of real individuals within the media, or of individuals who were involved in creating the media, such as a firm's employees or management. Firms thus make (at least implicit) decisions about what personalities to project in their media; Our aim is therefore to investigate whether firms can uncover empirical insights to understand what personalities may be more effective at appealing to their audience, and thus generate greater consumption.

In assessing the role of personality on the consumption of online videos, we contribute to a nascent, yet growing body of literature on *content engineering*. This research explores the role of content features on the effectiveness of various media, including traditional offline ads, digital ads, and non-advertising media. For example, research has examined the effects of appealing to intuition vs. reason in direct advertising (Bertrand et al. 2010), and of focusing on action, information, or emotion in TV advertising (Liaukonyte et al. 2015). In a digital context, research has also considered the benefits of ad personalization (Tucker 2014), and of features of Facebook posts on user engagement (Lee et al. 2018). Finally, some work has explored the role of content for media besides advertisements, including the effect of emotional content on the digital sharing of *New York Times* articles (Berger and Milkman 2012), and the effect of political slant on newspaper readership (Gentzkow and Shapiro 2010).

While prior research suggests an association between content and the spread of WOM, we build on that work in three key ways. First, previous studies focus on media whose popularity is inherently ephemeral, such as newspapers providing timely information, or Facebook posts that quickly get drowned out in new content. However, our study focuses on online videos, which exhibit dynamic consumption patterns that we can examine over an extended time period. Second, this study is the first, to our knowledge, to examine the role of personality in digital media consumption. In doing so, we answer calls to consider the role of rich, multi-dimensional aspects of human behavior, and moving beyond binary or one-dimensional metrics such as sentiment (Kim et al. 2013).

Given increasing sophistication of content analysis techniques, our analyses may provide a useful example to inspire future research. Third, our study uncovers not only "global" insights that may apply to all content creators, but also demonstrates that it can be even more useful to identify high-performing content features for a particular content creator.

2 Theory and Methdology

2.1 How Content Personality Affects Media Consumption

To understand the connection between personality and media consumption, we draw from literature on WOM, information diffusion, and personality theory to propose the mechanism illustrated in Figure 1. First, we note that any speech-driven media featuring a focal persona or narrator will project their personality through its speech. Although personality is considered an internal property of individuals, it can be inferred with high accuracy by observing external constructs such as word choice and phrasing (Fast and Funder 2008; Goldbeck et al. 2011). Moreover, speech can be used to infer personalities associated not only with individuals (Roccas et al. 2002; Salgado 2003), but also with entities created with human input (Aaker 1997; Corr and Matthews 2009), including digital media (Nass and Lee 2001). Thus, we can reliably extract personality traits from the speech associated with a video's narrator, without directly administering a psychological personality test (Hirsch and Peterson 2009). Although personality may correlate with features besides speech, text-based methods are considered the best and most accurate way to infer personality (Pennebaker 2013, ch. 4). Hence, one can argue that through the script or speech associated with a video's protagonist, we can infer the personality of the media. It is worth noting that we focus on this overall personality, rather than the words themselves, because higher-level constructs such as personality will offer more prescriptive value (Song et al. 2013).

Given that speech-driven media exhibit personalities, we consider how this personality could affect media consumption. We argue that the personality of media can affect the nature of the WOM around the media. Depending on who the content of the media appeals to, the quantity and quality of this WOM may vary. One reason for this may be that the media content resonates with its consumers by exhibiting similar personalities. Because interpersonal similarity tends to increase trust and decrease social friction (Byrne 1997; Lichetenthal and Tellefsen 2001), one can argue that media with personalities that match those of their consumer base may tend to generate more WOM. Similar benefits of personality similarity have been found in a variety of contexts, including friendship formation (Morry 2007), marital stability (Kelly & Conley 1987), and attraction to employers by employees (Devendorf and Highhouse 2010). In addition, individuals may be more prone to sharing media that reflects a personality to which they aspire (Malhotra 1988; Sirgy 1992). For example, if individuals wish to be perceived as more open, they may be more drawn to other individuals (or media) that exhibit high openness, regardless of whether they exhibit this trait themselves. Thus, due to interpersonal similarity and/or personal aspirations, the personality of media content may affect the personality of those who propagate WOM around the media upon consuming it. In turn, the personality of these consumers may affect the quantity, quality, and effectiveness of the WOM spread around the media (Adamopoulos et al. 2018; Devaraj et al. 2008; Lee et al. 2014).

Because WOM is a key driver of the popularity of digital media (Susarla et al. 2011), it is likely that the nature of this WOM will, in turn, affect the consumption of the media. As more individuals consume these media based on online chatter, they too may spread WOM around the media, creating a positive feedback loop between WOM and video consumption.

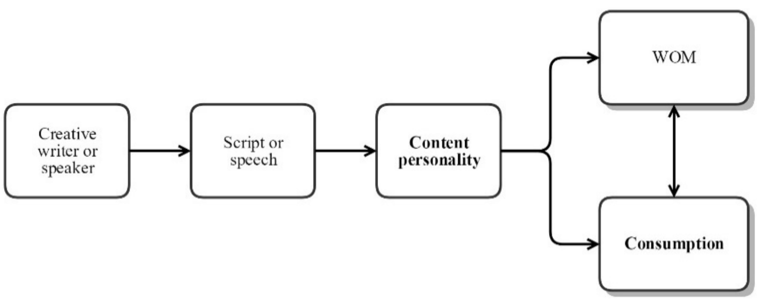

Figure 1. How Media Content Affects Consumption

2.2 Measuring Effect of Media Consumption on Personality

To extract predictive, economic, and prescriptive insights into the relationship between media content and its consumption, we introduce a three-step approach, outlined in Figure 2. Although we employ this approach in the context of online videos and personality, the methodology would allow for consideration of other content features (e.g., visuals, tone) as appropriate for a given context, as well as other media formats (e.g., images).

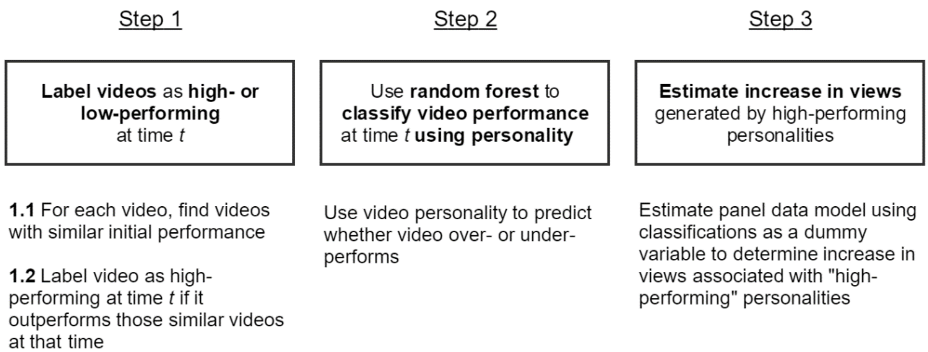

Figure 2. Overview of Methodology

To establish whether personality affects the consumption of online videos, we would first like to understand the predictive role of personality. To achieve this, our first step is to label each video based on the question: given its initial consumption momentum, does the video over- or under-perform? Because the early consumption of digital media reasonably predicts its long-term success (Szabo and Huberman 2010; Pinto et al. 2013)[3], one can argue that videos with similar initial views have similar potential. Per the "She's Mercedes" example in Figure 2, the early performance of media may be influenced by their superficial characteristics (e.g., brand, followers, audience size). On the other hand, as media are consumed over time, WOM plays an increasing role in their diffusion (Mahajan and Peterson 1985), suggesting that the actual content of the media will play a more salient role in their long-term consumption. Hence, our approach focuses on categorizing videos by performance relative to expectation, so that

[3] Past performance of a video is regarded as the best predictor of its future performance, regardless of the content or channel associated with the video.

we can eventually identify content features associated with over- and under-performance.

To estimate a video's expected views on a specific day *t*, we take the average of views on day *t* of a set of videos that had similar consumption to the focal video in their first 24 hours (i.e., on day one). We label videos that outperform their corresponding similar videos as "high performing" (i.e., labeled as "1") on day *t*, whereas those that underperform relative to expectation are labeled as "low-performing" (i.e., labeled "0"). We achieve this labelling in a two-step process, characterized by equations 1 and 2 below. Using Equation 1, we calculate the similarity in initial views of a pair of videos by simply taking the absolute value of the difference between these two view counts. In Equation 2, we obtain the median number of views on day *t* of *k* videos with the most similar initial performance. For our main analysis, we will use twenty videos with the most similar initial performance to a focal video (i.e., *k* = 20) – we will assess the robustness of this choice later. Finally, in Equation 3, we give video *i* label $H_i(t)$ in accordance with its relative performance at time *t*.

Equation 1. Similarity in initial performance between video *i* and video *i'*

$$s(v_i, v_i') = \sqrt{(Y_i(1) - Y_i'(1))^2}$$

Equation 2. Expected Views of video *i* at time *t*

$$E[Y_i(\mathrm{t})] = \text{median}(Y_i^k(t))$$

Equation 3. Labelling Videos by Performance

$$Y_i(t) > E[Y_i(\mathrm{t})] \rightarrow H_i(t) = 1$$
$$Y_i(t) < E[Y_i(\mathrm{t})] \rightarrow H_i(t) = 0$$

Where $s(v_i, v'_i)$ = similarity in views between video *i* and video *i'* on day 1
k = the number of videos similar to *i* used to calculate expected future performance
$Y_i^k(t)$ = views of the *k*th most similar video to video *i* on day *t*

Using these performance labels, we would like to assess the role of personality on media consumption. To do this, we use random forests to estimate the effect of video personalities (as independent variables), on the video labels (as the dependent variable). Hence, these forests classify video performance using only personality traits. It is worth noting that labels associated with a single video may evolve over time. To account for account for a potentially evolving role of personality in the consumption of videos, we estimate random forests at each time.

Since random forest prediction accuracy may depend on the underlying heterogeneity of training data, we test our approach using different training sets – namely, channel-specific (somewhat heterogeneous) and global (highly heterogeneous). While global forests allow us to uncover overall insights into what personalities are high-performing, channel-specific forests will identify personalities that are high-performing for a given content creator. The global forests use all videos in our dataset to learn what personalities are associated with high- and low-performing videos. Meanwhile, channel-specific forests use only videos within a given channel to predict performance based on personality[4]. Intuitively, a given channel may have specific personalities that perform well for their audience. For example, a channel such as McDonalds may cater to a different audience than that of Business Insider, and thus may benefit from different personalities being reflected in their media. These differences in personality may be due to factors such as differing audience demographics, or differing products offered by each firm. Furthermore, even if we can identify high-performing personalities for specific channels, it does not necessarily follow that there would be personalities that tend to perform well across all content creators. Thus, both global and channel-specific models warrant investigation.

Given the assessment of the predictive role of personality in video popularity, the next part of our analysis measures the economic effect of personality on views. That is, if we classify a video (whether accurately or not) as high-performing, what change in views can the video expect to see? To quantify this effect, we estimate a panel data model that considers the role of relevant parameters on the daily views achieved by videos. To estimate the expected benefits of a video being classified as high-performing, we include this personality-based performance classification as an independent variable in our model. To extract further insights on the role of personality traits, we additionally

[4] We estimate channel-specific forests for 80 channels for which we have data on at least 30 videos associated with the channel.

control for percentile scores of each "big five" trait. To isolate the effect of personality from time-specific shocks in WOM that may affect views, we consider the change in number of likes and dislikes in each time period. As a robustness check, we estimate this model with not only the video's classification, but with its likelihood score produced during the random forest estimation. This score reflects the proportion of trees that classified the video as "high-performing", and thus represents the confidence level associated with the classification. We estimate the below model using both global and channel-specific classifications.

Model 1. The Effect of Personality Classification on Video Views

$$\log Y_{ij,t} - logY_{ij,t-1} = \beta_0 + \beta_1 * \boldsymbol{C_{ij,t}} + \beta_P * P_{ij} + \beta_2 * \Delta likes_{ij,t} + \beta_3 * \Delta dislikes_{ij,t} + \varepsilon_{i,t}$$

$$\log Y_{ij,t} - logY_{ij,t-1} = \beta_0 + \beta_1 * \boldsymbol{L_{ij,t}} + \beta_P * P_{ij} + \beta_2 * \Delta likes_{ij,t} + \beta_3 * \Delta dislikes_{ij,t} + \varepsilon_{i,t}$$

Where $Y_{ij,t}$ = daily views for video *i* in channel *j* at time *t*

$C_{ij,t}$ = Classification (0 or 1) associated with video *i* in channel *j* at time *t*

$L_{ij,t}$ = Proportion of trees classifying video *i* in channel *j* as high-performing at time *t*

P_{ij} = Vector of percentile scores associated with each "big five" personality traits associated with video *i* in channel *j*

$\Delta likes_{ij,t}$ = change in number of likes associated with video *i* in channel *j* between time *t* and *t-1*

$\Delta likes_{ij,t}$ = change in number of dislikes associated with video *i* in channel *j* between time *t* and *t-1*

With our understanding of the predictive and economic effects of personality on views, a logical next step would be to examine what personalities are most effective in increasing views. To do so, we will cluster videos by personality, and examine the average performance classifications of each personality cluster.

3 Data

We examine the role of content personality on the consumption of digital media using a unique dataset consisting of 16,414 online videos from 363 YouTube channels. We collected daily statistics on these videos and channels over 365 days, as represented in Figure 3 and summarized in Table 1 below.

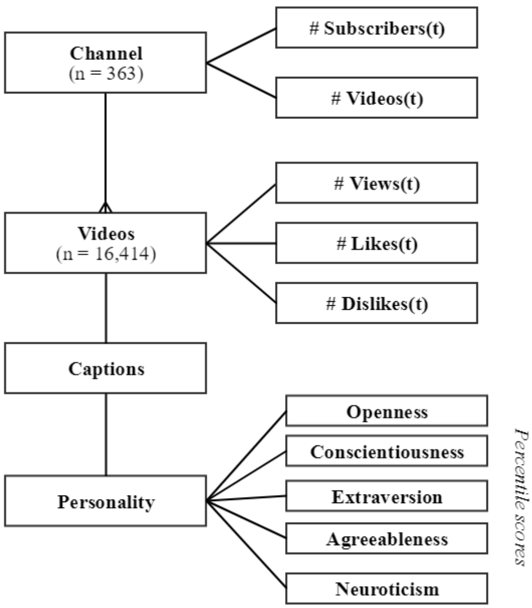

Figure 3. Data Overview

Table 1. Summary Statistics of Video and Channel Attributes

Attribute		Mean (St Dev)
Video	Caption length (# words)	923 (1,172)
Channel	# subscribers (max.)	2,595,446 (5,662,767)
Channel	# videos (max.)	1,760.91 (7,122.04)

Because we want to assess the relationship between videos' consumption patterns their personality, our data collection approach selects videos that were more likely to exhibit a discernable personality. To this end, we targeted videos that were speech-driven, rather than oriented around musical or visual elements. To identify such videos, we created a script that determined whether a video contained caption text, and whether this caption text was uploaded by the channel itself (as opposed to auto-generated)[5]. We target videos that contain caption text because psycholinguistic theory suggests that personality can be best inferred through speech, while theory that may help us infer personality through other components (e.g., visuals, music) is much less established. Speech-driven videos are therefore appropriate to the context of our study, as these videos typically have a discernable narrator or protagonist, who will project a specific personality.

To identify channels containing videos satisfying the aforementioned criteria, we considered channels associated with Fortune 500 companies, as well as over 1,000 channels associated with trending videos on YouTube over a two-week period[6]. We identified 61 such channels from the Fortune 500, and 302 channels associated with YouTube trending videos. To collect daily data on these videos from 363 channels, we executed a daily script. We obtained overvations on 6,640 videos with over 100 words of caption data, along with daily view, like, and dislike statistics over 365 days.

To infer the personalities of videos using caption text, we used IBM Watson Personality Insights[7]. Watson estimates the personality of a text corpus using natural language processing (NLP). This NLP analysis leverages a large database of diverse text corpuses with pre-labeled (i.e., known) personalities, and thus estimates the personality of each new corpus in a supervised manner. Based on this semantic similarity between video caption text and these pre-labeled corpuses, the IBM service outputs a vector with percentile scores for each of the "Big Five" personality traits.

Summary statistics on personality scores in Table 2 suggest that, with regard to most traits, YouTube videos are representative of personalities among the population. The one exception is openness, which is exhibited to a greater extent on YouTube captions than in other text corpuses.

[5] Captions can be viewed on YouTube by clicking on the 'CC' button on the lower-right corner of the video.
[6] The videos that were actually trending were not included in our dataset. Rather, trending videos helped us identify channels from which we would collect future data.
[7] https://console.bluemix.net/docs/services/personality-insights/science.html#science

Table 2. Summary Statistics for Video Personality Trait Percentiles

Personality Trait	Mean (St Dev)
Openness	.90 (.17)
Conscientiousness	.51 (.27)
Extroversion	.41 (.29)
Agreeableness	.33 (.33)
Neuroticism	.65 (.25)

While our data collection process selects a targeted sample of vidoes, our analysis approach can be implemented using various video features (e.g., visuals, tone). Speech-driven videos are simply selected due to the focus on personality.

4 Solution Design and Development

4.1 Predictive Insights: Personality and Video Performance

Per the first step of our methodology, we label all videos as high- or low-performing, based on whether they have more of fewer views than the median number of views of twenty similar videos at a particular time *t*. Using these labels, we estimate global and channel-specific random forests that classify video performance at each time period, using only personality traits as independent variables. Observing the accuracy of our random forest classifications in Figure 4, we find that both global and channel-level estimations achieve an accuracy greater than 50% over all time periods.

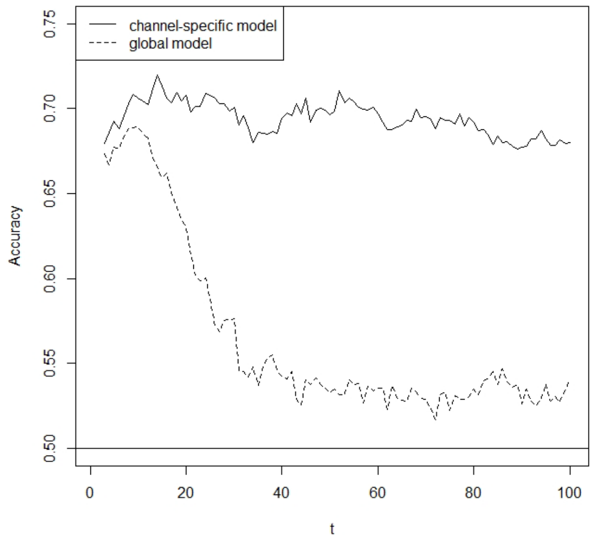

Figure 4. Accuracy of Random Forests over Time

Our findings offer evidence that we can indeed *learn* what personalities are associated with high-performing videos. Notably, accuracy could be improved by observing additional attributes of the video, including stochastic features such as view counts from prior days. However, to maintain our emphasis on content engineering, we focus on the relationship between the performance of a video and its time-invariant features, as only these features are manipulable during media creation.

Per Figure 4, channel-level accuracy remains consistently above the global accuracy. While the channel-level model peaks at 72% accuracy on day 16, the global accuracy peaks at 68% on day 12. This suggests there are both global and channel-level insights into the role of personality in video consumption, but that the channel-specific insights may be more informative. This is likely due to our prior argument that specific personalities may appeal to the target audience of each channel.

4.2 Economic Insights: Effect of Personality on Video Consumption

Building on our assessment of the predictive power of personality on video consumption, we assess the economic effects of personality classifications. To this end, we estimate Model 1 on both global and channel-specific forests to evaluate this economic impact. Estimating the global model produces results shown in Table 3[8]. Despite lower accuracy and robustness of global classifications, our estimates suggest that videos classified as high-performing based on their personality can expect to achieve 0.5% more views per day, relative to those with low-performing personalities. The positive coefficient on likelihood confirms the robustness of this result, and suggests that videos classified as high-performing with 10% greater confidence can expect to generate .028% more daily views.

Additionally, we find that videos with lower openness and lower conscientiousness may achieve more views. Our estimates indicate that a decrease of 10 percentile points in openness is associated with a 0.09% increase in daily views. Similarly, a 10 percentile decrease in conscientiousness is associated with a 0.13% increase in daily views. Finally, we find that one additional like or dislikes is associated with an increase in daily views by 0.002% and 0.006%, respectively. Because changes in likes and dislikes can be seen as a proxy for time-specific WOM associated with a video, we would expect to see this positive relationship. Furthermore, controlling for these time-specific factors allows us to control for exogenous shocks that may otherwise bias our estimates.

[8] Note that personality scores for both global and channel-specific models are normalized across all videos, and not just a specific subset of videos. In addition, multi-collinearity tests reveal no concerns over including all personality traits in one model – i.e., VIF is below 10 for all models.

Table 3. Effect of Global Performance Classification on Views

	Coefficient (SD)	Coefficient (SD)	Coefficient (SD)	Coefficient (SD)
Classification: $C_{ij,t}$	0.006*** (0.0003)	0.005*** (0.0003)	0.005*** (0.0003)	
Likelihood $L_{ij,t}$				0.028*** (0.0012)
Openness		-0.009*** (0.0026)	-0.005* (0.0026)	-0.005* (0.0026)
Conscientiousness		-0.013*** (0.0020)	-0.012*** (0.0019)	-0.012*** (0.0019)
Extroversion		0.003 (0.0017)	0.004 (0.0016)	0.004 (0.0017)
Agreeableness		0.002 (0.0014)	0.0002 (0.0014)	0.0001 (0.0015)
Neuroticism		0.002 (0.0024)	0.003 (0.0024)	0.003 (0.0024)
$\Delta Likes_{ij,t}$			0.00002*** (0.0000002)	0.00002*** (0.0000002)
$\Delta Dislikes_{ij,t}$			0.00006*** (0.000002)	0.00006*** (0.000002)
Intercept	0.017*** (0.0004)	0.029*** (0.0026)	0.022*** (0.0026)	0.011*** (0.0027)

*p < 0.1; *p < 0.05; ***p < 0.01

We observe in Table 4 that channel-specific personality classifications yield a one percent increase in daily views, having double the benefit of global classifications. Such a result is to be expected, given the greater accuracy and robustness of the channel-specific classifications. Supporting the robustness of this finding, our estimates suggest that videos classified as high-performing with 10% greater likelihood can expect to achieve 0.033% more daily views. Furthermore, we confirm our prior result on the negative effect of conscientiousness on video views, with our estimates suggesting that a 10 percentile decrease in conscientiousness would lead to a .17% increase in daily views.

Table 4. Effect of Channel-Specific Performance Classification on Views

	Coefficient (SD)	Coefficient (SD)	Coefficient (SD)	Coefficient (SD)
Classification: $C_{ij,t}$	0.010*** (0.001)	0.011*** (0.001)	0.010*** (0.001)	
Likelihood $L_{ij,t}$				0.033*** (0.002)
Openness		0.004 (0.11)	-0.001 (0.008)	0.003 (0.008)
Conscientiousness		-0.017** (0.008)	-0.013** (0.006)	-0.011* (0.006)
Extroversion		0.005 (0.007)	0.005 (0.005)	0.004 (0.005)
Agreeableness		0.006 (0.006)	0.0004 (0.005)	0.0002 (0.005)
Neuroticism		0.014 (0.010)	0.008 (0.008)	0.009 (0.008)
$\Delta Likes_{ij,t}$			0.00001*** (0.0000001)	0.00001*** (0.0000001)
$\Delta Dislikes_{ij,t}$			0.0002*** (0.0000003)	0.0002*** (0.0000004)
Intercept	0.035*** (0.002)	0.027*** (0.011)	0.030*** (0.001)	0.015* (0.009)

*p < 0.1; *p < 0.05; ***p < 0.01

A notable difference between the channel-specific and global model estimates is that while the global model suggests a negative effect of openness, the channel-level model does not. Given the greater accuracy and robustness of the channel model, this inconsistency may be due to the superior ability of the channel-level classifications to capture a preference for lower openness. At the same time, the notion that lower openness could be beneficial to many videos is supported by the high overall level of openness of YouTube videos (per Table 2), relative to the average openness of individuals. Because videos exhibiting high openness may not reflect the personality of their consumers, these viewers may be less likely to spread WOM about the video.

Given the aforementioned findings, we would like to illustrate the long-term, cumulative effects of our personality-based performance classifications. To do so, we apply the one percent increase in daily views suggested by our channel-level classifications across the lifespan of all videos in our dataset. We find that this daily increase in views increases cumulative views of videos by an average of 14.6% (SD = 3.2%). Hence, the daily increases in views associated with high-performing personalities may compound over time to generate meaningful long-run benefits. It should also be noted that content creators can reap these benefits across all videos from their channel, or a specific campaign, which could increase the effectiveness of their content marketing strategy.

5 Discussion

This research takes initial steps to evaluate the important yet underexplored relationship between content features and the consumption of digital media. Given growing emphasis on rich digital media, it is important to understand how the design of these media may influence their attractiveness. Through the lens of personality, we provide evidence of an association between the personality and the success of 6,440 videos from 80 YouTube channels. We find that personality can identify high-performing media with strong accuracy and robustness, and with meaningful benefits.

The implications of our work concern marketers, as well as other creators of rich digital media. First, these content creators should consider our global findings regarding what personalities tend to be associated with high-performing videos. By creating content that reflects a high-performing personality, they can create digital media that has a higher likelihood of achieving greater popularity. Second, content creators may want to obtain more detailed insights into what personalities are high-performing for their audience. We find that these channel-specific insights are superior in both accuracy and impact. This is likely due to the specificity of each channel's audience, which may not be a representative sample of the population, or even of the YouTube community. Thus, there may be specific personalities that appeal to these audiences.

Regarding specific personality traits, we find that videos of lower conscientiousness tend to achieve greater views. These videos may project a personality that is more spontaneous, disorderly, and fun. Such personalities are often associated with non-conformity and social differentiation (DeYoung et al. 2002). Due to individuals' desire for social differentiation and originality (Lemaine 1974), more consumers may be drawn to such videos. Because individuals enjoy differentiating themselves through their consumption preferences (Vandecasteele and Geuens 2010), these individuals may also be more prone to sharing WOM about these videos.

In addition to our insights into the role of personality, we introduce a novel methodology that can identify high-performing content features in general. This approach allows for the consideration of complex, multi-dimensional constructs such as visual features and tone, which are of increasing relevance due to advancements in content analysis techniques. Future research can consider employing this approach to understand the role of other features for other forms of media.

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The Effects of Positive and Negative Emotions During Online Shopping Episodes on Consumer Satisfaction, Repurchase Intention, and Recommendation Intention

MARKUS MAKKONEN, JANNE RIEKKINEN, LAURI FRANK & JARI JUSSILA

Abstract The aim of this study is to examine the emotions that consumers experience during their online shopping episodes as well as their effects on consumer satisfaction and two types of post-purchase behavioural intentions: repurchase and recommendation intentions. By hypothesising a research model and testing it with the data from 1,786 Finnish online shoppers, which was collected in co-operation with 18 Finnish online stores between September 2018 and December 2018 and is analysed by using structural equation modelling (SEM), the study makes several interesting findings. First, we find positive emotions to have stronger effects in comparison to negative emotions. Second, we also find that whereas the effects of negative emotions on repurchase and recommendation intentions are completely mediated by satisfaction, positive emotions affect them not only indirectly via satisfaction but also directly. Finally, we discuss the implications of these findings for the Turku managers of online stores.

Keywords: • Online Shopping • Consumer Emotions • Consumer Satisfaction • Repurchase Intention • Recommendation Intention • Online Survey • Finland •

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1 Introduction

In the traditional offline context, the emotions that consumers experience have been identified as important antecedents of consumer satisfaction and post-purchase behaviours, such as repurchase, recommendation, complaint, and word-of-mouth behaviour (Westbrook, 1987; Oliver & Swan, 1989; Westbrook & Oliver, 1991; Mano & Oliver, 1993; Oliver, 1993; Mooradian & Olver, 1997). However, in the online context, the emotions that consumers experience during their online shopping episodes and their effects on consumer satisfaction and post-purchase behaviours remain much more poorly understood. In part, this has been due to the tendency of both information systems (IS) and marketing research to focus more on the rational rather than emotional aspects of consumer behaviour (Bagozzi, Gopinath & Nyer, 1999; Beaudry & Pinsonneault, 2010). In part, it has also been due to some severe shortcomings in the prior studies on the topic. On one hand, the prior studies have typically focused on examining the effects of emotions on either satisfaction or some specific type of post-purchase behaviour only one construct at a time instead of considering also the effects that these constructs may have on each other. This has left us unaware of the exact mechanisms how emotions affect consumer behaviour in the online context. For example, do emotions affect post-purchase behaviours only directly or also indirectly via satisfaction? Or does satisfaction act as a central construct that mediates all the effects of emotions on post-purchase behaviours, similar to what has been suggested in the traditional offline context (e.g., Mooradian & Olver, 1997)? On the other hand, the prior studies have also typically focused on a very small subset of emotions in comparison to the full set of emotions that have been suggested as relevant in the consumption context (e.g., Richins, 1997; Laros & Steenkamp, 2005). This has partly been due to research design, such as the deliberate decisions by Childers et al. (2001) as well as Koufaris (2002) to focus only on the perceived enjoyment of online shopping in their studies. However, it has also partly been due to poor operationalisations of the research constructs. An example of this is found in the studies by Kuo and Wu (2012) as well as Pappas et al. (2014), in which the measures of positive emotions focused only on feeling happy, warm, and valued, whereas the measures of negative emotions focused only on feeling angry and upset as well as being in a bad mood.

In this study, our objective is to address the aforementioned shortcomings by hypothesising and testing a research model that both (1) examines the effects of emotions on consumer satisfaction and post-purchase behavioural intentions while also considering the effects of the outcome constructs on each other and (2) measures emotions by focusing not only a small sub-set of emotions but the full set of emotions that have been found relevant in the consumption context. Of the post-purchase behavioural intentions, we concentrate on two types of intentions that have been commonly considered as central dimensions of behavioural customer loyalty: repurchase and recommendation intentions. The data for testing the research model comes from 1,786 Finnish online shoppers, which was collected in co-operation with 18 Finnish online stores between September 2018 and December 2018 and is analysed by using structural equation modelling (SEM).

The paper consists of six sections. After this introductory section, we will next describe the research model of the study in Section 2. This is followed by a brief description of the methodology of the study in Section 3. The results of the study are reported in Section 4 and discussed in more detail in Section 5. Finally, we will conclude the paper with a discussion of the limitations of the study and potential paths of future research in Section 6.

2 Research Model

There are numerous frameworks that have aimed to identify the basic emotions that are common to all humans (e.g., Ekman & Friesen, 1971; Izard, 1977; Russell & Mehrabian, 1977; Plutchik, 1980; Russell, 1980; Roseman, 1984; Roseman, Antoniou & Jose, 1996). In this study, we base our research model on two such frameworks that have been suggested specifically for the consumption context. The first of these frameworks is the consumption emotions set (CES) by Richins (1997), which identifies 16 basic emotions and defines a set of descriptors for measuring them. These emotions and their descriptors (in parenthesis) are anger (frustrated, angry, and irritated), discontent (unfulfilled and discontented), worry (nervous, worried, and tense), sadness (depressed, sad, and miserable), fear (scared, afraid, and panicky), shame (embarrassed, ashamed, and humiliated), envy (envious and jealous), loneliness (lonely and homesick), romantic love (sexy, romantic, and passionate), love (loving, sentimental, and warm-hearted), peacefulness (calm and peaceful), contentment (contented and fulfilled), optimistic (optimistic, encouraged, and hopeful), joy (happy, pleased, and joyful), excitement (excited, thrilled, and enthusiastic), and surprise (surprised, amazed, and astonished). The second framework is the hierarchical framework by Laros and Steenkamp (2005), which is based on CES, but excludes some basic emotions which may not be so relevant in all consumption contexts (e.g., loneliness, love, and romantic love). In addition, the framework also defines a hierarchical structure for emotions that consists of three levels. At the superordinate level, the emotions are differentiated into positive affect and negative affect. The two affects, in turn, are measured by six basic emotions at the intermediate level, which are contentment and happiness in the case of positive affect and anger, fear, sadness, and shame in the case of negative affect. Finally, the six basic emotions are measured by 33 specific emotions or emotion words at the subordinate level, which are based on the descriptors of CES.

Of these two frameworks, we base our research models mainly on the hierarchical framework by Laros and Steenkamp (2005) but modify it slightly based on the CES by Richins (1997). First, the hierarchical framework measures contentment with descriptors that are used to measure both contentment (contented and fulfilled) and peacefulness (peaceful) in CES. Thus, in our research model, we decompose this construct into two different constructs: contentment and peacefulness. Second, the hierarchical framework measures happiness with descriptors that are used to measure optimism (optimistic, encouraged, and hopeful), joy (happy, pleased, joyful), and excitement (excited, thrilled, enthusiastic) in CES. Thus, in our research model, we decompose this construct into three different constructs: optimism, joy, and excitement.

The final research model after the aforementioned modifications is illustrated in Figure 1. As can be seen, it consists of five first-order positive emotion constructs (contentment, peacefulness, optimism, joy, and excitement) and four first-order negative emotion constructs (anger, fear, sadness, and shame), of which the former act as reflective measures of the second-order positive emotions construct and the latter act as reflective measures of the second-order negative emotions construct. The positive and negative emotions, in turn, are hypothesised to have direct effects on satisfaction as well as repurchase and recommendation intentions. In addition, they are also hypothesised to have indirect effects on repurchase and recommendation intentions via satisfaction, which has been found to act as an antecedent of these intentions in the prior studies by Anderson and Sullivan (1993), Anderson (1998), as well as Mittal and Kamakura (2001).

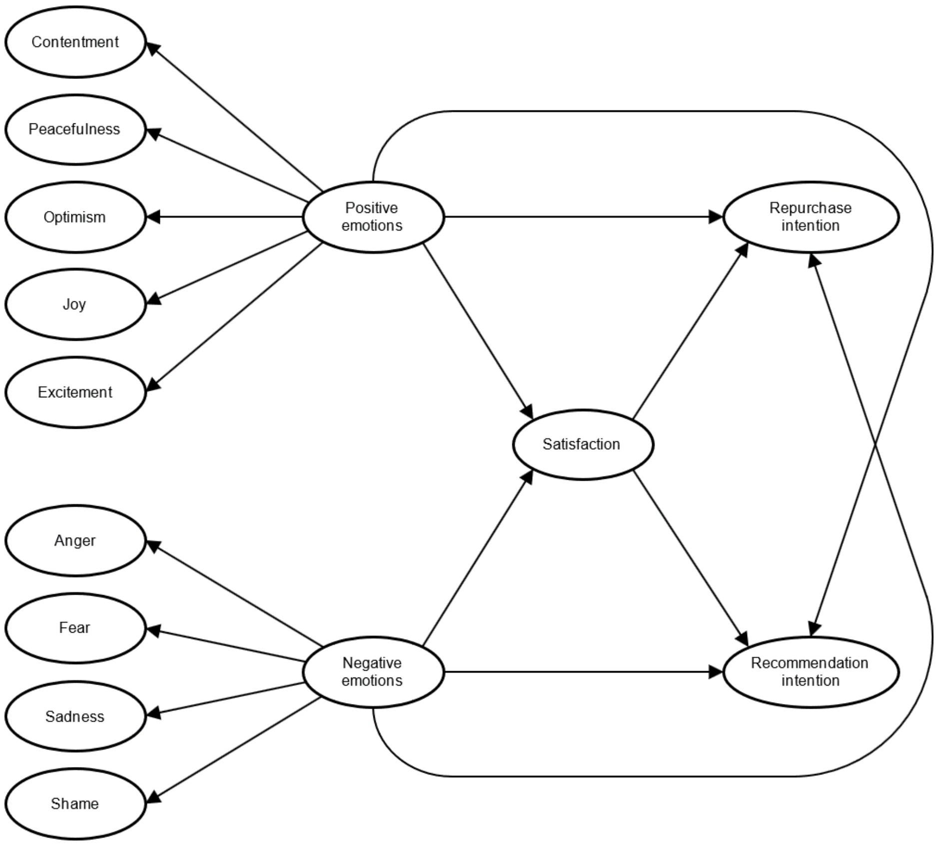

Figure 1: Research model

3 Methodology

The data for the study was collected from Finnish online shoppers via an online survey in co-operation with 18 Finnish online stores between September 2018 and December 2018. The stores, which were mainly focused on groceries and consumables, clothing, cosmetics, and furnishings, added a link to the survey on the webpage that was shown to their customers after a successful order. In the survey, the respondents were first inquired about their gender and age as well as how often do they shop online, what they had just ordered, and how many times they had previously shopped in that online store. After this, the respondents were inquired about the emotions that they had experienced during the online shopping episode that had just ended as well as about their satisfaction, repurchase intention, and recommendation intention. The nine first-order emotion constructs of our research model were measured reflectively by using a set of 28 emotion words (e.g., contented or angry) that were taken from the hierarchical framework by Laros and Steenkamp (2005). The respondents rated all these emotions with a scale ranging from one to seven, in which one meant that they had not experienced that specific emotion at all during the online shopping episode and seven meant that they had experienced that specific emotion very strongly during the online shopping episode. Satisfaction as well as repurchase and recommendation intentions were measured reflectively by three items each. The items measuring satisfaction were taken from the American Customer Satisfaction Index (ACSI – Fornell et al., 1996) and the Extended Performance Satisfaction Index (EPSI – Selivanova et al., 2002), which are both based on the Swedish Customer Satisfaction Barometer (SCSB – Fornell, 1992) and have also been previously applied to the online setting by Hsu (2008). Together, the items measure satisfaction in three different dimensions: (1) overall satisfaction, (2) expectancy (dis)confirmation (i.e., the performance that falls short of or exceeds expectations), and (3) the performance versus the customer's hypothetical ideal product or service. The measurement scale of these items ranged from one to seven, in which one meant extreme dissatisfaction and seven meant extreme satisfaction. In turn, the items measuring repurchase and recommendation intentions were adapted from the studies by Khalifa and Liu (2007) as well as Zeithaml, Berry, and Parasuraman (1996). The measurement scale of these items was the traditional seven-point Likert scale. Responding to all the aforementioned measurement items was non-mandatory, meaning that also missing values were possible. The wordings of all the measurement items are reported in Appendices A and B. In addition to above, the respondents were also asked to tell in their own words about the causes of their experienced emotions during the online shopping episodes. However, these responses are not utilised in this particular study.

The collected data was analysed by using covariance-based structural equation modelling (SEM) conducted with the Mplus version 7.11 statistical software (Muthén & Muthén, 2019). Due to the non-normal distributions of many of the indicator variables, the model estimation was conducted by using the MLR estimator, which stands for maximum likelihood estimator robust to non-normal data. The missing values in the indicator variables were handled by using the FIML estimator, which stands for full information maximum likelihood and uses all the available data in the model estimation.

4 Results

The online survey was completed by 1,803 respondents. However, 17 of these respondents had to be dropped from the study due to invalid or missing data, resulting in a sample size of 1,786 responses to be used in the actual analyses. The descriptive statistics of this sample are reported in Table 1. As can be seen, most of the respondents were women, which can be explained by the fact that many of the co-operating online stores were more targeted to women than to men. The age of the respondents ranged from 18 to 80 years, with a mean of 39.9 years and a standard deviation of 13.0 years. On average, most of the respondents (79.1 %) shopped online at least monthly, and most of them (66.9 %) also had previously shopped in the online store that they were inquired about in the survey.

The descriptive statistics of the measurement items in terms of the percentages of missing data, means, and standard deviations (SD) are reported in Appendices A and B. As can be, the respondents reported having experienced a wide variety of emotions during their online shopping episodes, but the positive emotions were clearly experienced more strongly than the negative emotions. The respondents also reported high satisfaction as well as strong repurchase and recommendation intentions. This can be explained by the fact that the data was collected only on online shopping episodes that ended in a successful order. The percentages of missing data were all relatively low, thus indicating that all the measured emotions were relevant for the online shopping episodes and that the respondents also had no difficulties in rating their satisfaction as well as repurchase and recommendation intentions.

Table 1: Descriptive sample statistics (N = 1,786)

	N	%
Gender		
Man	282	15.8
Woman	1,504	84.2
Age		
Under 30 years	441	24.7
30–39 years	507	28.4
40–49 years	393	22.0
50–59 years	288	16.1
60 years or over	157	8.8
On average, how often do you shop online?		
Daily	23	1.3
Weekly	457	25.6
Monthly	932	52.2
Yearly	355	19.9
Less than yearly	19	1.1
How many times have you shopped in this online store?		
Never	592	33.1
1–3 times	647	36.2
4–10 times	412	23.1
Over 10 times	135	7.6

In the following four sub-sections, we report the results of estimating the research model by concentrating first on the reliability and validity of its indicators and constructs and finally on the goodness-of-fit of the estimated model and the actual estimation results.

4.1 Indicator Reliability and Validity

Indicator reliabilities and validities were evaluated by using the standardised loadings of the indicators, which are reported in Appendices A and B for the first-order constructs and in Appendix C for the second-order constructs. In the typical case where each indicator loads on only one construct, it is commonly expected that the standardised loading of each indicator should be statistically significant and greater than or equal to 0.707 (Fornell & Larcker, 1981). This is equal to the standardised residual of each indicator being less than or equal to 0.5, meaning that at least half of the variance of each indicator is explained by the construct on which it loads. As can be seen from Appendix A, in the case of the first-order constructs, all the indicators of the satisfaction, repurchase intention, and recommendation intention constructs as well as the five positive emotion constructs were found to meet this criterion. In contrast, the four negative emotion constructs each had indicators that did not meet the criterion. As a consequence, we decided to drop the two indicators with the lowest loadings, of which one was related to feeling guilty and measured the sadness construct, whereas the other was related to feeling humiliated and measured the shame construct. In addition, we decided to decompose the anger construct into two distinct constructs: anger and frustration. Of these, the more intense anger construct was defined to be measured by the indicators related to feeling angry, annoyed, and irritated, whereas the less intense frustration construct was defined to be measured by the indicators related to feeling frustrated, discontented, and disappointed. This decomposition is supported by the emotions system by Roseman (1984) as well as its more recent revision by Roseman, Antoniou, and Jose (1996), which both identify anger and frustration as two distinct emotions. In addition, the prior studies by Éthier et al. (2006, 2008) on emotions during online shopping episodes have concentrated on frustration instead of anger, thus suggesting that frustration may actually be a more relevant emotion than anger in this context. As can be seen from Appendix B, after these modifications, all the indicators of the new frustration construct now met the criterion, whereas the other four negative emotion constructs still had indicators that did not meet it. However, all these indicators now had standardised loadings that were statistically significant and greater than or equal to 0.6, which has been suggested as a slightly less strict criterion in methodological literature (Bagozzi & Yi, 1988). Thus, we considered all the remaining indicators of the first-order construct to have satisfactory reliability and validity. As can be seen from Appendix C, in the case of the second-order constructs, all the indicators were found to meet also the stricter criterion after the aforementioned modifications. Thus, their reliability and validity can also be considered as satisfactory.

4.2 Construct Reliability and Validity

Construct reliabilities were evaluated by using the composite reliabilities (CR) of the constructs (Fornell & Larcker, 1981), which are commonly expected to be greater than or equal to 0.6 (Bagozzi & Yi, 1988). In turn, construct validities were evaluated by examining the convergent and discriminant validity of the constructs by using the two criteria proposed by Fornell and Larcker (1981). Both of them are based on the average variance extracted (AVE) of the constructs, which refers to the average proportion of variance that a construct explains in its indicators. In order to exhibit satisfactory convergent validity, the first criterion expects that each construct should have an AVE of at least 0.5, meaning that, on average, each construct should explain at least half of the variance in its indicators. Respectively, in order to exhibit satisfactory discriminant validity, the second criterion expects that each construct should have a square root of AVE greater than or equal to its absolute correlation with the other constructs in the model, meaning that, on average, each construct should share at least an equal proportion of variance with its indicators than it shares with these other constructs.

The CR and AVE of each construct after the aforementioned modifications are reported in Appendix B for the first-order constructs and in Appendix C for the second-order constructs. As can be seen, all the first-order and second-order constructs were found to have satisfactory reliability. Most the first-order and second-order constructs were also found to have satisfactory convergent validity, with the exception of fear, sadness, and shame. However, we still decided to keep these three constructs in the model because dropping them would have limited the negative emotions only to anger and frustration, thus being in conflict with our original objective of measuring the full set of emotions that have been found relevant in the consumption context. In addition, the AVEs of these three constructs were all found to be greater than 0.4, thus being relatively close to the threshold of 0.5 and also in line with the AVEs that the emotion constructs in the original hierarchical framework by Laros and Steenkamp (2005) were found to have. For example, based on the standardised loadings reported in their paper, the sadness construct in the original hierarchical framework can be calculated to have an AVE of about 0.426.

As suggested by Koufteros, Babbar, and Kaighobadi (2009), the examination of discriminant validity concentrated on the satisfaction, repurchase intention, and recommendation intention constructs as well as on the second-order emotion constructs, whose interrelationships we were interested in. The discriminant validity of the first-order emotion constructs can be seen to be of less importance because these constructs act as reflective indicators of the second-order emotion constructs and are, therefore, expected to be highly correlated. One also cannot, at the same time, aim to maximise the discriminant validity of the first-order constructs that act as reflective measures of a second-order construct and the convergent validity of that second-order construct because the former would require the first-order constructs to be as weakly correlated as possible, whereas the latter would require the first-order constructs to be as strongly correlated as possible. Thus, Koufteros, Babbar, and Kaighobadi (2009) suggest that the examination and establishment of the convergent validity of the second-order constructs should take precedence. The correlations between the satisfaction, repurchase intention, and recommendation intention constructs as well as the second-order emotion constructs (off-diagonal cells) and their square roots of AVEs (on-diagonal cells) are reported in Appendix D. As can be seen, they were all found to have a satisfactory discriminant validity.

4.3 Goodness-of-Fit

In accordance with the guidelines by Gefen, Rigdon, and Straub (2011), the goodness of-fit of the estimated model was assessed by using the χ^2 test of model fit and four alternative fit indices recommended in recent methodological literature (Hu & Bentler, 1999): the comparative fit index (CFI), the Tucker-Lewis index (TLI), the root mean square error of approximation (RMSEA), and the standardized root mean square residual (SRMR). Together, they assess the model fit comprehensively from both relative (CFI and TLI) and absolute (RMSEA and SRMR) perspectives (Hooper, Coughlan & Mullen, 2008). As it is typical for models estimated by using large sample sizes (Bentler & Bonett,1980), especially in the case of multivariate non-normality (Hooper, Coughlan &

Mullen, 2008), the χ^2 test of model fit rejected the null hypothesis of the model fitting the data ($\chi^2(540) = 1{,}393.894$, $p < 0.001$). In contrast, the four fit indices (CFI = 0.960, TLI = 0.956, RMSEA = 0.030, SRMR = 0.045) all indicated an acceptable fit by clearly meeting the cut-off criteria (CFI $\geq$ 0.95, TLI $\geq$ 0.95, RMSEA $\leq$ 0.06, and SRMR $\leq$ 0.08) suggested by Hu and Bentler (1999).

4.4 Construct Reliability and Validity

The standardised estimation results of the research model are reported in Figure 2. In terms of the proportion of explained variance (R^2), the model was able to explain 45.0 % of the variance in satisfaction, 27.3 % of the variance in repurchase intention, and 47.2 % of the variance in recommendation intention. As hypothesised in our model, satisfaction was found to have a positive and statistically significant effect on both repurchase and recommendation intentions. Of the second-order emotion constructs, positive emotions were found to have a positive and statistically significant effect on satisfaction as well as on repurchase and recommendation intentions. In contrast, negative emotions were found to have a negative and statistically significant effect only on satisfaction, whereas their effects on repurchase and recommendation intentions were found to be close to zero and statistically not significant. This means that satisfaction acts as a partial mediator of the effects of positive emotions on both repurchase intention and recommendation but a complete mediator of the effects of negative emotions on both repurchase intention and recommendation (Baron & Kenny, 1986). The indirect effects via satisfaction and the total effects of positive and negative emotions on repurchase and recommendation intentions are reported in Table 2.

Table 2: Direct, indirect, and total effects on repurchase and recommendation intentions (* = p < 0.001, ** = p < 0.01, * = p < 0.05)**

Effect	Direct effect	Indirect effect via satisfaction	Total effect
Positive emotions on repurchase intention	0.207***	0.180***	0.387***
Negative emotions on repurchase intention	-0.025	-0.124***	-0.150***
Positive emotions on recommendation intention	0.261***	0.248***	0.509***
Negative emotions on recommendation intention	-0.006	-0.171***	-0.177***

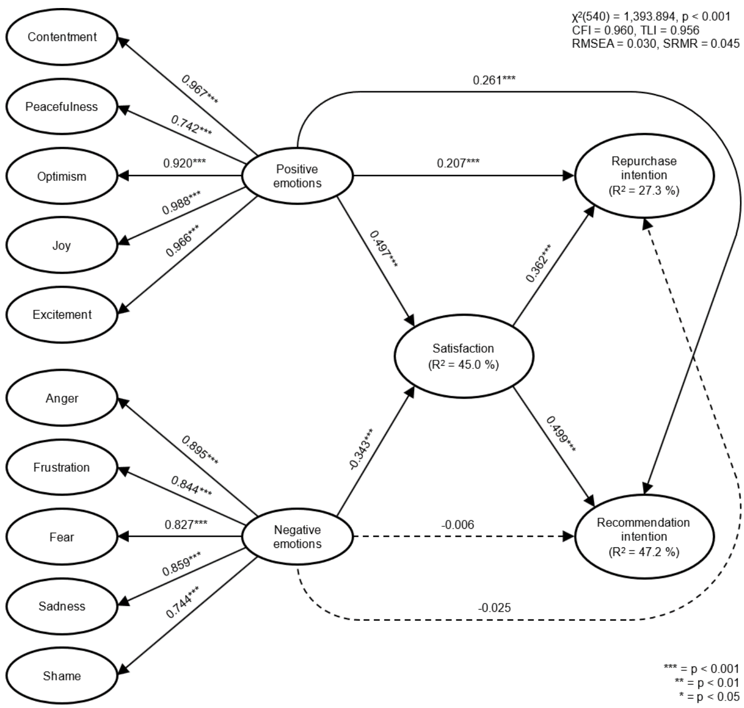

Figure 2: Estimation results of the research model

5 Discussion and Conclusions

In this study, our objective was to examine consumer emotions during online shopping episodes as well as their effects on consumer satisfaction and two types of post-purchase behavioural intentions: repurchase and recommendation intentions. All in all, we found consumers to experience a wide variety of emotions during their online shopping episodes. Of these, we found the positive emotions to be experienced more strongly than the negative emotions, which was not surprising when considering that we were examining only online shopping episodes that ended in a successful order.

We also made several interesting findings concerning the effects of positive and negative emotions on satisfaction as well as on repurchase and recommendation intentions. First, we found positive emotions to affect all the three constructs more strongly than negative emotions. For the repurchase and recommendation intentions, this was equally true when considering the direct effects, the indirect effects via satisfaction, and the total effects. This finding can be seen to be in line with some prior studies (e.g., Westbrook, 1987; Oliver, 1993) but in conflict with some others (Westbrook & Oliver, 1991; Mano & Oliver, 1993; Mooradian & Olver, 1997). Second, we also found that positive and negative emotions differ in terms of the mechanisms how they affect repurchase and recommendation intentions. Whereas the effects of negative emotions on them are completely mediated by satisfaction, positive emotions affect them not only indirectly via satisfaction but also directly. In other words, even if consumers would feel unsatisfied with their online shopping episode at the cognitive level, the positive experiences at the emotional level could still encourage them to purchase from that same online store again or recommend that online store to other consumers. These findings partly support but are also partly in conflict with the prior findings by Mooradian and Olver (1997), which have suggested that satisfaction acts as a key construct that completely mediates the effects of both positive and negative emotions on repurchase and recommendation intentions. In the context of online shopping, although this would seem to be true in the case of negative emotions, it would not seem to be true in the case of positive emotions.

The aforementioned findings can be considered not only interesting in theoretical terms, but also having important practical implications. On one hand, they suggest that the managers of online stores should put more emphasis on arousing positive emotions among consumers than on avoiding the arousal of negative emotions. Some ways for this kind of emotional arousal have been suggested by Jones, Spence, and Vallaster (2008). This suggestion stems not only from the stronger effects of positive emotions in comparison to negative emotions but also from their more certain effects on repurchase and recommendation intentions due to affecting them not only indirectly via satisfaction but also directly. In other words, even if their positive effects on satisfaction may be cancelled out by an equal drop in satisfaction that is caused by other incidents during the online shopping episodes, they will still end up in having a positive total effect on repurchase and recommendation intentions due to affecting them directly. On the other hand, because negative emotions lack these kinds of direct effects, the findings also suggest that even if consumers experience negative emotions during their online shopping episodes, it is possible for the managers of online stores to prevent them from ultimately having a negative effect on repurchase and recommendation intentions through recovery measures that compensate the potential drop in satisfaction. Some examples of these kinds of recovery measures could be giveaway products that are added to the shipped orders or discount codes and coupons that consumers can use in their future orders. These have been discussed in more detail, for example, by Kuo and Wu (2012).

6 Limitations and Future Research

We consider this study to have three main limitations. First, we collected the data only on online shopping episodes that ended in a successful order because the co-operating online stores were willing to add a link to our online survey only on the webpage that was shown to their customers after completing an order. This is likely to introduce bias to the balance of the experienced positive and negative emotions in terms of their strength. Although this bias should not affect our findings concerning the effects of the experienced emotions on satisfaction as well as on repurchase and recommendation intentions (e.g., even if there were relatively few respondents with strong negative emotions, these few respondents reported practically equally strong repurchase and recommendation intentions as the respondents with no negative emotions), future studies would benefit from collecting data also on other kinds of online shopping episodes in order to confirm our findings. Second, we collected the data only via Finnish online stores from Finnish online shoppers. Because emotions often are somewhat culture-specific (Russell, 1991), future studies are obviously required to replicate our study in other countries and cultures in order to promote the generalisability of its findings. Third, some of the indicators and constructs in our research model had issues in terms of their reliability and validity, which may be seen to question some of our findings concerning especially the effects of negative emotions. However, we do not see these issues as particularly severe, especially when considering that no issues were found in the overall goodness-of-fit of our model. For example, Bagozzi and Yi (2012) have suggested placing more emphasis on the overall goodness-of-fit of the model instead of rigidly requiring that each and every indicator and construct in the model meets a specific cut-off criterion in terms of their reliability and validity. As stated above, many of the issues also seemed to originate already from the hierarchical framework by Laros and Steenkamp (2005), which was used as the main basis of our theoretical model. Thus, future studies may be required to refine the operationalisations of some of its constructs. All in all, we also see that future studies are needed to more thoroughly explain some of the findings made in the present study, such as why positive emotions seem to have a stronger effect on satisfaction as well as on repurchase and recommendation intentions in comparison to negative emotions as well as why positive and negative emotions seem to differ in terms of the mechanisms how they affect repurchase and recommendation intentions. Here, a more qualitative approach would probably be a more productive one than the quantitative approach applied in this study.

Appendix A: First-Order Constructs and Their Indicators before the Modifications

Construct or indicator	Missing	Mean	SD	Loading
Contentment (CR = 0.768, AVE = 0.624)				
Contented	0.9 %	5.268	1.246	0.817***
Confident	2.9 %	5.007	1.327	0.762***
Peacefulness (CR = 0.908, AVE = 0.621)				
Calm	5.9 %	4.532	1.470	0.813***
Peaceful	4.6 %	4.924	1.374	0.755***
Optimism (CR = 0.823, AVE = 0.608)				
Optimistic	5.4 %	4.609	1.479	0.790***
Encouraged	12.1 %	3.727	1.705	0.741***
Hopeful	5.8 %	4.411	1.543	0.806***
Joy (CR = 0.867, AVE = 0.686)				
Happy	5.9 %	4.452	1.454	0.813***
Pleased	2.7 %	4.925	1.362	0.808***
Joyful	2.6 %	4.724	1.423	0.862***
Excitement (CR = 0.831, AVE = 0.622)				
Excited	2.1 %	4.724	1.519	0.831***
Thrilled	6.8 %	3.833	1.880	0.744***
Attracted	1.6 %	5.239	1.314	0.789***
Anger (CR = 0.841, AVE = 0.469)				
Angry	1.0 %	1.116	0.481	0.640***
Annoyed	1.2 %	1.166	0.558	0.700***
Irritated	1.3 %	1.190	0.607	0.703***
Frustrated	1.4 %	1.468	0.893	0.715***
Discontented	1.2 %	1.446	0.805	0.682***
Disappointed	1.5 %	1.436	0.824	0.667***
Fear (CR = 0.682, AVE = 0.417)				
Afraid	1.5 %	1.136	0.514	0.635***
Nervous	2.2 %	1.428	0.870	0.608***
Worried	1.5 %	1.421	0.845	0.692***
Sadness (CR = 0.648, AVE = 0.381)				
Depressed	2.1 %	1.138	0.487	0.670***
Sad	1.8 %	1.176	0.576	0.612***
Guilty	1.3 %	1.422	0.920	0.566***
Shame (CR = 0.679, AVE = 0.415)				
Embarrassed	2.0 %	1.142	0.517	0.713***
Ashamed	1.4 %	1.113	0.467	0.626***
Humiliated	1.6 %	1.081	0.455	0.587***
Satisfaction (CR = 0.859, AVE = 0.670)				
How satisfied are you with your online store visit overall?	0.7 %	6.136	0.936	0.777***

How satisfied are you with your online store visit in relation to your expectations?	5.3 %	5.917	1.113	0.826***
How satisfied are you with your online store visit in relation to your idea of an ideal online store visit?	2.3 %	5.871	1.091	0.850***
Repurchase intention (CR = 0.912, AVE = 0.776)				
I am likely to repurchase from this online store in the near future.	2.1 %	6.041	1.054	0.875***
I anticipate to repurchase from this online store in the near future.	2.7 %	6.002	1.031	0.890***
I expect to repurchase from this online store in the near future.	3.9 %	5.911	1.080	0.878***
Recommendation intention (CR = 0.900, AVE = 0.751)				
I will say positive things about this online store to others.	2.9 %	5.999	1.021	0.873***
I will recommend this online store to all who seek my advice.	2.8 %	5.916	1.115	0.854***
I will encourage my friends to do business in this online store.	3.0 %	5.809	1.139	0.872***

*** = $p < 0.001$, ** = $p < 0.01$, * = $p < 0.05$

Appendix B: First-Order Constructs and Their Indicators after the Modifications

Construct or indicator	**Missing**	**Mean**	**SD**	**Loading**
Contentment (CR = 0.768, AVE = 0.624)				
Contented	0.9 %	5.268	1.246	0.817***
Confident	2.9 %	5.007	1.327	0.762***
Peacefulness (CR = 0.908, AVE = 0.621)				
Calm	5.9 %	4.532	1.470	0.813***
Peaceful	4.6 %	4.924	1.374	0.755***
Optimism (CR = 0.823, AVE = 0.608)				
Optimistic	5.4 %	4.609	1.479	0.790***
Encouraged	12.1 %	3.727	1.705	0.741***
Hopeful	5.8 %	4.411	1.543	0.806***
Joy (CR = 0.867, AVE = 0.686)				
Happy	5.9 %	4.452	1.454	0.813***
Pleased	2.7 %	4.925	1.362	0.808***
Joyful	2.6 %	4.724	1.423	0.862***
Excitement (CR = 0.831, AVE = 0.622)				
Excited	2.1 %	4.724	1.519	0.831***
Thrilled	6.8 %	3.833	1.880	0.744***
Attracted	1.6 %	5.239	1.314	0.789***
Anger (CR = 0.771, AVE = 0.529)				
Angry	1.0 %	1.116	0.481	0.700***
Annoyed	1.2 %	1.166	0.558	0.736***

Irritated	1.3 %	1.190	0.607	0.746***
Frustration (CR = 0.788, AVE = 0.554)				
Frustrated	1.4 %	1.468	0.893	0.749***
Discontented	1.2 %	1.446	0.805	0.751***
Disappointed	1.5 %	1.436	0.824	0.733***
Fear (CR = 0.682, AVE = 0.417)				
Afraid	1.5 %	1.136	0.514	0.627***
Nervous	2.2 %	1.428	0.870	0.619***
Worried	1.5 %	1.421	0.845	0.690***
Sadness (CR = 0.617, AVE = 0.447)				
Depressed	2.1 %	1.138	0.487	0.709***
Sad	1.8 %	1.176	0.576	0.625***
Shame (CR = 0.646, AVE = 0.479)				
Embarrassed	2.0 %	1.142	0.517	0.754***
Ashamed	1.4 %	1.113	0.467	0.624***
Satisfaction (CR = 0.858, AVE = 0.669)				
How satisfied are you with your online store visit overall?	0.7 %	6.136	0.936	0.776***
How satisfied are you with your online store visit in relation to your expectations?	5.3 %	5.917	1.113	0.826***
How satisfied are you with your online store visit in relation to your idea of an ideal online store visit?	2.3 %	5.871	1.091	0.850***
Repurchase intention (CR = 0.912, AVE = 0.776)				
I am likely to repurchase from this online store in the near future.	2.1 %	6.041	1.054	0.875***
I anticipate to repurchase from this online store in the near future.	2.7 %	6.002	1.031	0.889***
I expect to repurchase from this online store in the near future.	3.9 %	5.911	1.080	0.878***
Recommendation intention (CR = 0.900, AVE = 0.751)				
I will say positive things about this online store to others.	2.9 %	5.999	1.021	0.873***
I will recommend this online store to all who seek my advice.	2.8 %	5.916	1.115	0.854***
I will encourage my friends to do business in this online store.	3.0 %	5.809	1.139	0.872***

*** = $p < 0.001$, ** = $p < 0.01$, * = $p < 0.05$

Appendix C: Second-Order Constructs and Their Indicators after the Modifications

Construct or indicator	**Loading**
Positive emotions (CR = 0.965, AVE = 0.848)	
Contentment	0.967***
Peacefulness	0.742***
Optimism	0.920***
Joy	0.988***
Excitement	0.966***
Negative emotions (CR = 0.920, AVE = 0.698)	
Anger	0.895***
Frustration	0.844***
Fear	0.827***
Sadness	0.859***
Shame	0.744***

*** = $p < 0.001$, ** = $p < 0.01$, * = $p < 0.05$

Appendix D: Construct Correlations and Square Roots of AVEs

	Positive emotions	**Negative emotions**	**Satisfaction**	**Repurchase intention**	**Recommendation intention**
Positive emotions	0.921				
Negative emotions	-0.248***	0.835			
Satisfaction	0.583***	-0.467***	0.818		
Repurchase intention	0.424***	-0.246***	0.495***	0.881	
Recommendation intention	0.553***	-0.304***	0.653***	0.803***	0.866

*** = $p < 0.001$, ** = $p < 0.01$, * = $p < 0.05$

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Does Quality Influence the Required Capacity of Business Information Management? The Case of Agriculture

MELISSA HARTSINK, FRANK VAN OUTVORST, MATTHIJS TER BRAAK & BENNY M.E. DE WAAL

Abstract In order to be able to optimise the usage of IS/IT services within an organization, the Business Information Management (BIM) role is pivotal. Many organizations struggle to determine what the required number of staff for the BIM department should be. In earlier research a preliminary model to determine the required capacity of BIM was designed. In this paper the model is validated within a specific industry: the agricultural sector. From a sense that quality of IS/IT services might influence the relationship between the determining factors in the model and the required capacity for BIM, also research is conducted to analyse if quality of IS/IT service interferes with determining the required BIM capacity. As part of a literature study seven aspects of quality were found which provide a good overview of the quality of the IS/IT service within an organization. These seven aspects were included in a survey which had 37 respondents from organizations within the agricultural sector. Data was collected about a set of eight determining factors that were taken from prior research and about quality of IS/IT. Based upon these data correlations were tested. The first connections were tested by using Pearson's product-moment correlation coefficient which showed a significant correlation between several factors and the number of FTEs. After which a multiple regression-analysis was done to check if the number of FTEs for the executive processes would increase or decrease when the number of business processes increases or decreases. The quality of the IS/IT service doesn't seem to influence the relationship between the several factors and the number of FTEs investigated in this research. This research shows that the quality of IS/IT service has no influence on determining the required capacity of a BIM department.

Keywords: • Quality • Business Information Management • Capacity • Agriculture • Quantitative research •

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1 Introduction

The relevance of information technology (IT) is still growing. Usage of information systems (IS) and IT services is increasingly penetrating into the core of organizational performance and expenditure on IS/IT is high (e.g. Göbel, Cronholm and Seigerroth, 2013). As a consequence of this the demand for business information management (BIM) as an instrument to govern, direct and control the use of information technology and information systems from a business perspective is growing as well (Johnsson, 2017). In many organizations the responsibilities of business information management are concentrated into a BIM department. To optimize the usage of IS/IT within a company it is necessary to have an adequate number of personnel within the BIM department to let the BIM processes work accordingly. Even though this seems obvious, many organizations struggle to determine the required number of staff of their BIM department. Without an adequate number of staff, there is a risk that the BIM department can't perform the BIM role adequately and cannot meet the expectations. BIM managers are seeking for an instrument that helps them determine the required BIM capacity and the relationship with the quality of IS/IT services. This is also visible in the agricultural sector. There is a lot of demand for improved agricultural technologies such as fertilizing, seeding and cropping techniques (Aker, 2011). Therefore the agricultural sector is interested in finding out how many budget they should allocate for BIM. Earlier research indicated that a set of 20 ICT factors can help to determine the capacity within a BIM department (Van Outvorst, De Vries and De Waal, 2016). More recent research from 2018 shows that eight of these factors are relevant for collecting in an easy way data about these factors (Van Outvorst, Meijnen, Timens, Walenbergh, & De Waal, 2018). Therefore, in this research we look for relationships between these ICT factors and the required capacity of BIM and the influence of the quality of IS/IT services on these relationship.

The following section of this paper discusses the theoretical background of the capacity of the BIM department and the quality of IS/IT. After that the research method and findings are presented. This paper ends with conclusions and discussion.

2 Theoretical Background

2.1 Required capacity of BIM

Based on earlier research on the required capacity (meaning the required number of staff for the BIM department) for the BIM function, three main categories were classified which could have influence on the required capacity: 1) complexity of the user organization, 2) complexity of the BIM department, and 3) complexity of the information systems landscape (Van Outvorst, De Vries & De Waal, 2016; Achmea et al, 2009; Quint Wellington Redwood, 2014; Van der Pols, 2009; Rakhorst, 2013). Further research showed that within these categories eight factors appear to be the ultimate set that affects capacity (Van Outvorst, Meijnen, Timens, Walenbergh and De Waal, 2018). These factors are:

- Number of users of IS/IT;
- Number of Stakeholders involved with IS/IT;
- Size of IT projects;
- Number of IT projects;
- Number of Processes that are supported by IS/IT;
- Number of applications;
- Functional stability of the applications;
- Technical stability of the applications.

2.2 Quality of IS/IT

The quality of information systems and supporting or underlying IT services (IS/IT services) has so far been mentioned in research (Van Outvorst, Meijnen, Timens, Walenbergh and De Waal, 2018) but was not yet tested to full extent. According to Van der Pols et al. (2012) business information management controls the quality of IS/IT services by execution of one of the BIM processes: the process of demand management. This process aims at having the information systems connect to the business processes in terms of employees/end users, information to be used in the business processes, the process flow of the organization and the environment of the organization. Johnsson (2017) describes that information services provide the necessary information to an organization. Information services consist of 3 components: functionality, data & technology and support of the business processes. Quality of support of the business processes is one of the four aspects that are commonly examined when managing the information service and is determined by the need for information. Taale (2004) states that there are four aspects that can be distinguished on which a qualitative judgment about IS/IT services can be made: 1) the information provided, 2) the information-processing process as part of the relevant system, which must provide qualitatively sound information, 3) the design and development process that provided the information management system in this case as a product, and 4) the way in which the management and maintenance of the information management system are embedded in the organization. Delen and Rijsenbrij (1990) have a description of the quality aspects that are recognized for assessing an information system. They categorized four quality aspects: 1) Process - development of the information system, 2) Static - intrinsic properties of the information system and documentation, 3) Dynamic - functioning of the information system for the user, and 4) Information - as output. The ISO 25010 standard (SYSQA B.V., 2012) state that three perspectives exist for IS/IT quality management: 1) Quality of Use, 2) Product Quality, and 3) Data Quality. Looijen and Van Hemmen (2017) state that quality of information systems is determined by the requirements and prerequisites that an information system must and should meet. In order to establish if the requirements are met business information management must measure if the formal qualitative and quantitative quality standards are met. A reference model for this can be found in ISO 20000 according to Looijen and Van Hemmen (2017).

The NOREA (Nederlandese Overheid Referentie Enterprise Architectuur) model (Van Bienen, Noordenbos & Van Der Pijl, 1998) offers an overarching model for the quality of IS/IT services. This model states that there are seven aspects of quality. Measuring these aspects provides a proper overview of the extent of the quality of IS/IT services. The following seven aspects are defined:

- Effectiveness: The extent to which IS/IT services are in accordance with the requirements and goals of the end users and to the extent of which an object contributes to the organization objectives, as laid down in the information strategy;

- Efficiency: The relation between the realized costs and the budgeted costs for the IS/IT services. The budgeted costs are the costs that are intended to realize the desired performance level of the IS/IT services;
- Exclusiveness: this is the extent to which only authorized persons or equipment use IS/IT services through authorized procedures and limited powers;
- Integrity: this is the extent to which the data within the IS/IT services are in accordance with the depicted reality;
- Verifiability: this is the extent to which it is possible to obtain knowledge about the structuring (documentation) and operation of the IS/IT services;
- Continuity: this is the extent to which the IS/IT services are continuously available and data processing can proceed undisturbed;
- Controllability: this is the extent to which the IS/IT services management can be controlled so that they can meet the requirements.

2.3 Conceptual model

Earlier research (Van Outvorst, De Vries and De Waal, 2016) describes the responsibilities and roles of the BIM function based upon the Business information Services Library (BiSL) (Van der Pols et al 2012). The number of staff required to fulfil these responsibilities and roles is defined as our dependent variable. According to Van der Pols (2017) the BiSL framework defines three levels of responsibilities of BIM: 1) operational level: daily support of usage of information systems and determining new developments of information systems; 2) steering level: demand and contract management and management of time and money and 3) executive level: business governance of IS/IT.

This paper investigates the influence of specific ICT factors on this required BIM capacity. In the conceptual model these are modelled as eight independent factors (see Figure 1). As explained earlier, the relationship between the eight factors and the required capacity can be influenced by the level of quality of IS/IT services. In the conceptual model this is depicted as a moderating variable.

In the next section we describe how the research was conducted to test our conceptual model.

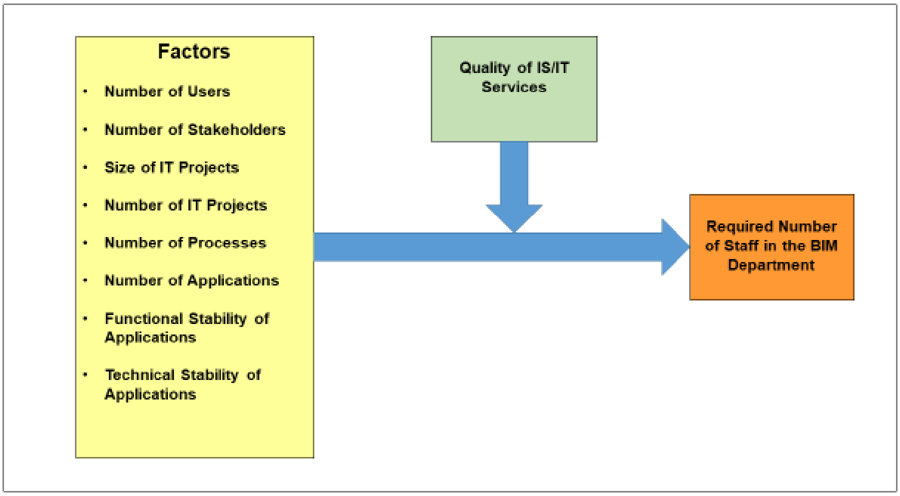

Table 2: Comparison of different leading international oncology inforamtion systems (OIS) in Australian context

3 Research method

3.1 Data collection

To investigate the influence of quality of IS/IT service on the relation between the eight relevant determining factors and the required capacity of BIM a survey was sent to 39 different companies of which 37 participated in the research. The companies were selected through the personal network of one of the researchers and convenient sampling. The data was collected in November 2018. All the organizations were located in the agriculture sector or were closely connected with this industry. For example, one ICT company was contacted that developed special software for the agriculture sector. The size of the organizations ranged of 1 to 5000 FTE's. The business functions of the respondents were all related to IT/IS management and the respondents were familiar with the concepts in the questionnaire.

3.2 Operationalization of quality of IS/IT service

The questions about the 8 determining factors were based upon the survey from previous research (Van Outvorst et al, 2018), although some questions were made more specific, in order to get unambiguously comprehensible questions. An important supplement to the survey was the addition of questions about the quality of IS/IT services. In the theoretical part of this paper we found seven aspects of quality of IS/IT services. By measuring these seven aspects within an organization, the IS/IT quality can be measured. The seven aspects were converted to seven questions to be measurable within organizations. The questions could be scored on a scale of 1 to 10. The questions were (translated from Dutch):

- Effectiveness: which grade would indicate to what extent the IS/IT quality is in line with the requirements and objectives of the users and the entire organization?
- Efficiency: which grade would indicate the extent to which the budgeted costs of the quality of IS/IT services correspond to the realized costs?
- Exclusivity: which grade would indicate the extent to which only authorized persons use IT processes through authorized procedures?
- Integrity: which grade would indicate the extent to which the quality of IS/IT service is in accordance with the reality depicted?
- Verifiability: which grade would indicate the extent to which it is possible to obtain knowledge about the documentation and operation of the IS/IT?
- Continuity: which grade would indicate the extent to which the IS/IT service is continuously available without the progress being disrupted?
- Controllability: which grade would indicate the extent to which the quality of IS/IT can be controlled , so that the IS/IT service can continue to meet the requirements set?

All questions were designed by the junior researchers independently and were reviewed by the senior researchers on comprehensibility. Assuming that all aspects are equally important, the quality of IS/IT service was calculated as the mean of the scores on the seven aspects.

4 Results

In this section the results of the survey will be presented. In Table 1, the outcomes of each variable are indicated.

Table 1: Results of variables

Variable	Average	Standard deviation	Minimum value	Maximum value	Mode	Skewness
Capacity operational processes	4,68	4,82	0,20	20	2 (1)	1,71
Capacity executive/ steering processes	2,65	2,55	0,20	13	2 (1)	2,39
Capacity all processes	7,47	7,00	0,00	28	4	1,70
Number of users	138,05	248,87 (2)	1,00	1400	15	3,88
Number of stakeholders	37,06	90,75 (2)	1,00	500	10	4,39
Size of IT projects	2,01	0,44	1,10	2,70	2	-0,49 (7)
Number of IT projects	5,39	5,26	0,50	25	3	1,86
Number of processes	49,61	74,19 (2)	1,00	300	5	1,90
Number of applications	14,58	13,27	2,00	70	5	2,60
Functional stability of applications	8,01	10,38	0,50	50	2	2,33
Technical stability of applications	4,94	6,96	0,00 (3)	30	2	2,96
Quality of IS/ IT service	6,97 (5)	0,96 (4)	4,00	9	7	-0,55 (6)

1. In Table 1 several interesting findings can be seen: The mode is two for the number of FTEs for operational processes, but also for the number of FTEs for steering and executive processes. Most of the organizations have 2 FTEs;
2. Especially the number of users, but also the number of stakeholders and processes, show a large deviation. The number of users, stakeholders and processes are very different per organization;
3. At least one organization has IS/IT that is always available;
4. The standard deviation is not large for the quality of IS/IT;
5. The average figure of the total quality of the IS/ IT service management is 7;
6. The variables 'size of projects' and 'all quality aspects' have a value between -1 and 1 in relation to the distribution. These variables have a reasonable to good normal distribution.

To answer the research question on the relation between the eight factors of ICT and the required capacity of Business Information Management function, we first performed a Pearson correlation analysis on the data from the 37 organizations. The results of the test are shown in Table 2.

Table 2: Correlations between eight factors of ICT and the capacity of Business Information Management

	Capacity operational processes	Capacity of executive/steering processes	Capacity of all BIM processes
Number of users	0,189	0,121	0,168
Number of stakeholders	0,176	0,130	0,168
Size of IT projects	**0,398***	0,254	**0,375***
Number of IT projects	0,019	0,049	0,020
Number of processes	**0,430***	0,229	**0,378***
Number of applications	**0,344***	0,191	0,297
Functional stability of applications	**0,351***	0,100	0,274
Technical stability of applications	0,101	0,138	0,109

The findings show a moderate significant relationship between respectively Project size (0.40), Number of processes (0.43), Number of applications (0.34), Functional stability of applications (0.35) and the Capacity of operational processes. The overall Capacity of BIM processes has only a moderate significant relationship with Project size (0.38) and Number of processes (0.38). The capacity of strategic and steering processes has no significant relationships with the eight factors of ICT. All the significant relationships can be interpreted as mere moderate, according to statistical research theory (Field, 2013).

As described above, the main hypothesis that was tested concerns the relationship between the eight factors of ICT and the capacity of the BIM function and the moderating effect of quality of IS/IT services. Assuming linearity, we can model this hypothesis into a regression equation in which quality of IS/IT services is a pure moderator, influencing the shape of the relationship between the eight factors of ICT and the capacity of the BIM function (cf. Sharma, Durand, and Gur-Arie, 1981). The regression model can be written as:

$$\text{Capacity of BIM function} = \alpha + ß1\ \text{ICT Factor}_n + ß2\ \text{ICT Factor}_n \times \text{quality of IS/IT service} + \varepsilon$$

From this equation, it is to be expected that the main effect of an ICT factor (ß1) will be not significant, and we also explored whether the interaction effect between an ICT factor and quality of IS/IT service (ß2) had an additional (net) significant effect, in accordance with the hypotheses. Before presenting the subsequent results of the regression analyses, we checked that both the dependent variables (capacity of the BIM function) and the independent variable (ICT factors) were normally distributed. The basic descriptions of the variables are in Table 1.

Table 3: Regression analysis: Predictive power of ICT Factors and Capacity of BIM function for IS/IT Quality Management (N=37)

	Operational Capapcity		Executive/Steering Capacity		Total Capacity	
	Coefficient	p	Coefficient	p	Coefficient	p
Users	-1.25	.37	-.23	.88	-.93	.52
Users x Quality	1.45	.30	.35	.81	1.10	.45
Stakeholders	-2.50	.29	-.95	.70	-2.14	.38
Stakeh x Quality	2.68	.26	1.08	.66	2.31	.35
Size	.37	.24	.21	.54	.34	.30
Size x Quality	.03	.93	.05	.88	.04	.91
Projects	-.18	.87	-.43	.69	-.31	.77
Projects x Quality	.20	.85	.48	.65	.33	.76
Processes	-.68	.68	-1.49	.41	-1.02	.55
Processes x Quality	1.11	.51	1.73	.34	1.40	.42
Applications	.35	.77	-.13	.92	.19	.88
Appl x Quality	-.01	.99	.33	.79	.11	.93
Functional stability	2.39	.08	.93	.53	1.98	.16
Func x Quality	-2.05	.13	-.83	.57	-1.72	.22
Technical stability	-.08	.96	.22	.90	.05	.98
Tech x Quality	.18	.92	-.08	.96	.07	.97

Before the regression models were applied, the potential problem of multicollinearity was investigated by computing VIF factors for each predictor in the regression model. Although in some cases correlations between independent variables were relatively high, VIF factors in most of the models didn't exceeded 5 – a commonly applied rule of thumb (Hair, et al., 1998; Rogerson, 2001). The results of the regression analyses to test our hypotheses are presented in Table 3.

From Table 3, we can see that in none of the regression models, one of the determining factors has a significant effect on the capacity of the BIM function. It also appears that the interaction effect of quality of IS/IT services on the capacity of the BIM function is not significant. This means that quality of IS/IT services doesn’t have an influence on the relationship between a determining factor and capacity of the BIM function. In conclusion, these results don’t support the hypothesis, that quality of IS/IT services has influence on the relationship between the determining factor and the capacity of the BIM function.

5 Discussion

In earlier research a predictive model was defined. After having a qualitative review on this model and the defined determining factors we had a first quantitative validation of this model in the research which is discussed in this paper. We found that some of the determining factors show a significant correlation with the number of staff needed. This is a promising result compared to previous research (Achmea et al, 2009; Quint Wellington Redwood, 2014; Rakhorst, 2013). These studies were based on more ICT factors and used complex models to estimate the required number of BIM staff. The findings in our research indicate that this is possible with few factors. An influence of a moderating effect of quality of IS/IT services was not found in this research. However, due the limitations of our dataset more research is needed in the agricultural section as well in other industries. Another issue for further research is also to analyse the level of education of the employees as a moderating factor.

6 Conclusion and Limitations

Studies from past years have shown that eight factors determine the BIM-function (Van Outvorst, De Vries and De Waal, 2016). During this research, these eight factors were tested in 37 organisations. An important adjustment to this research is that a distinction is made between different levels of activities performed by the BIM function. Because of this distinction, several factors have a significant correlation with the capacity of the BIM function. The factors 'number of processes', 'size of projects', 'functional stability' and 'number of applications' have a significant correlation with the number of staff. The factors 'number of processes' and 'size of projects' can also be seen in the correlation between the total number of staff for all BIM responsibilities.

In addition, the influence of quality of IS/IT on the relationship between a determining factor and the capacity of the BIM function was investigated during this research. This research shows that quality of IS/IT services has no influence on this relationship. However, it is uncertain if the grades for quality of IS/IT services are realistic. One respondent could be more optimistic in his answers than the other. Also, in the calculations all aspects of quality were weighed equally. There was no possibility for the respondents to add different weights to the various quality aspects.. Another limitation of this study is the small size of the sample. This has negative consequences for representativeness, and also the quality of data. The skewness of some variables were too high and also the VIF factor was by some variables too high. These aspects may have influenced the results.

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The Effects of Individual Values on Online Shopping Spending

MARKUS MAKKONEN, LAURI FRANK & TIINA KEMPPAINEN

Abstract Although individual values have been found as important antecedents of human behaviour, their effects on online shopping behaviour remain poorly understood. In this study, we aim to address this gap in prior research by examining the effects of individual values on both total online shopping spending and the specific types of online shopping spending in terms of orders made (1) with traditional computers versus mobile devices, (2) from businesses versus other consumers, and (3) from domestic versus foreign online stores. The examination is based on the data from 565 Finnish online shoppers, which was collected via an online survey between February 2019 and March 2019 and is analysed by using structural equation modelling (SEM). The findings of the study suggest that stimulation and humility act as the most important antecedents of online shopping spending but there are also seven other individual values with interesting effects on specific types of online shopping spending.

Keywords: • Online Shopping Spending • Individual Values • Mobile Online Shopping • Business-to-Consumer • Consumer-to-Consumer • Domestic Online Stores • Foreign Online Stores • Online Survey • Finland •

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1 Introduction

Individual values have been found as important antecedents of human behaviour. For example, in the context of information systems (IS), values have been found to influence, information and communication technology (ICT) use (Goncalves, Oliveira & Cruz-Jesus, 2018), Internet use (Bagchi et al., 2015; Choden et al., 2019), the evaluation of IS and ICT products and services (Kujala & Väänänen-Vainio-Mattila, 2009; Partala & Kujala, 2016), technology adoption (Isomursu et al., 2011; Partala & Saari, 2015), technology design (Kinnula et al., 2018), the adherence to information security rules (Myyry et al., 2009), the motivations of hackers (Madarie, 2017), the motivations for contributing to open source initiatives (Oreg & Nov, 2008), project team success (Jetu & Riedl, 2013), as well as online gaming (Ramírez-Correa, Rondán-Cataluña & Arenas-Gaitán, 2018). Respectively, in the context of marketing, values have been found to influence various aspects of consumer behaviour, such as sustainable consumption (Thøgersen & Ölander, 2002), ethical consumption (Shaw et al., 2005), conscious consumption (Pepper, Jackson & Uzzell, 2009), and fair-trade consumption (Doran, 2009). However, at the intersection of IS and marketing – electronic commerce – there have been very few prior studies on the effects of values on online shopping behaviour. The few exemptions to this are the studies by Jayawardhena (2004), Hansen (2008), as well as Wu, Cai, and Liu (2011), but they also have focused only on very abstract and general conceptualisations of both values and online shopping behaviours instead of more in-depth inquiries.

In this study, our aim is to address the aforementioned gap in prior research by examining the effects of individual values on online shopping spending. However, in addition to focusing only on total online shopping spending, we will focus also on the specific types of online shopping spending in terms of orders made (1) with traditional (i.e., desktop or laptop) computers versus mobile devices (e.g., mobile phones and tablet computers), (2) from businesses (i.e., business-to-consumer, B2C) versus other consumers (i.e., consumer-to-consumer, C2C), and (3) from domestic versus foreign online stores. These specific types of online shopping spending were selected both due to their practical relevance to the managers of online stores and due to the interest shown in them in prior research (e.g., Leonard & Jones, 2010; Groß, 2015; Huang & Chang, 2017; Mou et al., 2017). The examinations are based on the data from 565 Finnish online shoppers, which was collected via an online survey between

February 2019 and March 2019 and is analysed by using structural equation modelling (SEM).

The paper consists of six sections. After this introductory section, we will next briefly discuss individual values in Section 2. This is followed by a description of the methodology of the study in Section 3. The results of the study are reported in Section 4 and discussed in more detail in Section 5. Finally, we will conclude the paper with a discussion of the limitations of the study and some potential paths of future research in Section 6.

2 Individual Values

According to Schwartz (1992), individual values are commonly considered to have five formal features: (1) they are concepts or beliefs, (2) they pertain to desirable end states or behaviours, (3) they transcend specific situations, (4) they guide the selection or evaluation of behaviour and events, and (5) they are ordered by relative importance. Over the years, numerous studies (e.g., Rokeach, 1973; Schwartz & Bilsky, 1987; Schwartz, 1992) have suggested that the values held by individuals have a significant impact on their behaviours. As a consequence, multiple ways to measure values have been proposed. These include the Rokeach Value Survey (RVS) by Rokeach (1973), the Values and Lifestyles (VALS) by Mitchell (1983), and the List of Values (LOV) by Kahle (1983). However, probably the two most well-known and widely-used measures of values are the Schwartz Value Survey (SVS) by Schwartz (1992) and the Portrait Values Questionnaire (PVQ) by Schwartz et al. (2001), which are both based on the theory of basic human values by Schwartz (1992). In this study, we will also base our measurement of values on this same theory, or more specifically its more recent refinement by Schwarz et al. (2012). This refined theory of basic individual values identifies a total of 19 individual values with different motivational goals, which are all listed in Table 1.

Table 1: Individual values and their motivational goals (Schwartz et al., 2012)

Individual value	Definition in terms of motivational goals
Self-direction–thought	Freedom to cultivate one's own ideas and abilities
Self-direction–action	Freedom to determine one's own actions
Stimulation	Excitement, novelty, and change
Hedonism	Pleasure and sensuous gratification
Achievement	Success according to social standards
Power–dominance	Power through exercising control over people
Power–resources	Power through control of material and social resources
Face	Security and power through maintaining one's public image and avoiding humiliation
Security–personal	Safety in one's immediate environment
Security–societal	Safety and stability in the wider society
Tradition	Maintaining and preserving cultural, family, or religious traditions
Conformity–rules	Compliance with rules, laws, and formal obligations
Conformity–interpersonal	Avoidance of upsetting or harming other people
Humility	Recognizing one's insignificance in the larger scheme of things
Benevolence–caring	Devotion to the welfare of ingroup members
Benevolence–dependability	Being a reliable and trustworthy member of the ingroup
Universalism–concern	Commitment to equality, justice, and protection for all people
Universalism–nature	Preservation of the natural environment
Universalism–tolerance	Acceptance and understanding of those who are different from oneself

These values are assumed to from a circular motivational continuum as illustrated in Figure 1. As described by Schwartz et al. (2012), closest to the centre are the values themselves, which are arranged in a circular order so that the values that have compatible motivational goals are closest to each other, whereas the values that have conflicting motivational goals are furthest away from each other. The second circle from the centre groups the 19 values into four higher-order values. Of them, the openness to change values emphasise readiness for new ideas, actions, and experiences. They contrast with the conservation values that emphasise self-restriction, order, and avoiding change. In turn, the self-enhancement values emphasise pursuing one's own interests. They contrast with the self-transcendence values that emphasise transcending one's own interests for the sake of others. The two outmost circles depict the more in-depth theoretical basis behind the order of the values. The values bounded by the right side of the third circle from the centre have a personal focus, so they are concerned with the outcomes for self. In contrast, the values bounded by the left side of the third circle from the centre have a social focus, so they are concerned with the outcomes for others or for established institutions. Finally, the values bounded by the top half of the fourth circle from the centre foster growth and self-expansion and are more likely to motivate people when they are free of anxiety. In contrast, the values bounded by the lower half of the fourth circle from the centre serve self-protection and aim to avoid anxiety.

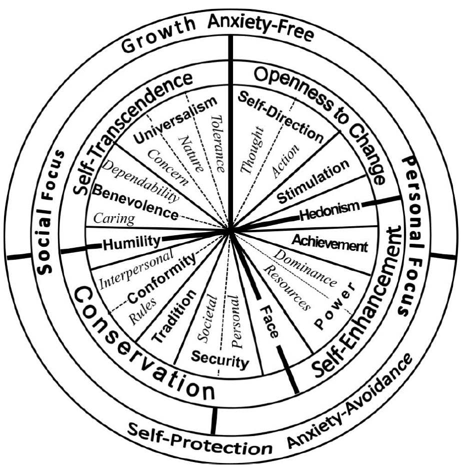

Figure 1: Refined theory of basic individual values (Schwartz et al., 2012)

3 Methodology

The data for this study was collected via an online survey between February 2019 and March 2019. The respondents were recruited mainly by sharing the survey link through the internal communication channels (e.g., mailing list, newsletters, and bulletin boards) of our university. In addition, because the respondents who completed the survey were able to take part in a price draw of ten cinema tickets, the survey link was also posted to six websites promoting online competitions. The survey questionnaire consisted of multiple items related to the demographics of the respondents (e.g., gender, age, and income), their online shopping behaviour (e.g., how often do they shop online), as well as their personality and values. The aforementioned 19 individual values were measured reflectively by two items each. This set of 38 items was adapted from Schwartz et al. (2012) and is reported in Appendix A. The measurement scale of the items was the standard five-point Likert scale. There was also the option to give no response, which resulted in a missing value. In turn, online shopping spending was measured by first asking the respondents to assess their average monthly online shopping spending in euros. After this, the respondents were asked to assess with three pairs of percentages how this spending is distributed between the orders made (1) with traditional computers versus mobile devices, (2) from businesses versus other consumers, and (3) from domestic versus foreign online stores. Each of these three pairs of percentages was required to sum up to one hundred.

The collected data was analysed by using covariance-based structural equation modelling (SEM) conducted with the Mplus version 7.11 statistical software (Muthén & Muthén, 2019). Due to the non-normal distributions of many of the indicator variables, the model estimation was conducted by using the MLR estimator, which stands for maximum likelihood estimator robust to non-normal data. The missing values in the indicator variables were handled by using the FIML estimator, which stands for full information maximum likelihood and uses all the available data in the model estimation. In total, we estimated seven separate models, in each of which we examined the effects of the same value constructs on a different outcome variable. In the first model, we examined the effects of individual values on total online shopping spending. In the remaining six models, we examined the effects of individual values on the specific types of online shopping spending in terms of orders made (1) with traditional computers, (2) with mobile devices, (3) from businesses, (4) from other consumers, (5) from domestic online stores, and (6) from foreign online stores. These specific types of online shopping spending were calculated by simply multiplying the total online shopping spending with the appropriate percentages. In each of the seven models, we also controlled the effects of gender, age, and income by using these variables as covariates of the outcome variable. In the case of gender, men were coded as zero and women were coded as one. In the case of income, the values of the control variable ranged from one to seven, which represented the seven income classes reported in Table 2.

4 Results

In total, we received 580 responses to our online survey. However, 15 of these responses had to be dropped from the study due to invalid or missing data, resulting in a sample size of 565 responses to be used in the actual analyses. The descriptive statistics of this sample are reported in Table 2. As can be seen, the majority of the respondents were women. The age of the respondents ranged from 18 to 78 years, with a mean of 35.1 years and a standard deviation of 13.3 years. Because of the recruitment strategy, students constituted a considerable share of the respondents (34.9 %). However, the respondents were relatively active online shoppers, and most of them (74.9 %) shopped online at least monthly. The reported average monthly online shopping spending of the respondents ranged from 0 € to 1,500 €, with a mean of 86.39 € and a standard deviation of 126.53 €. Of this total spending, the respondents reported using about 61 % on orders made with traditional computers and about 39 % on orders made with mobile devices, which resulted the spending on orders made with traditional computers to have a mean of 49.26 € and a standard deviation of 86.70 € and the spending on orders made with mobile devices to have a mean of 37.12 € and a standard deviation of 83.25 €. Respectively, of the total spending, the respondents reported using about 77 % on orders made from businesses and about 23 % on orders made from other consumers, which resulted the spending on orders made from businesses to have a mean of 67.22 € and a standard deviation of 98.18 € and the spending on orders made from other consumers to have a mean of 19.17 € and a standard deviation of 44.51 €. Finally, of the spending on orders made from businesses, the respondents reported using about 63 % on orders made from domestic online stores and about 37 % on orders made from foreign online stores, which resulted the spending on orders made from domestic online stores to have a mean of 39.97 € and a standard deviation of 58.97 € and the spending on orders made from foreign online stores to have a mean of 27.25 € and a standard deviation of 65.19 €. The percentages of missing data, means, and standard deviations (SD) of the 38 items measuring the 19 individual values are reported in Appendix A.

Table 2: Descriptive sample statistics (N = 565)

	N	%
Gender		
Man	168	29.7
Woman	397	70.3
Age		
Under 30 years	262	46.4
30–39 years	127	22.5
40–49 years	76	13.5
50–59 years	62	11.0
60 years or over	38	6.7
Yearly taxable income		
Under 10,000 €	159	28.1
10,000–19,999 €	105	18.6
20,000–29,999 €	60	10.6
30,000–39,999 €	67	11.9
40,000–49,999 €	45	8.0
50,000–59,999 €	17	3.0
60,000 € or over	18	3.2
No response	94	16.6
Socioeconomic status		
Student	197	34.9
Employed or entrepreneur	259	45.8
Unemployed or unable to work	63	11.2

Retired	36	6.4
Other	10	1.8
On average, how often do you shop online?		
Weekly	63	11.2
Monthly	360	63.7
Yearly	121	21.4
Less than yearly	17	3.0
No response	4	0.7

In the following three sub-sections, we will first evaluate the reliability, validity, and goodness-of-fit of the generic measurement model that contains all the value constructs but does not yet contain any of the outcome variables. In the final sub-section, we will report the estimation results for the seven models that contain also the outcome variables.

4.1 Indicator Reliability and Validity

Indicator reliabilities and validities were evaluated by using the standardised loadings of the indicators, which are reported in Appendix B. In the typical case where each indicator loads on only one construct, it is commonly expected that the standardised loading of each indicator should be statistically significant and greater than or equal to 0.707 (Fornell & Larcker, 1981). This is equal to the standardised residual of each indicator being less than or equal to 0.5, meaning that at least half of the variance of each indicator is explained by the construct on which it loads. However, also a less strict criterion of the standardised loading of each indicator being statistically significant and greater than or equal to 0.6 has been commonly used (Bagozzi & Yi, 1988). As can be seen form Appendix B, 36 out of the 38 indicators were found to meet the former stricter criterion, and also the two remaining indicators met the latter less strict criterion. Thus, we consider all the indicators to have satisfactory reliability and validity.

4.2 Construct Reliability and Validity

Construct reliabilities were evaluated by using the composite reliabilities (CR) of the constructs (Fornell & Larcker, 1981), which are reported in Appendix B. In order to have satisfactory reliability, it is commonly expected that the CR of the construct should be greater than or equal to 0.6 (Bagozzi & Yi, 1988). As can be seen, all the constructs were found to meet this criterion. In turn, construct validities were evaluated by examining the convergent and discriminant validity of the constructs with the two criteria proposed by Fornell and Larcker (1981). Both of them are based on the average variance extracted (AVE) of the constructs, which refers to the average proportion of variance that a construct explains in its indicators. In order to have satisfactory convergent validity, the first criterion expects that each construct should have an AVE that is greater than or equal to 0.5. This means that, on average, each construct should explain at least half of the variance in its indicators. The AVE of each construct is reported in Appendix B. As can be seen, all the constructs were found to meet also this criterion.

In order to have satisfactory discriminant validity, the second criterion expects that each construct should have a square root of AVE greater than or equal to its absolute correlation with the other constructs in the model. This means that, on average, each construct should share at least an equal proportion of variance with its indicators than it shares with these other constructs. The correlations between the constructs (off-diagonal cells) and their square roots of AVEs (on-diagonal cells) are reported in Appendix D. As can be seen, there were three pairs of constructs that were not found to meet this criterion: self-direction–thought and self-direction–action, security–personal and security–societal, as well as benevolence–caring and benevolence–dependability. Because of this, we decided to modify our model by specifying these six first-order constructs as reflective measures of three more general second-order constructs: self-direction (measured by self-direction–thought and self-direction–action), security (measured security–personal and security–societal), and benevolence (measured by benevolence–caring and benevolence–dependability). The standardised loadings of the indicators of these three new constructs as well as their CRs and AVEs are reported in Appendix C. As can be seen, based on the aforementioned criteria, all their indicators were found to have satisfactory reliability and validity, and also the constructs themselves were found to have satisfactory reliability and convergent validity. Finally, Appendix E reports the revised correlations between the constructs (off-diagonal cells) and their square roots of AVEs (on-diagonal cells). As can be seen, all the constructs were now found to meet the aforementioned criterion. Note that as suggested by Koufteros, Babbar, and Kaighobadi (2009), this examination excludes the six constructs that were previously found problematic. The discriminant validity of these first-order constructs can be considered to be of less importance because they act as reflective indicators of the second-order constructs and are, therefore, expected to be highly correlated. One also cannot, at the same time, aim to maximise the discriminant validity of the first-order constructs that act as reflective measures of a second-order construct and the convergent validity of that same second-order construct because the former would require the first-order constructs to be as weakly correlated as possible, whereas the latter would require the first-order constructs to be as strongly correlated as possible. Thus, Koufteros, Babbar, and Kaighobadi (2009) suggest that the examination and establishment of the convergent validity of the second-order constructs should take precedence.

4.3 Goodness-of-Fit

In accordance with the guidelines by Gefen, Rigdon, and Straub (2011), the goodness of-fit of the aforementioned modified model was assessed by using the χ^2 test of model fit and four alternative fit indices recommended in recent methodological literature (Hu & Bentler, 1999): the comparative fit index (CFI), the Tucker-Lewis index (TLI), the root mean square error of approximation (RMSEA), and the standardized root mean square residual (SRMR). Together, they assess the model fit comprehensively from both relative (CFI and TLI) and absolute (RMSEA and SRMR) perspectives (Hooper, Coughlan & Mullen, 2008). As it is typical for models estimated by using large sample sizes (Bentler & Bonett,1980), especially in the case of multivariate non-normality (Hooper, Coughlan & Mullen, 2008), the χ^2 test of model fit rejected the null hypotheses of the model fitting the data ($\chi^2(539) = 636.863$, $p = 0.002$). In contrast, the four fit indices (CFI = 0.988, TLI = 0.984, RMSEA = 0.018, and SRMR = 0.029) all indicated an acceptable fit by clearly meeting the cut-off criteria (CFI $\geq$ 0.95, TLI $\geq$ 0.95, RMSEA $\leq$ 0.06, and SRMR $\leq$ 0.08) suggested by Hu and Bentler (1999).

4.4 Estimation Results

The estimation results of the seven models in terms of the standardised regression coefficients and their statistical significance, the proportions of explained variance (R^2), as well as the goodness-of-fit statistics are reported in Table 3. As can be seen, also in this case, the χ^2 test of model fit rejected the null hypotheses of the models fitting the data, whereas the four fit indices all indicated the models to have an acceptable fit. In addition, because of the high number of explanatory variables in the regression equations, we examined the potential multicollinearity issues by using the estimated factor scores and the variance inflation factors (VIF). The VIFs were all clearly below ten, thus indicating no multicollinearity issues in any of the models.

Table 3: Estimation results of the models (* = p < 0.001, ** = p < 0.01, * = p < 0.05)**

	Total	Computer	Mobile	B2C	C2C	Domestic	Foreign
Controls							
Gender	**-0.156****	**-0.179*****	-0.051	**-0.171*****	-0.066	**-0.120****	**-0.152****
Age	-0.083	-0.104	-0.050	-0.080	-0.076	-0.018	-0.101
Income	**0.256****	**0.315*****	**0.133***	**0.288*****	0.124	**0.307*****	**0.145***
Values							
Self-direction	0.005	**0.156***	-0.161	0.026	-0.047	0.020	0.027
Stimulation	**0.275***	0.204	0.214	0.236	**0.267****	0.017	**0.341***
Hedonism	-0.137	-0.146	-0.056	-0.110	-0.153	**0.157***	-0.313
Achievement	-0.166	-0.226	-0.024	-0.173	-0.088	-0.082	-0.182
Power–dominance	0.124	0.081	0.101	0.105	0.118	0.043	0.118
Power–resources	0.072	**0.157***	-0.063	0.086	0.011	0.084	0.055
Face	0.033	-0.106	0.158	0.044	-0.006	-0.018	0.078
Security	0.120	-0.005	0.194	0.102	0.123	-0.126	**0.273***
Tradition	-0.117	-0.043	-0.128	-0.122	-0.062	-0.061	-0.130
Conformity–rules	0.072	0.119	-0.022	0.080	0.026	**0.176***	-0.039

Conformity–interpersonal	0.097	**0.192***	-0.043	0.088	0.082	0.131	0.015
Humility	**-0.140***	**-0.128***	-0.077	**-0.143***	-0.081	-0.107	-0.117
Benevolence	0.124	0.095	0.092	0.127	0.074	0.110	0.090
Universalism–concern	-0.179	0.020	**-0.281***	-0.197	-0.063	-0.083	-0.226
Universalism–nature	-0.004	-0.082	0.066	-0.001	-0.017	-0.031	0.033
Universalism–tolerance	-0.054	-0.178	0.100	-0.030	-0.096	-0.007	-0.040
R^2							
Controls	8.6 %	11.8 %	2.1 %	10.9 %	1.7 %	10.6 %	4.1 %
Values	8.9 %	7.0 %	10.3 %	8.2 %	5.8 %	5.5 %	14.8 %
Total	17.4 %	18.8 %	12.4 %	19.1 %	7.5 %	16.2 %	19.0 %
Goodness-of-fit							
χ^2	805.799	816.062	817.811	802.787	810.299	804.924	809.023
df	627	627	627	627	627	627	627
p	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
CFI	0.980	0.979	0.978	0.980	0.979	0.980	0.979
TLI	0.972	0.971	0.970	0.973	0.971	0.972	0.971
RMSEA	0.022	0.023	0.023	0.022	0.023	0.022	0.023
SRMR	0.030	0.030	0.030	0.030	0.030	0.030	0.030

In terms of control variables, gender was found to have statistically significant effects on total online shopping spending as well as the spending on orders made with traditional computers, from businesses, and from domestic and foreign online stores. All these effects were negative, meaning that women spent less than men. Age was found to have no statistically significant effects, whereas income was found to have statistically significant effects on total online shopping spending as well as the spending on orders made with traditional computers and mobile devices, from businesses, and from domestic and foreign online stores. All these effects were positive, meaning that those with higher income also spent more. The proportions of explained variance by the control variables ranged from about 1.7 % in the case of orders made from other consumers to about 11.8 % in the case of orders made with traditional computers.

In terms of individual values, we found nine out of the 16 values to have statistically significant effects on online shopping spending. First, total online shopping spending was found to be affected positively by stimulation and negatively by humility. In turn, the spending on orders made with traditional computers was found to be affected positively by self-direction, power–resources, and conformity–interpersonal and negatively by humility. In contrast, the spending on orders made with mobile devices was found to be affected negatively by universalism–concern. The spending on orders made from businesses was found to be affected negatively by humility, whereas the spending on orders made from other consumers was found to be affected positively by stimulation. Finally, the spending on orders made from domestic online stores was found to be affected positively by hedonism and conformity–rules, whereas the spending on orders made from foreign online stores was found to be affected positively by stimulation and security. The proportions of explained variance by the values ranged from about 5.5 % in the case of orders made from domestic online stores to about 14.8 % in the case of orders made from foreign online stores.

5 Discussion and Conclusions

In this study, we examined the effects of individual values on both total online shopping spending and the specific types of online shopping spending in terms of orders made (1) with traditional computers versus mobile devices, (2) from businesses versus other consumers, and (3) from domestic versus foreign online stores. The study focused on 16 values that were based on the refined theory of basic individual values by Schwartz et al. (2012). From a purely statistical perspective, these values were found to act as relatively weak antecedents of online shopping spending. For example, the values were found to explain only a small proportion of the observed variance in both total online shopping spending and the specific types of online shopping spending, with only nine out of the 16 values having statistically significant effects. However, from a more substantial perspective, the role of the values as antecedents of online shopping spending can still be considered as surprisingly strong. After all, one must keep in mind that human behaviour is always a challenging phenomenon to explain or predict, and the examined values were all very general in nature and by no means specific to the context of online shopping. Values are also typically considered to affect online shopping behaviour through multiple mediating constructs, such as attitude and intention (e.g., Jayawardhena, 2004), which limits their explanatory or predictive power.

The two individual values that were found to act as the most important antecedents of online shopping spending were stimulation and humility. These were the only two values that were found to have a statistically significant effect on not only on a specific type of online shopping spending but also on total online shopping spending. The effect of stimulation on total online shopping spending was found to be positive. This finding is in line with prior research, in which a higher optimal stimulation level (i.e., the personally preferred level of stimulation) has been found to be associated with a higher level of consumer innovativeness (Raju, 1980; Steenkamp & Baumgartner, 1992) and consumer innovativeness, in turn, has been found to have a positive effect on the adoption of online shopping (Citrin et al., 2000). More specifically, stimulation was also found to increase the spending on orders made from foreign online stores and from other consumers. Also these findings are largely in line with prior research, in which a higher optimal stimulation level has been found to be associated not only with a higher level of consumer innovativeness but also with a higher level of risk-taking (Raju, 1980; Steenkamp & Baumgartner, 1992). This tendency for risk-taking, in turn, is required especially when ordering from foreign online stores and other consumers, which is why these two specific types of online spending are most strongly affected by stimulation. In contrast, the effect of humility on total online shopping spending was found to be negative. This finding is not particularly surprising when considering that consumers who value humility and modesty are likely to avoid luxury or conspicuous consumption, which causes them to spend less both online and offline. More specifically, humility was also found to decrease the spending on orders made with computers and from businesses. Also these findings are not surprising when considering that luxury goods are most commonly purchased from businesses rather than other consumers. Respectively, because of the higher price, consumers typically spend considerable amounts of time on information search and the evaluation of alternatives when making these purchase decisions, which is why the purchases are more likely to be made with traditional computers rather than with mobile devices. Thus, when the luxury or conspicuous consumption is reduced, it has the strongest effects on these two specific types of online spending.

The remaining seven individual values with statistically significant effects were found to affect only one specific type of online shopping spending. For example, hedonism was found to increase the spending on orders made from domestic online stores and decrease the spending on orders made from foreign online stores, although this latter effect was not quite statistically significant. This would seem to suggest that whereas shopping in domestic online stores is perceived as a pleasurable activity by many consumers, the opposite is often true for shopping in foreign online stores. In turn, universalism–concern was found to decrease the spending on orders made with mobile devices. This likely due to its strong associations with consumption movements like sustainable consumption (Thøgersen & Ölander, 2002), ethical consumption (Shaw et al., 2005), conscious consumption (Pepper, Jackson & Uzzell, 2009), and fair-trade consumption (Doran, 2009), which all highlight responsible consumer behaviour instead of impulsive purchasing that often characterises mobile online shopping (Schwartz, 2012; Lee, Park & Jun, 2014; Zheng et al., 2019). In contrast, the spending on orders made with mobile devices seemed to be slightly increased by the motivation of maintaining one's face, although this effect was not quite statistically significant. This finding may be explained by the fact that especially younger consumers often see mobile online shopping as a somewhat trendier way to shop online in comparison to traditional online shopping. Thus, if one is motivated to maintain a trendy public image, one is likely to favour this specific type of online shopping spending. The same logic, although inversely, may also be used to explain the finding that self-direction was found to increase the spending on orders made with traditional computers. That is, if the motivation to maintain one's face causes consumers to spend more on orders made with mobile devices, then the freedom from such social pressure is likely to reduce this tendency or even result in an opposite tendency of spending more on orders made with traditional computers. In addition, the spending on orders made with traditional computers was found to be increased by power–resources, which may simply be due to the fact that consumers with more materialistic motivations often have more materialistic possessions, including also a traditional computer that is required for this specific type of online shopping spending. Finally, we found security to increase the spending on orders made from foreign online stores as well as conformity to increase the spending on orders made from domestic online stores and with computers. Of these, the latter findings are not particularly surprising because making orders with traditional computers from domestic online stores represents a very conservative way of shopping online, which is likely to be more common among consumers who foster conservative values like conformity. In contrast, the former finding can be considered a bit more surprising but is perhaps explainable by the fact that consumers who value security are also likely to be more security conscious and aware of the risks that relate to making orders in foreign online stores. This awareness, in turn, may help them to mitigate these risks and increase this specific type of online shopping spending.

In addition to providing the aforementioned theoretical insights, the findings of this study also have important practical implications for the managers of online stores in terms of promoting online spending. For example, on one hand, the findings highlight the fact that especially for foreign online stores and online services that facilitate C2C commerce it is important to lower the level of perceived risk associated with shopping in them in order to promote their usage also among consumers with lower optimal stimulation levels and lower risk-taking tendencies. This lower level of perceived risk is also likely to promote the level of perceived hedonic value associated with shopping in them, thus causing them to be more actively used also by consumers with more hedonic shopping tendencies. On the other hand, the findings highlight the fact that online stores should be cautious in terms of employing marketing practices that promote impulse purchasing and other kinds of irresponsible consumer behaviour. Although these practices may have a positive effect on their sales among some consumers, their effect on sales is likely to be negative especially among consumers who value universalism and consumption movements like sustainable, ethical, conscious, and fair-trade consumption, which all seem to be increasing rather than decreasing in popularity.

6 Limitations and Future Research

We see this study to have two main limitations. First, we collected the data for this study only from Finnish consumers, and our sample was also dominated by women and younger consumers. This obviously limits the generalisability of our findings and calls for future replications of this study in other countries and by using more balanced samples. Second, our measurements of online shopping spending were based on self-reported retrospective assessments, which is likely to result some inaccuracies. Thus, in future studies, it is important to aim at improving the measurement accuracy through methodological advancements. For example, one alternative could be to ask the study participants to keep a diary of their online shopping behaviours and use these diaries as the data source of the study. Of course, in future studies, it would also be interesting to focus on other specific types of online shopping spending than the ones that were examined in this study. One example of this would be to consider the context in which the orders were made (e.g., while at home or while on the go).

Appendix A: Item Wordings and Descriptive Statistics

Item	Missing	Mean	SD
Self-direction–thought (SDT)			
SDT1 It is important to me to form my own opinions.	0.2 %	4.392	0.752
SDT2 Thinking independently and drawing my own conclusions is important to me.	0.2 %	4.374	0.725
Self-direction–action (SDA)			
SDA1 It is important to me to make my own decisions about my life.	0.2 %	4.496	0.696
SDA2 The freedom to choose what I do is important to me.	0.4 %	4.497	0.684
Stimulation (STI)			
STI1 I am always looking for different kinds of new things to do.	0.5 %	3.436	1.053
STI2 It is important to me to have all sorts of new experiences.	1.4 %	3.833	0.963
Hedonism (HED)			
HED1 Having a good time is important to me.	0.9 %	4.084	0.910
HED2 Enjoying life's pleasures is important to me.	0.5 %	4.372	0.798
Achievement (ACH)			
ACH1 It is important to me to be ambitious.	0.4 %	3.506	1.096
ACH2 It is important to me to be successful and others to admire my achievements.	0.4 %	3.522	1.100
Power–dominance (PD)			
PD1 I want to be in a position where people do what I say.	0.4 %	2.588	1.107
PD2 It is important to me to be the one who tells others what to do.	0.2 %	2.642	1.113
Power–resources (PR)			
PR1 The power and possibilities that money can bring are important to me.	0.2 %	2.949	1.198
PR2 Being wealthy is important to me.	0.4 %	3.041	1.143
Face (FAC)			
FAC1 It is important to me that no one should ever shame me.	0.4 %	3.742	1.072
FAC2 It is important to me not to lose my face in the eyes of others.	1.1 %	3.717	1.067
Security–personal (SP)			
SP1 My personal security is important to me.	0.7 %	4.488	0.735
SP2 It is important to me to live in secure surroundings.	0.2 %	4.516	0.721
Security–societal (SS)			
SS1 It is important to me that my country protect itself against all threats.	0.9 %	4.473	0.702
SS2 Having order and stability in the society is important to me.	1.4 %	4.334	0.818
Tradition (TRA)			
TRA1 Following the customs of my society is important to me.	1.2 %	3.509	1.036
TRA2 It is important to me to maintain the traditions of my society.	1.6 %	3.385	1.089
Conformity–rules (CR)			
CR1 It is important to me to follow rules even when no one is watching.	0.4 %	3.895	1.051

CR2 Being law-abiding and obeying all the laws is important to me.	0.2 %	3.998	1.019
Conformity–interpersonal (CI)			
CI1 It is important to me to avoid annoying or upsetting other people.	0.4 %	3.657	1.115
CI2 It is important to me to be tactful and avoid irritating other people.	1.1 %	3.773	1.014
Humility (HUM)			
HUM1 It is important to me to be humble and inconspicuous.	0.4 %	2.897	1.140
HUM2 It is important to me to be modest and not to draw attention to myself.	0.7 %	3.036	1.180
Benevolence–caring (BC)			
BC1 It is important to me to help the people dear to me.	0.0 %	4.573	0.695
BC2 Caring for the well-being of the people I am close to is important to me.	0.4 %	4.512	0.734
Benevolence–dependability (BD)			
BD1 I go out of my way to be a dependable and trustworthy friend.	0.2 %	4.606	0.703
BD2 I want the people who are close to me to be able to rely on me completely.	0.2 %	4.631	0.668
Universalism–concern (UC)			
UC1 It is important to me that every person in the world has equal opportunities in life.	0.9 %	4.200	0.926
UC2 It is important to me that also the society's weakest members are treated justly.	0.4 %	4.433	0.748
Universalism–nature (UN)			
UN1 It is important to me to care for the nature and the environment.	0.4 %	4.302	0.865
UN2 Protecting the nature from pollution or other threats is important to me.	0.5 %	4.258	0.867
Universalism–tolerance (UT)			
UT1 It is important to me to listen to people who are different from me.	0.4 %	4.147	0.827
UT2 Even when I disagree with people, it is important to me to understand them.	0.2 %	4.094	0.855

Appendix B: First-Order Constructs and Their Indicators

Construct or indicator	Before modifications				After modifications			
	CR	**AVE**	**Loading**	**Residual**	**CR**	**AVE**	**Loading**	**Residual**
Self-direction–thought (SDT)	0.740	0.588			0.740	0.588		
SDT1			0.819***	0.329***			0.816***	0.334***
SDT2			0.711***	0.494***			0.714***	0.491***
Self-direction–action (SDA)	0.725	0.569			0.726	0.569		
SDA1			0.748***	0.440***			0.749***	0.439***
SDA2			0.760***	0.422***			0.760***	0.423***
Stimulation (STI)	0.695	0.533			0.695	0.533		

STI1			0.679***	0.539***			0.678***	0.541***
STI2			0.778***	0.394***			0.779***	0.393***
Hedonism (HED)	0.812	0.684			0.811	0.683		
HED1			0.764***	0.416***			0.767***	0.412***
HED2			0.886***	0.215***			0.882***	0.221***
Achievement (ACH)	0.785	0.646			0.786	0.647		
ACH1			0.806***	0.350***			0.807***	0.349***
ACH2			0.802***	0.356***			0.802***	0.358***
Power–dominance (PD)	0.807	0.677			0.808	0.678		
PD1			0.859***	0.261***			0.856***	0.267***
PD2			0.785***	0.383***			0.789***	0.378***
Power–resources (PR)	0.812	0.684			0.812	0.684		
PR1			0.791***	0.375***			0.790***	0.376***
PR2			0.861***	0.258***			0.862***	0.257***
Face (FAC)	0.863	0.760			0.864	0.760		
FAC1			0.878***	0.229***			0.879***	0.227***
FAC2			0.865***	0.251***			0.865***	0.253***
Security–personal (SP)	0.764	0.619			0.765	0.620		
SP1			0.747***	0.443***			0.743***	0.448***
SP2			0.825***	0.320***			0.829***	0.313***
Security–societal (SS)	0.699	0.538			0.700	0.539		
SS1			0.772***	0.405***			0.780***	0.391***
SS2			0.693***	0.519***			0.686***	0.529***
Tradition (TRA)	0.771	0.628			0.772	0.630		
TRA1			0.834***	0.304***			0.841***	0.293***
TRA2			0.749***	0.439***			0.743***	0.447***
Conformity–rules (CR)	0.826	0.704			0.826	0.704		
COR1			0.805***	0.352***			0.806***	0.351***
COR2			0.872***	0.240***			0.871***	0.241***
Conformity–interpersonal (CI)	0.827	0.705			0.826	0.704		
COI1			0.828***	0.315***			0.828***	0.314***
COI2			0.851***	0.277***			0.850***	0.278***
Humility (HUM)	0.851	0.741			0.851	0.741		
HUM1			0.885***	0.217***			0.884***	0.219***
HUM2			0.836***	0.301***			0.837***	0.299***
Benevolence–caring (BC)	0.795	0.660			0.795	0.660		
BC1			0.825***	0.320***			0.828***	0.314***
BC2			0.799***	0.361***			0.796***	0.367***
Benevolence–dependability (BD)	0.794	0.658			0.794	0.658		
BD1			0.797***	0.366***			0.793***	0.371***
BD2			0.825***	0.319***			0.829***	0.313***

Universalism–concern (UC)	0.753	0.604			0.754	0.605		
UC1			0.775***	0.399***			0.774***	0.402***
UC2			0.779***	0.392***			0.781***	0.390***
Universalism–nature (UN)	0.883	0.791			0.884	0.792		
UN1			0.858***	0.263***			0.860***	0.261***
UN2			0.920***	0.153*			0.919***	0.156*
Universalism–tolerance (UT)	0.765	0.619			0.765	0.619		
UT1			0.827***	0.317***			0.827***	0.316***
UT2			0.745***	0.445***			0.745***	0.445***

*** = p < 0.001, ** = p < 0.01, * = p < 0.05

Appendix C: Second-Order Constructs and Their Indicators

Construct or indicator	**CR**	**AVE**	**Loading**	**Residual**
Self-direction (SD)	0.904	0.825		
Self-direction–thought (SDT)			0.953***	0.092
Self-direction–action (SDA)			0.861***	0.259***
Security (SEC)	0.988	0.976		
Security–personal (SP)			0.984***	0.032
Security–societal (SS)			0.992***	0.015
Benevolence (BEN)	0.924	0.858		
Benevolence–caring (BC)			0.901***	0.188**
Benevolence–dependability (BD)			0.951***	0.095

*** = p < 0.001, ** = p < 0.01, * = p < 0.05

Appendix D: Construct Correlations and Square Roots of AVEs Before Modifications

	SDT	**SDA**	**STI**	**HED**	**ACH**	**PD**	**PR**	**FAC**	**SP**	**SS**	**TRA**	**CR**	**CI**	**HUM**	**BC**	**BD**	**UC**	**UN**	**UT**
SDT	0.767																		
SDA	0.818	0.754																	
STI	0.293	0.380	0.730																
HED	0.401	0.469	0.590	0.827															
ACH	0.239	0.298	0.499	0.254	0.804														
PD	0.061	0.101	0.318	0.027	0.621	0.827													
PR	0.094	0.160	0.270	0.204	0.653	0.522	0.823												
FAC	0.152	0.232	0.085	0.199	0.341	0.120	0.277	0.872											
SP	0.549	0.484	0.125	0.438	0.258	0.018	0.204	0.450	0.787										
SS	0.580	0.489	0.140	0.370	0.248	0.065	0.179	0.470	0.979	0.734									
TRA	0.073	0.143	0.128	0.225	0.241	0.131	0.192	0.480	0.471	0.533	0.793								
CR	0.256	0.222	0.009	0.163	0.275	0.039	0.122	0.404	0.620	0.670	0.579	0.839							
CI	0.080	0.144	0.038	0.181	0.192	-0.112	0.063	0.597	0.435	0.450	0.493	0.558	0.840						
HUM	-0.052	-0.006	0.016	0.011	-0.029	-0.022	0.052	0.397	0.162	0.218	0.381	0.374	0.509	0.861					
BC	0.514	0.473	0.316	0.413	0.223	-0.066	0.036	0.294	0.698	0.649	0.394	0.460	0.347	0.119	0.811				
BD	0.577	0.484	0.266	0.517	0.244	-0.100	0.062	0.320	0.673	0.649	0.363	0.501	0.374	0.139	0.858	0.812			
UC	0.463	0.480	0.343	0.468	0.137	-0.131	-0.077	0.213	0.452	0.482	0.194	0.332	0.363	0.119	0.589	0.626	0.777		
UN	0.369	0.375	0.273	0.329	0.047	-0.019	-0.025	0.169	0.421	0.430	0.177	0.270	0.232	0.050	0.480	0.440	0.520	0.890	
UT	0.497	0.431	0.423	0.451	0.261	-0.048	0.004	0.209	0.416	0.440	0.296	0.371	0.360	0.168	0.566	0.660	0.700	0.400	0.787

Appendix E: Construct Correlations and Square Roots of AVEs After Modifications

	SD	STI	HED	ACH	PD	PR	FAC	SEC	TRA	CR	CI	HUM	BEN	UC	UN	UT
SD	0.908															
STI	0.356	0.730														
HED	0.464	0.593	0.827													
ACH	0.284	0.499	0.255	0.805												
PD	0.083	0.318	0.027	0.622	0.827											
PR	0.129	0.270	0.205	0.652	0.522	0.823										
FAC	0.198	0.086	0.200	0.341	0.121	0.277	0.872									
SEC	0.588	0.134	0.413	0.256	0.039	0.195	0.464	0.988								
TRA	0.107	0.127	0.224	0.242	0.131	0.192	0.480	0.502	0.794							
CR	0.264	0.009	0.162	0.275	0.040	0.122	0.404	0.648	0.579	0.839						
CI	0.113	0.038	0.181	0.192	-0.112	0.063	0.597	0.446	0.493	0.558	0.839					
HUM	-0.038	0.016	0.010	-0.029	-0.022	0.052	0.397	0.188	0.380	0.374	0.509	0.861				
BEN	0.612	0.310	0.508	0.252	-0.091	0.054	0.333	0.727	0.403	0.520	0.389	0.141	0.926			
UC	0.512	0.344	0.469	0.137	-0.131	-0.077	0.213	0.471	0.194	0.332	0.363	0.119	0.657	0.778		
UN	0.404	0.274	0.330	0.046	-0.019	-0.025	0.170	0.429	0.176	0.270	0.233	0.050	0.491	0.520	0.890	
UT	0.514	0.423	0.451	0.261	-0.047	0.004	0.209	0.431	0.296	0.371	0.360	0.168	0.666	0.700	0.401	0.787

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Does BMI help business to succeed?

MARIKKA HEIKKILÄ, JUKKA HEIKKILÄ, HARRY BOUWMAN & OLLI HEIMO

Abstract This study investigates if BMI helps business innovation to succeed. We analyzed 27 SME cases having differing combinations of Business Model Innovation (BMI), New Product Development (NPD) and effectuation methods. We also analyzed the drivers and market strategy of the SMEs. We found out that typical SME innovation success cases combine at least two methods of implementation, such as BMI and NPD, and focus on low-end market. Effectuation in combination with the aforementioned seems to play significant role as well.

Keywords: • Business Model Innovation • New Product Development • Effectuation • SME • Success • Markets •

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1 Introduction

In economics, innovation is an important catalyst for growth. Without innovation business is eventually deemed to fade away, as competitors bring new solutions to market. Previously, it was commonly accepted that companies should follow New Product Development (NPD), a typical research and development (R&D) process leading to market entry (Samli & Weber, 2000; Bishop & Magleby, 2004). Today, by far most organisations have heard about Business Modelling; Business Model Innovation (BMI) has been found to have a positive impact on overall business performance (Pucihar et al., 2019) and has been promoted as a must when creating new products and services regardless of maturity of the markets, also for micro, small and medium sized organizations (SMEs) (Heikkilä et al., 2018). At the same time, the entrepreneurship literature has proposed a new theory, effectuation, which describes entrepreneurial action when innovating new market artefacts (Sarasvathy, 2001a,2001b).

NPD is suggested to improve the capability of the organisations to bring new innovations into market. Similarly, effectuation is suggested by the literature as the force that provides the entrepreneurs stamina to adapt and carry out their business. BMI, in turn, is suggested to lead to viable business. Despite the wide interest in the abovementioned innovation approaches, there are not yet studies combining these three topics. To fill this gap, *this paper analyses whether BMI, or effectuation and NPD have an effect on the success of SME innovation.* We construct an analysis framework, which we utilize in evaluation of 27 cases of SMEs. We categorize case SMEs in three groups according to the performance (success, survival, failure), and then analyze their innovation process' drivers (technology push, market pull), approaches (NPD, BMI, effectuation) and market strategy (low end, high end, new market). This allow us to draw conclusions on the interplay between BMI, NPD and effectuation, and especially on the importance of the BMI for SMEs.

The paper is structured as follows: In chapter 2, we describe our analysis framework which consists of the drivers, innovation approaches, market strategies and performance of SMEs. We explain data collection in chapter 3 and analysis in chapter 4. Results are described in chapter 5. The paper end with conclusions.

2 How SMEs innovate and perform: the framework

Our analysis framework consists of three innovation drivers, three innovation approaches, three market strategies and, finally, three levels of performance. Next, we will explain each in turn.

2.1 Innovation drivers

Technology pull is often the starting point in R&D projects within the organisations. These projects follow a process were the new innovation is developed into a product that can be manufactured effectively and economically and then sold on the market. Radical breakthroughs are more likely to be achieved through technology push.

Alternative innovation driver is *Market pull*, which refers to market demand for a new product or a solution to a problem. These needs might be perceived by an entrepreneur, for instance through market research, which assesses what needs exist, how far they are met by existing products and how the needs might be met more effectively by means of a new or improved innovation. Market pull more often leads to incremental innovations.

Recent research suggests that technology push and market pull are complementary and necessary for NPD (Scaringella et al., 2017; Sarja, 2016).

Sometimes, the driver for innovation is very *personal*. The entrepreneur has a strong need to do something, for instance improve some product, provide a service or solve a problem which the entrepreneur would value high personally. Or the entrepreneur enjoys the production itself, such as artists creating art pieces.

2.2 Innovation approaches

In *NPD* approach every new product innovation passes through a series of stages starting from idea generation and idea screening, then continuing with concept testing, feasibility study and product development, and ending with test marketing and market entry. It requires ample resources and competent staff not easily found in SMEs (Samli & Weber, 2000). This implies that the innovation would happen more in large organisations rather than in SMEs.

BMI thinking changes how an organization approaches innovation. Instead of focusing on development of new products, the company analyses the value proposition it can provide to selected customer segment(s), and describes the processes, resources, and partners needed to produce it, as well as the financial arrangements (Foss & Saebi, 2017). Evidence suggests that new business models have often been the source, and not the outcome, of industry change (Markides, 2008; Christensen et al., 2016). Companies in 'traditional' industries have been able to generate supernormal profits by designing new business models in the presence of major technological progress, or in the absence of regulatory limitations. These new business models have boosted large-scale disruptive industry change reaching far beyond reacting to changes in business environment, or developing new products. It is about being active in innovating and implementing radically new ways of doing business by the management.

Whereas BMI and NPD literature are mostly focused on causal approaches on developing business towards a given goal, the emerging entrepreneurial literature emphasizes the *effectual* side of businesses, which is considered as the inverse of causal. Whereas causal rationality starts with a pre-determined goal and a given set of means, and seeks to identify the optimal, such as fastest, cheapest, or most efficient alternative to achieve the given goal, the effectuation process is highly subjective, starting from the passion, capabilities and resources of the entrepreneur, and then selecting between possible effects that can be created with that set of means (Sarasvathy, 2001a). Studies on SMEs survival provide evidence that entrepreneurial originality and passion may compensate SMEs' limited resources (Stenholm & Renko, 2016). An effectuating entrepreneur focuses on the controllable aspects of an unpredictable future and is thus in better position to exploiting contingencies that arise unexpectedly over time (Sarasvathy, 2001b). The entrepreneur would define the market as a community of people willing and able to commit enough resources and talent to sustain the business, and creates the market by bringing together enough stakeholders, who buy into the business idea.

2.3 Market Strategies

For the analysis we categorize the market strategy using Christensen & Raynor (2003) division into three differing market strategy:

Many innovations are improvements of current products. These *High-end market* innovations seek to provide better and more sophisticated solutions to present market. The products have improved, rich, and expensive set of features.

Alternatively, the new innovation may also focus on *Low-end market* products, where the products compete by lower prices and quality. This means that some customers are served better by providing simple choice for unbundled service at more affordable price (e.g., Ryan Air vs. British Airways).

A third alternative *New market* takes place when it becomes possible to serve customers, who were not previously served by existing companies. Breakthrough on an uncovered market is a dream of every innovator, getting onto the 'blue ocean' instead of severe competition on the 'red ocean' (Kim and Mauborgne, 2005). New markets are claimed to be boosted by open networked innovative activities (Christensen et al., 2009), where the incumbents seem to be at their weakest. In essence, the New market creation is about design, thinking out of the box, relating it to the external environment, and managing the implementation fast.

2.4 Performance

We divided the SMEs into three groups according to their performance after the innovation:

Failure: The business/innovation fails. For instance, the product is redrawn from the markets, or business is in solvency, or bankrupt. *Survive*: The business/entrepreneur is hanging on, or at high burn rate. It is avoiding failure, but is not generating profit either. *Success*: Business building on the innovation is clearly profitable.

2.5 The framework

Figure 1. summarizes framework in this paper. It links three potential drivers (technology push, market pull, personal), three methods for innovating (NPD, BMI, effectuation) and three market strategies (low-end, high-end and new market) with performance, with three categories (failure, survival, success).

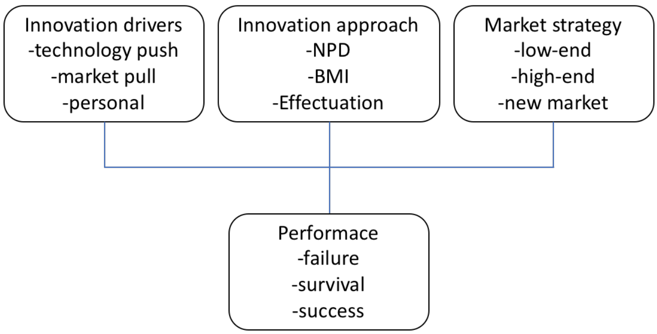

Figure 1. The framework

3 Data collection

The case studies of SMEs (as defined by EU, 2003/361/EC) were collected as a part of a European wide research project. The SME cases were selected on the basis of purposive sampling resting on the researchers' judgments aligned with research goal. We defined the following case selection: SMEs, which explained their innovation activities, market strategy and have clearly evaluated the successfulness of their innovation, or it is evident (such as bankruptcy). After using these criteria, we had a set of 27 cases.

Case data were collected between 2015 and 2017 by partners in the research project. A case study protocol, together with a fixed case report format, contained instructions for interviews and guidelines for the use of triangulation techniques, both in data collection and data analyses.

Studying SMEs is challenging because the key informants, as well as primary and secondary data sources, are scarce. The number of people that qualify for interviews is limited. Written documents with clear descriptions of strategic objectives and long-term plans are not often available. The interviewees were primarily with owners, core managers or people responsible for BM Innovation or business development. Interviews lasted from half an hour to two hours, but on average lasted about an hour. Following standard procedures in case study research, we further triangulated our primary data source with secondary documents and website information to cross validate factual information about the cases.

The case data includes background information, such as age, size, industry, ownership, and management team formation. We collected information on the firm's culture and innovativeness, backed up with factual information on R&D. We also collected information on the value proposition and BM, and the focus of innovation. All data (interview recordings, transcripts, the case reports etc.) are stored in a structured and secure database.

4 Analysis

We take a backwards approach and start the analysis from the performance: 10 of the cases ended up in failure, 7 were surviving, and 10 were successful.

<u>Failed SMEs</u>

Let's take the first example of a failure: **Atelier** (Table 1) started as self-employed artist 12 years ago. The driver for innovation was not technology, but mainly the entrepreneur wanted to create new and improved products following artistic visions. The entrepreneur was devoted to creating handicraft products (NPD) by combining raw materials in novel ways. Despite the innovative products, the production did not scale up, customers were hard to reach, and timing depended on fashion rather than on Atelier's action. The Atelier had a store where it sold products to tourists (mainly in summer), or locals looking for a birthday gift etc. It also imitated the competitors by being present in Facebook and in online store. In 2015 the entrepreneur hired a person to run the store and administrative matters. Unfortunately, the sales could not to cover increasing costs. The business was closed one year later. But, already the same year the entrepreneur started experimenting with a new business idea related to life style coaching. The case is typical case driven by effectuated entrepreneur.

Table 1: Atelier

DRIVER	INNOVATION APPROACH	MARKET STRATEGY	PERFORMANCE
Personal: *The entrepreneur wanted to create new and improved products following artistic visions of which customers appreciated.*	**NPD:** *The entrepreneur was putting majority of effort to development of new products.* **Effectuation:** *The entrepreneur combined raw materials in new ways.*	**High-end market:** *Unique, high style design products.*	**Failure.** *The business was closed. Soon the entrepreneur was experimenting with a new business idea.*

Another failure case is **EcoContainer** (Table 2). The aim of the start-up was to provide a new product/service to the market. For this purpose, the start-up was at the same time getting started with the technical design and designing the business model. The idea for the product initiated from a project in which the entrepreneur was employed a few years ago. The SME wanted to create a high-tech solution for cultivating salad and herbs. The solution comprises a renovated container, where ecological local food can be cultivated efficiently. "*Our solution is ideal for example for restaurants and institutional kitchens wanting to produce their own ingredients. The modules also serve as an excellent option for farmers to replace their traditional greenhouses with*", explained the entrepreneur. He hired two persons to his newly established company and started to do concept design. At the same time, the SME contacted many potential partners they needed in producing the product. It also contacted several research organisations, among others the local university which helped in business modelling. Already in the initial project they had sketched first BM, but now they had to rethink their customer segments; the SME listed many B-to-B segments they hoped to get interested in this new technology. However, the segments needed to be served with differing BM. Similarly, the partner analysis and matrix tools revealed big challenges in managing large partner network, especially because the start-up was not able to provide value (or money) back to them. Moreover, the funding institution, from which the SME applied funding for piloting, set as a prerequisite that the pilot is to be made with a potential customer. The SME did not manage to find a pilot customer or get a deal with partners, and run out of money. One year after establishment, the SME went into bankruptcy.

Table 2: EcoContainer

DRIVER	INNOVATION APPROACH	MARKET STRATEGY	PERFORMANCE
Technology: *The entrepreneur wanted to create a product making use of advanced technology.*	**NPD:** *The concept design and detail engineering design was carried out, pilot product was to be created.* **BMI:** *The SME designed BM Canvas and analyzed the partner network.* **Effectuation:** *As the start-up did not have own funds and no turnover, the entrepreneur took advantage of pay subsidies etc. to hire personnel. It also tried to convince partners to do work for free.*	**New market creation:** *A high-tech product or service for B-to-B customers. This would build a new market.*	**Failure.** *The business was closed after one year. No pilot product was made. Fail fast.*

Looking at the list of all **failure cases** below, there seem to be one recurring pattern - Technology driven product aiming at New market disruption. In all cases, except the Atelier case, the driver for innovation is technology. Furthermore, the new high-tech product typically aims at creation of new markets. Regardless of the implementation method these endeavors tend to fail. In five out of nine failures cases also BMI was used.

Table 3: Failure cases

CASE	DRIVER	INNOVATION APPROACH	MARKET STRATEGY	PERFORMANCE
Atelier	Personal	Effectuation, NPD	High-end	Failure
Share your storage	Technology	NPD	Low-end	Failure
EcoContainer	Technology	NPD, BMI, Effectuation	New market	Failure
FitCity	Technology	NPD, BMI	New market	Failure
In-store analytics	Technology	NPD	New market	Failure
MobiFish	Technology	NPD	New market	Failure
Poolhere	Technology	BMI	New market	Failure
Rate the club!	Technology	BMI	New market	Failure
Sports prescription	Technology	BMI	New market	Failure
Big Data analytics for SMEs	Technology	NPD, BMI, Effectuation	New market	Failure

Success SMEs

In total there were ten success cases. Next, we describe two of them.

Electronic Medicine Dispenser (Table 4), established in 2003, is a high-tech company with technology-push approach. Its innovative new dispenser service was expected to have pull from the market: in addition to its main value proposition of providing improved dispensation safety and quality of medication to the patients, it could promise cost savings to the hospitals and nursing homes. The company is experienced in NPD, but in this case, they used also BMI (BM canvas and ecosystem analysis) to support the process. Business modelling revealed that the envisioned product was not lucrative enough for one of the key partners in terms of business. Therefore, SME decided to discontinue the development, and instead, focus its NPD & BMI efforts onto more potentially profitable and feasible products. Even though the dispenser service failed first, company's partners eventually implemented a derivative design and brought it to market with SME's major incumbent partner, which is a visible actor with a credible reputation on the market. SME is employing around 120 persons and runs profit. Their present implementation of the service scales up well, and was synchronized on time with the incumbents' product launch to gain momentum. The case was relying on NPD combined with BMI.

Table 4: Electronic medicine dispenser

INNOVATION DRIVERS	INNOVATION APPROACH	MARKET STRATEGY	PERFORMANCE
Technology push: *Electronic dispensing device and remote monitoring of medicine use.* **Market pull:** *Cost saving through reduced need of patient visits, improved safety and quality.*	***NPD:*** *The company was accustomed to creating high-tech products.* ***BMI:*** *BM and ecosystem analysis revealed that the BM is not viable for one of the main partners.*	**Low-end:** *The aim was to use high-tech to provide cost saving and affordable service for current market.*	**Failing first, then success.** *The business development was discontinued, the SME put its effort in other business ideas, but ramping up at opportunity. The SME is profitable.*

Also**, My Apple tree** (Table 5) is an interesting case, because it is a rare example of business that has succeeded in New-market creation. A farmer in 6th generation, owns fields in the Southern Finland. The main business is grain production and snow removal. In 2013 Rikard decided to get serious with apple farming and planted 1100 apple trees. The risk in growing apples is quite high as the trees are easily damaged by the winter frosts and the crops are smaller compared to southern countries. Before launching the business, he studied consumer trends and alternative business models. Learning from two growing trends - sense of community and local food movement - and copying ideas from Community Supported Agriculture he launched his apple business. Instead of selling the apples in local markets or through supermarkets, he sells via his own web shop annual shares of apple trees. That is, instead of buying apples the customers are purchasing shares of the apple orchard. The value proposition is not really about apples that you can eat, but it is more the idea of owning a piece of beautiful orchard, and supporting cooperative local farming.

The SME keeps in touch with his clients by writing emails and posting pictures and stories on Facebook about growth of apples and other happenings and operations in the orchard. As the orchard is situated near its customers, they can also have picnics under the apple trees. This business model builds on yearly contracts of appleshares with fixed price paid in advance the autumn before for the actual harvest. The SME and the clients share both the upside and the downside risk in apple growing. If the crop of the particular summer is low, the clients will get less apples. On the other hand, if the crop is plentiful each customer gets more apples than expected. When harvesting the SME has no transportation costs; customers are fetching the apples from the farm. Of course, if a customer wishes to do so, she can also harvest the apples by herself - with no extra payment. Unfortunately, this new business model does not scale up easily. There is only limited number of trees that can be planted and demand is limited.

Table 5: MyAppletree

INNOVATION DRIVERS	INNOVATION APPROACH	MARKET STRATEGY	PERFORMANCE
Market pull: *The SME studied the consumer trends in food business and took advantage of growing trends - sense of community and local food movement.* ***Personal:*** *The SME is passionate in seeking ways to improve business in agriculture and food sector.*	***BMI:*** *The whole business is built on the innovative BM.* ***Effectuation:*** *The SME is passionate in seeking ways to improve business in agriculture and food sector.*	**New market:** *The value proposition of owning a piece of beautiful orchard, and supporting cooperative local farming is focused on new market.*	**Success but only with limited turnover.** *The business model does not scale up easily. The entrepreneur needs to have other businesses as well to earn his living.*

Typical for success cases that are listed below is that they tend to 1) focus on low-end market. The products are offering cost efficient solution to customers (such as easy scanning and sending of receipts to bookkeepers). They also typically 2) combine at least two methods of implementation, such as NPD and

BMI. Compared to failure cases 3) effectuation appears as a driver mostly in combination with some other driver. 8 out of 10 success cases had used BMI. High effectuation in low-market may also sometimes lead to success.

Table 6: Success cases

CASE	DRIVER	INNOVATION APPROACH	MARKET STRATEGY	PERFORMANCE
Electronic medicine dispenser	Technology	NPD, BMI	Low-end	First failure, then success
Electronic receipts for bookkeeping	Technology, Market	NPD, BMI	Low-end	Success
Green Bull	Market, personal	BMI, Effectuation	Low-end	Success
Portable Medical Device	Technology, personal	NPD, BMI, Effectuation	Low-end	Success
Sewing services	Market	NPD, Effectuation	Low-end	Success
SportEquipment eStore	Technology, personal	NPD, Effectuation	Low-end	Success
Hardware store	Technology, personal	NPD, BMI, Effectuation	Low-end	Success
Wind Energy Technology	Technology	NPD, BMI	Low-end	Success
Portable Solar Cells	Technology, Market, personal	NPD, BMI, Effectuation	High-end	Success
MyAppletree	Market, Personal	BMI, Effectuation	New market	Success (with small turnover)

Survival SMEs

We categorized seven cases as survivals. Let's have a closer look at three of them.

Bus tours (Table 7) is a micro-sized travel agency. It is owned by a married couple and arranges low-price tours to the neighboring country from where the wife originates from. In 1991 when the company was founded, the husband drove a mini-bus and the wife was a guide for small groups of tourists. Now they have three additional workers. The husband is sometimes pondering whether growth is a plausible option for their firm. However, the wife is reluctant to make the extra effort and therefore they have decided to keep it as it is. Therefore, the

SME cannot be reached through Internet, but the customers can phone, send email or visit their office. But, the company relies on a good reputation they have on the market. The decision of the SME not to make any changes in their business shows: during last three years their turnover has declined by 40%. The company is still in operation but is making loss.

Table 7: Bus Tours

DRIVER	INNOVATION APPROACH	MARKET STRATEGY	PERFORMANCE
-	***No.*** *Does not want to change*	***Low-end***	***Survive****. Radical decline in turnover. Making loss.*

Green wall (Table 8) started from the idea of the founder, who suffered from poor in-door air quality. He wanted to improve the air quality by bringing part of nature inside, i.e. living plants. He started to build a green wall with a fellow university student, who had both practical and theoretical knowledge on purifying water with ecological means. The first prototypes were put together of plastic and duct tape. Simultaneously, they were designing business models using BM canvas. The challenge was to make the product look good and the plants flourish. So, they developed a remote sensing system with embedded sensors to measure the status of the green wall and its environment. This data is analyzed automatically in a cloud software. The adjustments to the plants' growth parameters are fed back to the green wall at customer's premises. Yet, the system needs regular manual maintenance (watering etc.). Imitating benchmark companies from other industry sectors, the SME decided to bundle all – green wall, remote control and maintenance – into one service, which it leases to b-to-b customers. Right timing is hard, despite the good visibility, because the maintenance does not scale up well. Initially the target was new market entry, but later they redesigned the BM and refocused on clean tech markets, and have alliances with large incumbent firms, which could help in securing maintenance services in selected cities. The personnel of the company increased from 3 to 60 in five years of operation. It is making loss, but has doubled its turnover for the last two years. Thanks to its iterative BMI and NPD, (it's been awarded too), the SME is seen attractive by the investors and even crowd funders.

Table 8: Green wall

INNOVATION DRIVERS	INNOVATION APPROACH	MARKET STRATEGY	PERFORMANCE
Technology push: *Sensors, biodynamics, embedded SW (patented).* **Market pull:** *Clean-tech forerunner related with high growth potential.* **Personal:** T*he product idea came from the CEO who suffered from poor indoor air quality.*	***NPD:*** *The entrepreneurs created prototypes and minimum viable products to test the product with users.* ***BMI:*** *Simultaneous development of product and BM with canvas.* **Effectuation*:*** *The first prototypes were created of duct tape and some plastic boxes.*	**High-end:** *High-quality service, requiring both remote and on-site maintenance, cooperation with major, local incumbent firms.*	**Survive.** *The company is making loss, but has doubled its turnover for the last two years. The size of the company has increased from 3 (2012) to 60 (2017). Product story is lucrative to investors.*

Everyone deserves a garden (Table 9) is an SME initially established by a designer, who had the vision to create a beautiful consumer product for cultivation of herbs in-house. With partner network – such as researchers specialized in greenhouse cultivation - the micro-sized start-up company developed, and recently patented world-wide its unique IT-controlled led light and growth system. In parallel with NPD, they started using BMI tools to design and revise their business model and value proposition (they imitate the BM of Nespresso with alterations), analyze the potential markets, and to create user profiles (i.e., 'personas'). This way they dared to abandon a fancy and fashionable mobile app for the users, as their analyses proved that there were no markets for remote control feature. The product is competing with other high-end consumer products, because there have not been direct competing products. To increase its sales, the company refocused its sales channel strategy from design shops to high-end malls and warehouses. In four years of operation the size of the company has been growing from four to 13 people. Thanks to its awarded and patented product the SME is attractive to the investors to raise capital, but it has not been able to reach the planned turnover targets and is making loss. Scaling up the production is possible, but the market is still emerging – it seems the visibility of the product and timing of market entry are not optimal.

Table 9: Everyone deserves a garden

INNOVATION DRIVERS	INNOVATION APPROACH	MARKET STRATEGY	PERFORMANCE
Technology push: *IT controlled led lightning & growth system (patented).* **Market pull:** *There was not (yet) markets for product that consumer could control via mobile phone.*	***NPD:*** The product was designed by the founder. ***BMI:*** BM canvas and later Value proposition canvas was used. **Effectuation*:*** For expanding to international markets, they select the target cities/ countries by hunch, but want its viability affirmed by BM analysis before entry.	**New market:** *Novel, automated design product that was initially to be distributed via design shops, later switched to brand warehouses.*	**Survive**. *The company has not been able to reach the planned turnover targets and is making loss. The size of the company has increased from 4 (2013) to 13 (2015). SME is attractive to the investors.*

Survival cases can be found in all three market types (Table 10). In high-end market segment common to these survivals, is that they seem to have all the drivers, and all the implementation methods in use. Time may show whether these companies will fail or succeed.

Table 10: Survival cases

CASE	DRIVER	INNOVATION APPROACH	MARKET STRATEGY	PERFOR MANCE
MyFood	Technology, Market, Personal	NPD, BMI, Effectuation	High-end	Survival
Green wall	Technology, Market, Personal	NPD, BMI, Effectuation	High-end	Survival
Everyone deserves garden	Technology	NPD, BMI, Effectuation	New market	Survival
Plant in a bottle	Technology	NPD, Effectuation	High-end	Survival
Real estate management	Technology	NPD	Low-end	Survival
Smarp	Technology	NPD	Low-end	Survival
Bus tours	-	-	Low-end	Survival

5 Results

In this paper we utilized our framework to analyze 27 case SMEs. Ten failed, ten were successful, and seven were surviving cases.

Table 11: Success rate with and without BMI

CASES	BMI		NO-BMI		TOTAL
SUCCESS	8	47 %	2	20 %	**10**
SURVIVAL	3	18 %	4	40 %	**7**
FAILURE	6	35 %	4	40 %	**10**
	17	**100 %**	**10**	**100 %**	**27**

It seems that the utilization of BMI as an innovation approach improves the possibilities for success: 47% of cases using BMI succeed, compared to 20% when no BMI was used (see Table 11.). However, this result is not statistically significant and can not to be generalized to represent the whole industry. It indicates better changes for success where BMI is used, but BMI does not explain success of the innovation alone.

Technology seems to be the biggest driver in the whole set of cases (22 out of 27) which may be explained by the new business possibilities offered by technology as well as technology entrepreneurs being more active in participating these kinds of studies.

Yet, a typical failure case is where technology driven company is aiming at innovating something totally new (80% of failures). This assumingly happens because the product is something that perhaps customers do not (yet) know that they would need – or the company does not know who would be their customers. Even though the company utilized BMI in their implementation process, the end result is often a failure. An uncovered market, 'blue ocean' (Kim & Mauborgne, 2005), in reality is seldom reached.

On the other hand, majority of success cases in this study focused on low-end market and they combined at least two of the innovation approaches. Many of the success cases combined BMI and NPD approaches, but often also effectuation. Whereas the failure cases were heavily technology driven, the success cases had more drivers, 70% having two or three drivers. In six out of 10 success cases, the idea for the business came from the life or work experiences of the founder(s). The initial mind-set is product-centric and often with clearly altruistic mind-set of improving with technology the lives of the people, or their environment. Thus, it seems that successful innovations are driven by several drivers -not only technology, the SMEs typically combine BMI with NPD, but often also effectuation, and the aim is at low-end market.

The 7 survival cases seem to divide into two differing groups: three are aiming at low-end market. Of these, one is a company that did not want to innovate at all, but tried to keep the business on-going as it has been the last decades. The other two are technology driven innovations developed with NPD approach only. Based on our previous analysis of failure and success cases, our prediction is that these companies will eventually fail, unless they take into use also BMI approach.

The rest four survivals are attempting at high-end markets, and are driven not solely by technology, but also personal drivers. Three cases use all the three innovation approaches, but one relies only on NPD. Again, our prediction is that the last one will fail, unless NPD is enriched with other innovation approaches.

Last, looking at the all the 27 cases we can see a pattern that the more challenging the market (high-end or new market) the more drivers and innovation approaches are utilized. The idea of combining NPD, BMI and effectuation in complex markets seems to reflect the reality in the case companies mostly well.

6 Conclusions

This study investigated if BMI helps SME innovation to succeed. We analyzed 27 cases with differing combinations of Business Model Innovation (BMI), New Product Development (NPD) and effectuation methods. We categorized the cases in three groups according to the performance (success, survival, failure), and then analyzed their innovation process' drivers (technology push, market pull, personal), approaches (NPD, BMI, effectuation) and market strategies (low end, high end, new market).

We found that BMI does not explain success of the innovation alone, but the majority of success cases combined at least two of the innovation approaches, typically BMI and NPD approaches, but often also effectuation. Moreover, typically, successful innovations had a mixture of drivers – technology push, market pull and personal driver, and they focused on low-end market.

On the other hand, a typical situation leading to failure is when a technology driven company is aiming at innovating something to new markets. Our findings suggest that technology-driven innovations which are developed solely with NPD approach will probably lead to failure.

Our results indicate that by combining BMI and NPD – and preferably also effectuation - the innovation has better probability to succeed. It supports the recent literature that innovation projects should combine technology development with business modelling approach (Heikkilä et al., 2015). Interestingly, effectuation has resemblance with recent lean start-up ideologies (Ries, 2011), where the main argument is that it is rational to test and iterate, because it eventually leads - through an unpredictable groping process - to rational goal.

Based on the results we can make three recommendations for small firms. First, we believe that SMEs should systematically develop their competences in both BMI and NPD. Second, companies should always incorporate BMI approach also into traditional technology innovation projects. This ensures that they are better aware of the business possibilities and, when needed, are able to refocus their development efforts. Third, it is important for SMEs to notice that BMI can also help in redefining the target market strategy. Considering the limited resources available in SMEs, it is understandable why SMEs are more successful in *Low-end market* innovations, where the products are less complex and require fewer specific resources.

Further research is needed to analyze the differing combinations of innovation approaches and study how firms could achieve better performance. In addition, we should study what kind of innovation process and tools support both NPD and BMI, and whether there is a way to explicitly embed effectuation in the innovation processes at SMEs.

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SMEs business model innovation: does enterprise size matter?

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Abstract This paper extends previous studies on micro, small, and medium-sized enterprises (SMEs) perspective on business model innovation (BMI) by analysing the differences in opinions between SMEs of different sizes regarding the drivers of BMI and the level of BMI. Based on the literature review the hypotheses were developed. Results demonstrate that there are significant differences in opinion in SMEs of different sizes about the importance of environment and innovation as BMI drivers, while there were no significant differences in opinion about the importance of technology as BMI driver. In addition, the results show that there are significant differences between SMEs of different sizes about the level of BMI.

Keywords: • Business Model Innovation • Drivers • Small and Medium Enterprise • Differences • SMEs •

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1 Introduction

The rapid development of digital technologies is causing disruptive changes in business and our lives (Raskino & Waller, 2015). The exploitation of digital technologies leads enterprises to digital transformation. Digital transformation reflects the ability of the enterprise to redesign business activities, its competencies and business models (BM).

Business model innovation (BMI) is one of the key activities that has to be continuously undertaken in every enterprise to achieve competitiveness in the digital economy (Hanelt, Hildebrandt, & Polier, 2015). In such a disruptive environment no static business model can survive. Every enterprise has to continuously evaluate, re-think, re-design and innovate the way how value is created, captured and delivered (Amit & Zott, 2012; Florén & Agostini, 2015; Teece, 2010; C Zott & Amit, 2009).

BMs have started to raise the interest of researchers and practitioners in 1990s (Morris, Schindehutte, Richardson, & Allen, 2006). Since then, a lot of research has been carried out in the field of BM design and innovation. Several researchers have indicated that BMI contributes to business performance (Bouwman, Nikou, Molina-Castillo, & de Reuver, 2018; Casadesus-Masanell & Zhu, 2013). Nevertheless, many enterprises still lack the awareness and knowledge for a systematic approach towards business model design and innovation (Casadesus-Masanell & Ricart, 2010; Florén & Agostini, 2015; Giesen, Berman, Bell, & Blitz, 2007; Heikkilä, Bouwman, & Heikkilä, 2018).In the past, most of the research has been carried out and focused on large enterprises. Only recently more emphasis has been given to micro, small and medium-sized enterprises (SMEs), which represent 99% of the European marketplace and are key potential for economic growth, innovation and employment (European Commission, 2014).

Recent research indicates that most SMEs do not have a formal strategy when engaging in a BMI process (Lindgren, 2012) and typically experience BMI as a necessity to remain competitive (Laudien & Daxböck, 2017). Still, it is relatively unclear how SMEs actually innovate their BM (Carayannis, Sindakis, & Walter, 2014; Foss & Saebi, 2017) and how this improves business performance. Furthermore, the role of size when investigating BMI in SMEs has received less attention. While there are differences in behaviour towards innovation between large enterprises and SMEs (Vaona & Pianta, 2008), there might also be differences between micro, small, and medium-sized enterprises, especially because innovation increases with enterprise size (De Mel, Mckenzie, & Woodruff, 2009; Forés & Camisón, 2016).

The purpose of the study was to investigate whether there are any significant differences in opinions between enterprises of different sizes (micro, small and medium-sized) about 1) drivers that influence BMI and 2) level of BMI. The study has been carried out in 71 SMEs in Slovenia, engaged with BMI, in the years 2016 and 2017.

The remaining of the paper is organized as follows. First, we present a literature review that led towards the formulation of hypotheses. Next, the research methodology is presented, which is followed by the presentation of research results. Finally, discussion and conclusion are presented.

2 Literature review and hypotheses

In general, BM refers to a representation of firm's logic to create, distribute and capture value for its stakeholders (Bouwman, Zhengjia, Duin, & Limonard, 2008; Chesbrough & Rosenbloom, 2002). In this paper, we define BM as a description of how an enterprise or network of enterprises intends to create and capture value for both, (networked) enterprises and the customers (Bouwman, Vos, & Haaker, 2008). The BMI is defined as the activity-based perspective of BM, resulting in a change in an enterprise's BM that is new to the world or just new to the enterprises under analysis (Christoph Zott & Amit, 2010).

2.1 External and internal drivers

Drivers influencing BMI have been discussed in several studies. According to Foss & Saebi (2017) and Andreini & Bettinelli (2017), drivers of the BMI can be internal as well as external.

Among the external drivers, environment and technology were investigated several times in recent studies. Environment, consisting of competitive intensity (Jaworski & Kohli, 1993) and market turbulence (Jaworski & Kohli, 1993) was identified as an important component that drives BMI. Furthermore, rapid development of technology in recent years has also been identified to have a profound impact on business. For example, Bouwman et al. (2018) pointed out that technology turbulence has a direct impact on BMI, which influences the overall performance.

Innovation is an organizational driver that defines enterprises' ability or capacity to introduce new processes or new products/services in the enterprise (Hult, Hurley, & Knight, 2004). A positive relationship between innovation activity and BMI was already indicated by Bouwman et al. (2018).

2.2 Level of BMI

Several authors have provided different BM ontologies e.g. BM Canvas (Osterwalder & Pigneur, 2010), STOF (Bouwman, Faber, Haaker, Kijl, & De Reuver, 2008), and VISOR (El Sawy & Pereira, 2013) to name a few. The most widely known BM ontology is the BM canvas (Osterwalder & Pigneur, 2010). This ontology consists of nine building blocks, including value proposition, key partners, key resources, key activities, customer relationship, communication and distribution channels, customer segmentation, revenue streams, and cost structure. These components or at least some of them have been studied many times in the different contexts of BMI (Haaker, Bouwman, Janssen, & de Reuver, 2017; Hartmann, Zaki, Feldmann, & Neely, 2016). Some of the results have shown that BMI causes changes in BM components (e.g. Lambert & Davidson, 2013; C. Zott, Amit, & Massa, 2011).

Level of BMI has been measured in various ways. For instance, Clauss (2017) provided a hierarchical tree-level scale for measuring BMI. Another valuable conceptualisation is provided by Foss & Saebi (2017), who considered two different perspectives of BMI: scope and novelty. The scope dimension is characterized by architectural and modular changes of BM while novelty dimension describes BM changes as novel to an enterprise or an industry. The novelty dimension seems to play an important role as the existing literature on BMI argue that enterprises can become successful by introducing new business models (Teece, 2010; Christoph Zott & Amit, 2007).

2.3 SMEs and size

SMEs play a major role in the European economy and operate in almost every industry sector. There are different definitions of SMEs. According to OECD (2005), SMEs are non-subsidiary, independent enterprises which employ up to 250 employees in the European Union. In other countries like Australia threshold is at 200 employees, while the United States threshold is 500 employees (OECD, 2005). Besides the number of employees, annual sales turnover, and balance sheet total are commonly used to distinguish SMEs and large enterprises (Ayyagari, Beck, & Demirguc-Kunt, 2007). For instance, according to the European Commission, SMEs are defined by a number of employees and/or turnover or balance sheet total (million €). While the turnover or balance sheet total criteria are frequently treated as confidential by enterprises this can result in misleading classification (Grandon & Pearson, 2004). Therefore, this study will define SMEs as an enterprise with fewer than 250 persons employed.

Enterprise size has long been considered as one of the most important influential variables (Chelliah, Pandian, Sulaiman, & Munusamy, 2010) as it reflects the different characteristics and capabilities of enterprises. In recent studies, size was usually used as an independent variable (e.g. Shefer & Frenkel, (2005)) or as variable that moderates the relationship between different constructs (e.g. Leal-Rodríguez, Eldridge, Roldán, Leal-Millán, & Ortega-Gutiérrez, (2015); Uhlaner, van Stel, Duplat, & Zhou, (2013)).

2.4 Hypotheses

External drivers, such as technological development (Henry Chesbrough, 2010) or competitive imitation (Casadesus-Masanell & Zhu, 2013), have an effect on BMI. This external conditions may provide extra challenges for micro-enterprises, which do not have as many resources as small and medium-sized enterprises. Following the logic of the size differences, the following hypotheses were formulated:

H1: There are significant differences in opinion about the importance of environment as a BMI driver according to the SMEs size.

H2: There are significant differences in opinion about the importance of technology as a BMI driver according to the SMEs size.

Innovation is another driver that has been identified to have an effect on the level of BMI (Bouwman et al., 2018). Larger enterprises are likely to have more available human resources, which results in a greater management capacity, while in smaller enterprises the owners/managers have more influence on the staff which enables enterprises to react to the market demands faster (Uhlaner et al., 2013). Following that logic, the following hypothesis was formulated:

H3: There are significant differences in opinion about the importance of innovation as a BMI driver according to the SMEs size.

Internal and external BM drivers are constantly changing, resulting in either incremental or radical changes (Bucherer, Eisert, & Gassmann, 2012). There are mixed result regarding how the enterprise size effects radical and incremental innovation (Forés & Camisón, 2016). Nevertheless, the majority of research (e.g. Forsman & Annala, (2011); Laforet, (2013)) state that there are differences between enterprises of different sizes. Following the logic of the size differences, the following hypothesis was formulated:

H4: There are significant differences in opinion about the importance of BMI level according to the SMEs size.

3 Methodology

The empirical data for this paper were collected by a questionnaire in the scope of Horizon 2020 ENVISION project. The questionnaire consisted of several questions regarding BM and BMI, including BMI drivers, type of innovations, changes of BM, methods, and tools used for BM, and BMI outcomes. Data were collected through a professional research agency based in the Netherlands. The survey has been conducted in 11 countries (Netherlands, France, Finland, Austria, Italy, Lithuania, Poland, Portugal, Slovenia, Spain, Sweden). The SMEs were randomly selected from the Dun and Bradstreet database that collects data on enterprises on a regular basis from Chambers of commerce and other organizations. Respondents were collected in 2016 and 2017 from owners or managers who are involved in BMI, innovation or business development. A seven-point Likert-type scale (1 = totally disagree, 7 = totally agree) was used to measure the enterprise's level of agreement with a given statement. Every surveyed enterprise was categorized according to a number of employees into one of the following categories: micro enterprises (1 – 10 employees), small enterprises (11 - 50) and medium enterprises (51 to 249 employees).

In this paper, only the data from SMEs in Slovenia that were already engaged in BMI were considered. 71 valid responses were utilized for the statistical analysis using SPSS software. Based on the initial research model proposed by Marolt, Lenart, Kljajić Borštnar, Vidmar, & Pucihar (2018) we calculated means for all components of model variables to form constructs for further analysis of differences among groups of different size SMEs by using one way ANOVA analysis with Tukey post hoc test. All statistical tests were calculated with .05 confidence interval for statistically significant differences.

4 Results

In total 71 valid responses from SMEs in Slovenia were analysed, from which 28 were micro enterprises, 26 small enterprises, and 17 medium enterprises. The basic descriptive statistics are presented in Table 1 and Table 2.

Table 1: Descriptive statistics of model components by the enterprise size

	Micro (N=28)		Small (N=26)		Medium(N=17)	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
Environment						
Competitors offer similar products/services	3.68	2.038	3.58	1.880	4.76	1.562
Competitor's reactions to your enterprise initiatives	3.32	1.806	4.00	1.575	4.76	1.888
Frequently changing customer preferences	3.29	1.941	3.69	1.668	4.35	1.539
Technology						
Rapid changing technology	3.64	1.890	4.04	1.637	4.47	1.546
Rapid increasing technological development	3.82	1.945	3.73	1.458	4.47	1.281
Innovation						
Corporate culture is focused on constant innovation	4.61	1.750	4.69	1.644	4.82	1.131
Enterprise aims to create multiple innovations annually	4.11	2.025	4.04	1.732	4.94	1.345
Enterprise introduce innovations that are completely new to the market	3.36	2.094	2.38	1.388	4.47	1.463
Creating more than one innovation at the same time is common practice in enterprise	3.11	1.771	3.38	1.941	4.06	1.435
Enterprise is one of the first to introduce innovations	2.79	1.853	2.96	1.755	4.12	1.833
Level of BMI						
Enterprise made changes in your business model that were new to their industry	2.96	1.953	2.85	1.461	4.88	1.616

Enterprise made changes in your business model that have never been implemented by competitors before	2.21	1.686	2.12	1.862	3.12	1.453
Enterprise made changes in your business model that cannot be found in their industry	2.75	1.818	3.73	2.308	3.76	1.640

Table 2: Descriptive statistics of model variables by the enterprise size

		N	Mean	Std. Dev.	Std. Error
Environment	Micro	28	3.43	1.512	0.286
	Small	26	3.76	1.291	0.253
	Medium	17	4.63	1.269	0.308
	Total	71	3.84	1.437	0.171
Technology	Micro	28	3.73	1.853	0.350
	Small	26	3.88	1.451	0.285
	Medium	17	4.47	1.293	0.314
	Total	71	3.96	1.595	0.189
Innovation	Micro	28	3.59	1.502	0.284
	Small	26	3.49	1.137	0.223
	Medium	17	4.48	1.003	0.243
	Total	71	3.77	1.314	0.156
Level of BMI	Micro	28	2.64	1.463	0.276
	Small	26	2.90	1.546	0.303
	Medium	17	3.92	1.239	0.301
	Total	71	3.04	1.513	0.180

Results in Figure 1 show that medium-sized enterprises have generally higher positive opinion on all examined model variables. Furthermore, the examined variables do not substantially differ between micro and small enterprises.

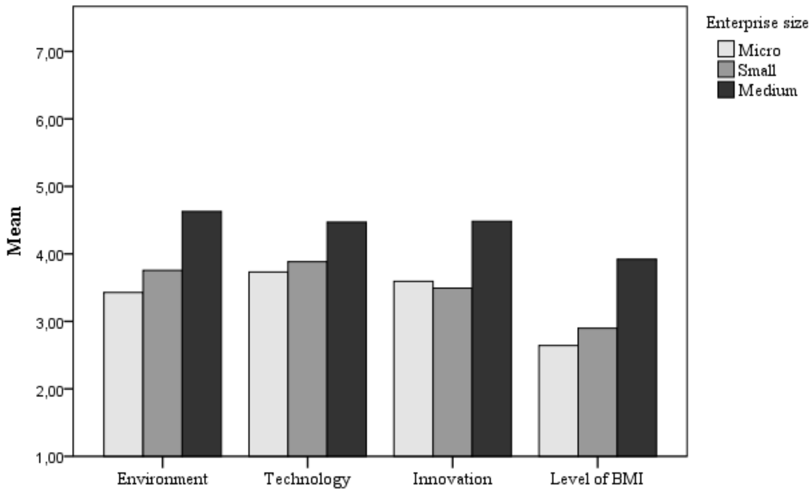

Figure 7: Average mean value of variables by the enterprise size

A one-way ANOVA was conducted to identify the differences in opinions of the enterprises of different sizes on analysed BMI drivers and level of BMI. The results showed that there are significant differences in opinions between enterprises of different sizes on the environment as BMI driver at the $p<0.05$ level [F(2.68) =4.069, p =0.021]. Furthermore, results showed that there are also significant differences in opinion of enterprises of different size on innovation as BMI driver at the $p<0.05$ level [F(2.68) =3.579, p =0.033] and on the level of BMI at the $p<0.05$ level [F(2.68) =4.346, p =0.170].

The results have supported three out of four hypotheses:

H1: There are significant differences in opinion about the importance of environment as a BMI driver according to the SMEs size – supported.
H2: There are significant differences in opinion about the importance of technology as a BMI driver according to the SMEs size. – not supported.
H3: There are significant differences in opinion about the importance of innovation as a BMI driver according to the SMEs size – supported.
H4: There are significant differences in opinion about the importance of BMI level according to the SMEs size – supported.

Furthermore, differences in opinion of enterprises of different sizes were analysed with Tukey post hoc test. Results are presented in Table 3.

The Tukey test indicated that the mean value of the importance of environment as BMI driver for micro enterprises (M = 3.43, SD = 1.512) was significantly lower than in medium-sized enterprises (M = 4.63, SD =1.269). However, the mean value of the importance of environment as a BMI driver in small enterprises (M = 3.76, SD = 1.291) did not significantly differ from the micro or medium enterprises.

Table 3: Post hoc Tukey HSD analysis of differences between enterprise size

Model Variable	(I) Company size	(J) Company size	(I-J) Mean Diff.	Std. Error	Sig.
Environment	Micro	Small	-0.33	0.375	0.659
		Medium	-1.19*	0.424	0.017
	Small	Micro	0.33	0.375	0.659
		Medium	-0.87	0.430	0.114
	Medium	Micro	1.19*	0.424	0.017
		Small	0.87	0.430	0.114
Technology	Micro	Small	-0.15	0.433	0.934
		Medium	-0.74	0.489	0.293
	Small	Micro	0.15	0.433	0.934
		Medium	-0.59	0.496	0.469
	Medium	Micro	0.74	0.489	0.293
		Small	0.59	0.496	0.469
Innovation	Micro	Small	0.10	0.345	0.954
		Medium	-0.89	0.390	0.065
	Small	Micro	-0.10	0.345	0.954
		Medium	-.99*	0.396	0.039
	Medium	Micro	0.89	0.390	0.065
		Small	.99*	0.396	0.039
Level of BMI	Micro	Small	-0.25	0.394	0.795
		Medium	-1.28*	0.444	0.015
	Small	Micro	0.25	0.394	0.795
		Medium	-1.02	0.451	0.067
	Medium	Micro	1.28*	0.444	0.015
		Small	1.02	0.451	0.067

The mean value of the importance of technology as a BMI driver did not significantly differ among groups of enterprises. Furthermore, the mean value of importance of innovation as BMI driver for small enterprises (M = 3.49, SD =

1.137) was significantly lower than in medium-sized enterprises (M = 4.48, SD =1.003). However, the innovation as BMI driver in micro enterprises (M = 3.59, SD = 1.502) did not significantly differ from small or medium enterprises. Largest differences for all examined model variables were revealed by comparing opinions about the level of BMI in micro enterprises (M = 2.64, SD = 1.463) against medium-sized enterprises (M = 3.92, SD =1.239).

5 Discussion and conclusions

The results of our study show that there are significant differences in opinions of enterprises of different sizes about the drivers for BMI and level of BMI. In average medium-sized enterprises estimate the importance of environmental, technological and innovation drivers for BMI as more important than small and micro-enterprises.

Significant differences were found in opinions of micro and medium-sized enterprises for environmental drivers and between small and medium-sized enterprises for innovation drivers. Medium sized enterprises perceive environment factors as more important (4.63) compared to micro enterprises (3.43). As SMEs are dependent on inter-organizational relationships (Brunswicker & Vanhaverbeke, 2015) we can emphasize that smaller enterprises are more dependent on their value networks and as such has fewer needs and possibilities to experiment with BMI. Results have shown that medium-sized enterprises perceive innovation factors as more important (4.48) compared to small enterprises (3.49). These results are aligned with expectations. Smaller enterprises in most cases have less available resources to focus on additional activities besides their core business, which is also the case of BMI activities. Concerning the level of BMI, there were significant differences in opinions of micro enterprises (2.64) compared to medium-sized enterprises (3.90). These results are also related to limited capabilities and resources to support BMI activities in micro and small enterprises. It is interesting that there were no significant differences in opinions found for the technology driver, although medium-sized enterprises estimate technology as a more important driver (4.47) compared to small (3.88) and micro enterprises (3.73). However, although technology has an important role in BMI activities as enabler and supporter, without a proper strategy, systematic approaches, appropriate methods and tools used, there will be no significant results.

Although the study has confirmed the significant impact of enterprises size on the importance of environment and innovation BMI drivers and BMI level, it also has its limitations, which suggest directions for further research. For a better understanding of the impact of enterprise size on BMI drivers, further analysis should be done on the level of individual factors. Since only 71 enterprises with previous BMI experiences were included, further research should obtain larger data sets to obtain more reliable results with greater precision. Furthermore, it would also be interesting to combine the study with in-depth interviews, which would offer more understandings of BMI practices in successful SMEs.

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Impact of Green IS Practices on Organizational Benefits: The Perspective of SMEs Managers

ALENKA BREZAVŠČEK, ANJA ŽNIDARŠIČ, MATJAŽ MALETIČ & ALENKA BAGGIA

Abstract The presented study investigates the impact of Green information system (Green IS) practices on organizational performance benefits in the context of a small and medium-sized enterprise (SME). Three categories of Green IS practices, namely pollution prevention, product stewardship and sustainable development are taken into consideration. Furthermore, organizational benefits are considered to capture the extent to which SMEs achieve environmental and social performance. Partial Least Squares Structural Equation Modeling (PLS-SEM) was used to analyse survey data collected from 156 managers of SMEs. The results indicate, that Green IS for pollution prevention and sustainable development have a significant impact on environmental and social performance, while product stewardship is not an effective source of perceived organizational benefits in neither of the proposed aspects. To achieve a higher level of organizational benefits arising from Green IS practices, more focus should be given to the strategic orientation of using Green IS in SMEs. From an academic perspective, the paper enhances the current knowledge in investigating the link between Green IS practices and organizational benefits, particularly in the SMEs perspective.

Keywords: • Green IS practices • Organizational benefits • Environmental performance • Social performance • Green IS •

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1 Introduction

Recently, several environmental and sustainability studies have suggested that smart use of information technology (IT) and information systems (IS) can substantially help greening the planet (Chen, Boudreau, & Watson, 2008; Melville, 2010). The role of smart use of IT/IS in contributing to environmentally responsible human activity has been widely discussed in the literature, whereas the terms Green IT and Green IS have often been used interchangeably, synonymously, and/or without acknowledging the differences (Recker, 2016b). Among others, Loeser (2013) precisely distinguishes the scopes of Green IT and Green IS, describing the concepts as follows:

- The Green IT concept refers to measures and initiatives that lower the negative environmental impact of manufacturing, operations, and the disposal of IT equipment and infrastructure.
- The Green IS concept refers to practices which determine the investment in, deployment, use, and management of IS in order to minimize the negative environmental impacts of IS, business operations, and IS-enabled products and services.

This paper focuses on the concept of Green IS which is more far-reaching and wider concept than Green IT (Loeser, 2013). Due to the substantial possible benefits of applying Green IS initiatives, this area has attracted the attention of many authors. However, an in-depth literature review (see Baggia, Maletič, Žnidaršič, & Brezavšček, 2019) reveals a lack of research referring the implementation of Green IS by small and medium-sized enterprises (SMEs). We tried to mitigate this gap and we developed a conceptual model to investigate the drivers and outcomes of Green IS adoption in SMEs environment (Baggia et al., 2019). We based our model on the Belief Action Outcome (BAO) framework (Melville, 2010), while the viewpoint of SMEs management were taken into account. The main contribution of this model lies in establishing a link between personal attitudes, institutional mechanisms, internal environmental/sustainability initiatives, and performance implications towards Green IS in SMEs.

Among other results, the model presented in Baggia et al. (2019) enables a direct analysis of perceived organizational benefits due to implementation of different categories of Green IS practices: Green IS for pollution prevention, Green IS for product stewardship, and Green IS for sustainable development. The results obtained reveal that Green IS for preventing pollution and sustainable development can be treated as an effective source of perceived organizational benefits, while the impact of Green IS for product stewardship was not recorded to be significant. Within the present study, we want to continue our work and investigate these relationships in detail. For this purpose, we distinguished the organizational benefits due to Green IS practices implementation into two aspects: environmental performance and social performance. We analysed the perceived impact of a particular category of Green IS practices on each aspect. Similarly as in Baggia et al. (2019) the viewpoint of SMEs' managers was taken into account. Accordingly, this study's research objective is to fill in this gap in the literature by carrying out an empirical research among SMEs managers. Therefore, in response to identified conceptual and empirical dispersion, this paper intends to propose a framework to formulate the hypotheses that build on a premise of positive impact of Green IS practices on specific organizational performance dimensions.

2 Literature Review

2.1 From Green IS Initiatives through Green IS Practices to Organizational Benefits

Green IS represents any kind of IS that assists individuals and organizations in making environmentally sustainable decisions and establishing environmentally sustainable work practices rather than environmentally unsustainable ones (Recker, 2016a). The primary focus of Green IS initiatives is therefore on designing and implementing systems to support environmental management processes (Watson, Boudreau, Chen, & Huber, 2008). (Loeser, Recker, Brocke, Molla, & Zarnekow, 2017) understand Green IS initiatives as a wide range of IS-related environmental actions, including the formulation of Green IS strategies, which should be translated into sustainability actions through different Green IS practices.

According to Chen, Watson, & Karahanna (2009) or Gholami, Sulaiman, Ramayah, & Molla (2013) the Green IS practices can be classified into three categories: Green IS practice with a focus on pollution prevention, Green IS practice with a focus on product stewardship, and Green IS practice with a focus on sustainable development. Green IS practices focusing on pollution prevention refer to the innovation and use of information systems (such as enterprise carbon and energy management systems) to reduce pollution generated by business operations. Green IS practices focusing on product stewardship refer to the innovation and use of IS (such as enterprise digital platforms and communication and collaboration systems) that enhance the environmental friendliness of upstream and downstream supply chains (Chen et al., 2009; Gholami et al., 2013). Moreover, Green IS practices focusing on sustainable development refer to the innovation and use of IS that transform business operations (Gholami et al., 2013; Ijab, Molla, & Cooper, 2012).

The implementation of Green IS practices leading from Green IS initiatives can bring many positive outcomes to organization. For example, Loeser et al. (2017) reported that Green IS initiatives **can generate at least three types of benefits:**

- reduce costs by increasing the resource efficiency of IT infrastructure resources and organization-wide business processes;
- enhance corporate reputation by shrinking the organization's environmental footprint while providing tools for tracking and reporting environmental performance; and
- facilitate and improve organizational capabilities for green product and process innovations, which can result in long-term organizational advantages.

2.2 Green IT/IS Initiatives in SMEs

Since SMEs make up for approximately 99% of all enterprises and two-thirds of employment in the OECD area (OECD, 2015), they account for a significant share of pollution. According to Miller, Neubauer, Varma, & Williams (2011), SMEs account for approximately 64% of industrial pollution in Europe. Walker, Redmond, Sheridan, Wang, & Goeft (2008) also asserted that SMEs are more 'pollution-intensive' than 'big business', with some estimates suggesting that the contribution of SMEs may be as high as 60-70% of global environmental pollution. This statements are in accordance with findings of Shah, Ganji, & Hasan (2016) who reported that SMEs share 70% of global pollution, with the majority of manufacturing sector. Therefore, reducing the environmental impact of SMEs in both manufacturing and services is a key factor in successfully greening the economy (OECD, 2015). A systematic overview of the abundant literature on sustainability initiatives in SMEs found several studies addressing the general green practices for improving SME business in a sustainable way (e.g. Hernandez-Pardo, Bhamra, & Bhamra, 2013; Kerr, 2006; Verdolini, Bak, Ruet, & Venkatachalam, 2018), while some authors (e.g. Álvarez Jaramillo, Zartha Sossa, & Orozco Mendoza, 2018) analysed the barriers faced by SMEs when implementing initiatives for sustainable development. Some studies also investigate the importance and drivers to environmental, green, or sustainable SMEs' innovations in a specific environment (e.g. the food and beverage sector (Cuerva, Triguero-Cano, & Córcoles, 2014); French SMEs (Pinget, Bocquet, & Mothe, 2015); European SMEs (Cecere & Mazzanti, 2017); Ecuador SMEs (Sarango-Lalangui, Álvarez-García, & Del Río-Rama, 2018); Malaysia SMEs (Moorthy, Yacob, Chelliah, & Arokiasamy, 2012; Musa & Mohamad, 2018; Yacob & Moorthy, 2012); Southern Brazil (Schmidt, Zanini, & Junior, 2018)) while Masocha & Fatoki (2018) discuss the impact of coercive pressure on sustainability practices of SMEs.

However, although the SMEs are important drivers of global sustainability, they are not addressed sufficiently in the Green IT/IS literature. SMEs differ from larger companies, since they generally face size-related resource constrains, skill deficit and knowledge limitations (OECD, 2015). They also express different behaviour when adopting new technologies (Gäre & Melin, 2011). Therefore, the existing research based on large companies cannot be directly transferred to SMEs. We found only a few papers which examined the drivers of Green IT adoption in SMEs in different countries all over the world (e.g. Czech (Buchalcevova & Gala, 2012, 2013), Philippines (Hernandez, 2018), Indonesia (Muafi, 2015), New Zealand (Coffey, Tate, & Toland, 2013)). Ramayah, Siew, Ahmad, Halim, & Lo (2013) developed a structured questionnaire to explore the views and issues of SMEs, who have already implemented Green IT practices, while the research of Daggag (2014) points at increasing awareness regarding the advantages and limitations on Green IT provides guidelines for its utilization. In addition, Foogooa & Dookhitram (2014) proposed a useful Green IT maturity assessment tool for SMEs.

The literature review reveals again that the area of Green IS adoption and/or the outcomes of Green IS evaluation in the SME environment remain rather unexplored. Unfortunately, with the exception of our studies (Baggia et al., 2016) and recently published (Baggia et al., 2019) we were unable to find any paper concerning Green IS adoption and/or the outcomes of Green IS initiatives and practices in the SME environment.

3 Research Model

As proposed in work of Baggia et al. (2019), the meaningful organizational benefits arising from Green IS initiatives are: lower waste and emissions (Bokolo, 2016; Gholami et al., 2013; Loeser, 2013; Melville, 2010), reduced energy consumption (Bokolo, 2016; Gholami et al., 2013), a higher level of social responsibility (Cuerva et al., 2014; Deng & Ji, 2015), a greater level of employees' environmental awareness (Brooks, Wang, & Sarker, 2012), and an improved company image (Gholami et al., 2013; Loeser et al., 2017). We also assumed that these benefits can be achieved through implementation of different categories of Green IS practices (see Section 2.1):

- **Green IS for pollution prevention** which includes the use of software to reduce overall emissions, waste and hazardous materials,
- **Green IS for product stewardship** which enhanced the use of software to enable environmentally friendly material sourcing and acquisition, product/service development, distribution and delivery,
- **Green IS for sustainable development**, which promotes the adoption of software to transform business.

In order to analyse the perceived organizational benefits due to implementation of different categories of Green IS practices more in detail we distinguished the construct "Organizational Benefits" from the model presented in Baggia et al. (2019) in two separated constructs as follows:

- **Environmental performance**, which may result in reduction of waste, reduction of emissions and/or energy consumption,
- **Social performance**, which can express in better company image, higher level of social responsibility as well as environmental awareness.

To investigate whether the SMEs' managers actually perceive the positive impact of Green IS practices on both aspects of organizational performance the following hypotheses are proposed:

H_{1a}: Green IS for pollution prevention is positively associated with environmental performance.
H_{1b}: Green IS for pollution prevention is positively associated with social performance.
H_{2a}: Green IS for product stewardship is positively associated with environmental performance.
H_{2b}: Green IS for product stewardship is positively associated with social performance.
H_{3a}: Green IS for sustainable development is positively associated with environmental performance.
H_{3b}: Green IS for sustainable development is positively associated with social performance.

The corresponding research model is shown in Figure 1.

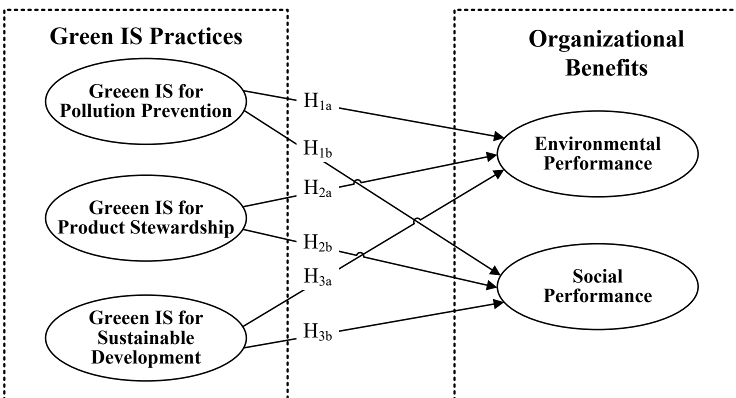

Figure 1: The research model

4 Results

4.1 Data Collection and Statistical Methods

To evaluate the model presented in Figure 1, we developed a questionnaire (Baggia et al., 2019) where every model construct was represented by several indicators (i.e., questions). The list of measured indicators used in this study is given in Table 1. All of them were measured on a 5-point, Likert-type scale of agreement, with 1 meaning strongly disagree, and 5 strongly agree.

In the survey, 156 Slovenian SMEs participated. They come from different areas (classified according to Eurostat (2008)), where the major portion of them (14.1%) are from Other Service Activities, 11.4% from Information and Communication, and 8.7% from Manufacturing. Regarding the respondents' position, 20.8% of them were CEOs, 20.1% heads of departments, 13.2% CIOs, 4.2% external IS consultants, while 41.7% of the respondents listed another job position.
The model from Figure 1 was evaluated using the PLS-SEM approach with R package plspm (Chin, 2010; Henseler & Sarstedt, 2013; Sanchez, 2013). The analysis was performed using the standard two-stage approach, where firstly the measurement model and, secondly, the structural model were evaluated (Sanchez, 2013). The PLS-SEM results are presented with the values of the path coefficient (representing the relationships between the model constructs) together with the values of *t*-statistics and the significance level. Besides, for the endogenous latent variables a coefficient of determination (R^2) was calculated, representing the percentage of the variance explained by the set of the variable predictors.

4.2 Descriptive statistics

The results of descriptive statistics for the model constructs and corresponding indicators are given in Table 1.

Table 1: Descriptive statistics for the model constructs and corresponding indicators

Model construct	Indicator	*M*	*SD*
Pollution Prevention (PP) ***M*=3.835** ***SD*=0.792**	***Our company promotes the use of software for:***		
	reduction of emissions (PP1)	3.776	0.913
	reduction of waste (PP2)	3.885	0.894
	reduction of dangerous and toxic materials (PP3)	3.846	0.903
Product Stewardship (PS) ***M*=3.697** ***SD*=0.788**	***Our company promotes the use of software to enable environmentally friendly:***		
	material sourcing and acquisition (PS1)	3.679	0.872
	product development (PS2)	3.718	0.818
	product/service development process (PS3)	3.731	0.904
	distribution and delivery (PS4)	3.660	0.861
Sustainable Development (SD) ***M*=3.325** ***SD*=0.778**	***Our company promotes:***		
	the use usage of online collaboration tools to reduce travelling (SD1)	3.917	0.908
	employee teleworking (SD2)	2.878	1.177
	transformation of business processes to paperless (SD3)	3.667	0.946
	the use of tools to measure and follow environmental impact (SD4)	2.840	1.013
Environmental Performance (EP) ***M*=3.462** ***SD*=0.646**	***The perceived environmental performance due to Green IS practices implementation is:***		
	reduction of waste (EP1)	3.532	0.731
	reduction of emissions (EP2)	3.397	0.768
	reduction of energy consumption (EP3)	3.455	0.721
Social Performance (SP) ***M*=3.404** ***SD*=0.692**	***The perceived social performance due to Green IS practices implementation is:***		
	improved company image (SP1)	3.212	0.771
	higher level of social responsibility (SP2)	3.500	0.766
	higher level of environmental awareness of employees (SP3)	3.500	0.783

4.3 Evaluation of the Measurement Model

The measurement model can be evaluated in terms of the unidimensionality of the latent variables, convergent validity, and discriminant validity (Ravand & Baghaei, 2016). Results of measurement models evaluation are listed in Tables 2-4.

The unidimensionality of latent variables is assessed by Cronbach's alpha, composite reliability through Dillon–Goldstein's rho (both indices should exceed 0.7), and principal component analysis by examining the first two eigenvalues where the first one should be larger than 1 while the second one should be below 1. It can be seen from Table 2 that all the indices easily satisfy the threshold criterion and therefore the measurement model's unidimensionality can be proved.

The measurement model's convergent validity is achieved when the average variance extracted (*AVE*) (measuring the amount of variance captured by the model construct relative to the amount of variance attributable to measurement error) of each construct exceeds 0.5 (Fornell & Larcker, 1981) and the factor loadings of its indicators are above 0.7 (Ravand & Baghaei, 2016). Table 3 reveals that all the factor loadings are larger than 0.7. Moreover, Table 4 shows the values of *AVE* for all constructs exceed 0.5 (the smallest is for *SD* 0.580), indicating the model has high convergent validity.

The model's discriminant validity is examined in two ways: first, by analysis of the indicators' loadings and cross-loadings and, second, by comparing the value of the square root of *AVE* of each construct with the correlations between other constructs. To prove discriminant validity, the loadings of the indicators of a particular construct must be greater than the corresponding cross-loadings. It may be seen from Table 3 that this condition is fulfilled. Furthermore, the values of the square root of *AVE* for a particular construct must be greater than the corresponding correlations between other constructs (Fornell & Larcker, 1981). The correlations between the model's constructs are shown in the right panel of Table 4, while the values of the square root of *AVE* are given in the diagonal elements in the correlation matrix. It is evident from Table 4 that the values of the square root of *AVE* for a particular model construct are all greater than the interconstruct correlations. Therefore, also discriminant validity of all model constructs can be approved.

Table 2: Evaluation of the unidimensionality of latent variables

Latent variable	No. of indicators	Cronbach's alpha	Dillon-Goldstein's rho	1st eigenvalue	2nd eigenvalue
PP	3	0.850	0.909	2.310	0.455
PS	4	0.932	0.952	3.326	0.327
SD	4	0.768	0.852	2.363	0.653
EP	3	0.845	0.907	2.292	0.471
SP	3	0.875	0.925	2.415	0.512

Table 3: Loadings (in bold) and cross-loadings of the model constructs and their indicators

Model construct	Indicator	PP	PS	SD	EP	SP
PP	**PP1**	**0.895**	0.625	0.472	0.356	0.423
	PP2	**0.922**	0.623	0.439	0.358	0.368
	PP3	**0.809**	0.651	0.443	0.270	0.286
PS	**PS1**	0.619	**0.894**	0.474	0.311	0.347
	PS2	0.685	**0.930**	0.529	0.293	0.353
	PS3	0.649	**0.937**	0.532	0.262	0.302
	PS4	0.657	**0.885**	0.484	0.252	0.314
SD	**SD1**	0.355	0.421	**0.772**	0.323	0.361

	SD2	0.249	0.292	**0.761**	0.209	0.240
	SD3	0.406	0.429	**0.772**	0.314	0.255
	SD4	0.507	0.503	**0.754**	0.349	0.373
EP	EP1	0.381	0.305	0.275	**0.833**	0.736
	EP2	0.313	0.264	0.371	**0.879**	0.668
	EP3	0.296	0.238	0.408	**0.908**	0.745
SP	SP1	0.320	0.248	0.271	0.618	**0.771**
	SP2	0.376	0.342	0.413	0.791	**0.945**
	SP3	0.418	0.373	0.414	0.784	**0.962**

Table 4: Average Variance Extracted (*AVE*), square root of *AVE* (on the diagonal) and correlations among the model constructs

Model constr.	*AVE*	Correlations				
		PP	PS	SD	EP	SP
PP	0.769	**0.877**				
PS	0.831	0.716	**0.912**			
SD	0.585	0.513	0.554	**0.765**		
EP	0.764	0.378	0.308	0.402	**0.874**	
SP	0.805	0.416	0.363	0.415	0.820	**0.897**

4.4 Evaluation of the Structural Model and Hypotheses Testing

The structural model from Figure 1 was evaluated by estimating paths between the model constructs. Results from Table 5 show that 4 out of 6 hypotheses were supported, while 2 were rejected.

Table 5: Results of the structural model evaluation and hypotheses testing

Hypothesis	Path	Path coefficient	*t*-statistics	p-value	Hyp. supported	Sig. level
H_{1a}	PP → EP	0.253	2.388	0.0182	Yes	*
H_{1b}	PP → SP	0.257	2.464	0.0149	Yes	*
H_{2a}	PS → EP	-0.034	-0.308	0.7587	No	n.s.
H_{2b}	PS → SP	0.032	0.300	0.7644	No	n.s.
H_{3a}	SD → EP	0.290	3.269	0.0013	Yes	**
H_{3b}	SD → SP	0.265	3.037	0.0028	Yes	**

*$p<0.05$; **$p<0.01$; ***$p<0.001$

Figure 2 shows the evaluated structural model with significant and non significant path. The coefficient of determination R^2 is also calculated for both endogenous latent variables. This coefficient determines the model's predictive capability if its value is greater than 0.1 (Escobar-Rodriguez & Monge-Lozano, 2012). It can be seen from Figure 2 that in our case this requirement is fulfilled.

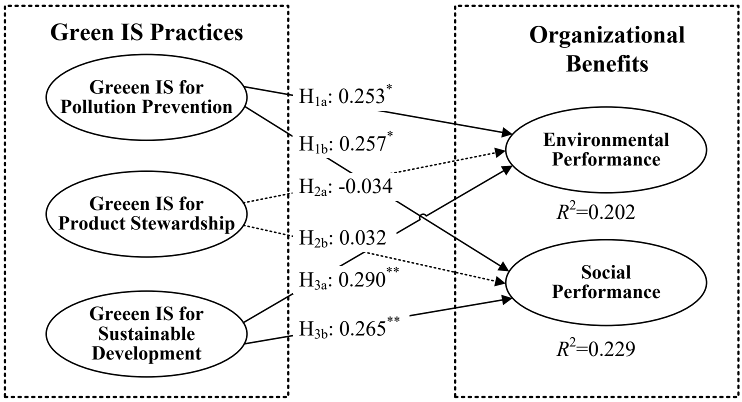

Figure 2: The evaluated relationships among the structural model constructs

5 Discussion & Conclusions

The key factor in greening the economy is the reduction of environmental impact of SMEs (OECD, 2015). Even though the majority of SMEs is struggling for survival on the competitive market, their environmental impact must not be overseen. Green IS are an appropriate tool to enable SMEs a smooth transition to sustainable practices. The findings of our study show the importance of Green IS practices adoption to general organizational benefits, as seen by managers. In addition to the multiplicity of factors influencing the perceived organizational benefits of Green IS usage in SMEs (Baggia et al., 2019), this paper extends the study with the detailed examination of relationships of Green IS practices and perceived organizational benefits. Aligned with this goal, perceived organizational benefits were categorized into two groups, namely benefits in environmental performance and benefits in social performance of the SME.

The proposed model was evaluated with PLS-SEM approach. The evaluation of the measurement model showed that the latent variables are unidimensional, the model has high convergent validity and the discriminant validity of all model construct is approved. According to the results, hypotheses H1a, H1b, H3a and H3b can be confirmed. Green IS for pollution prevention and Green IS for sustainable development have a significant impact on environmental, as well as social performance of an SME. Even though, it was anticipated that Green IS for product stewardship will affect at least a part of perceived organizational benefits, this is not the case. Similar as in Baggia et al. (2019), Green IS for product stewardship does not significantly impact perceived organizational benefits in environmental performance, nor in social performance. According to (Gholami et al., 2013), a short term orientation focuses on using IS for pollution prevention, and a strategic orientation focuses on using IS for product stewardship and sustainable development. Although we could not confirm the impact of Green IS for product stewardship on perceived environmental or social performance, it is evident from the model that SMEs do not focus only on short term orientation, but tend to extend their Green IS Practices also to the strategic orientation using Green IS for sustainable development. This shows a high potential that SMEs have in performing Green IS practices and further on in other sustainable practices.

This paper contribution is twofold: From an academic perspective, it enhances the current knowledge by investigating the performance implications of Green IS practices, especially by taking into account the SMEs perspective. From the managerial point of view, it is necessary to recognize the sustainable value creation as a result of behaviours and actions of an organization directed towards Green IS. As such, the results of our study demonstrate that SMEs could benefit from using IS to manage green and sustainable aspects. Therefore, the results of our study demonstrate that SMEs would benefit from efforts to create and maintain Green IS practices. Well-established techniques and strategies that help foster sustainable principles include product stewardship that aims to take responsibility for minimizing the product's environmental impact throughout all stages of the products' life cycle. The use of Green IS has a potential to stimulate the practitioners in SMEs to proactively focus on pollution prevention initiatives to reduce overall emissions, waste and hazardous materials, to reduce costs by using collaborating tools as well as to improve environmental friendliness of SMEs' processes. Although not directly addressed by the results of our study, it is necessary to emphasize the importance of stimulating the pro-environmental behaviour of employees in SMEs. Thus, managers in organizations should be aware of the important role they play in creating the climate that promotes employee green behaviours (Norton, Zacher, & Ashkanasy, 2014).

Limitations and Future directions

The Green IS topic has mainly gained attention among the research sector. Further research on Green IS should follow specific methodology (i.e. Action design research, Design Science Research) to enable the extension and promotion of research results to the economy sector. In addition, this research was focused to Slovenian SMEs, therefore it would be valuable to extend the research to other countries and compare results. It would also be useful to upgrade this cross-sectional study to a longitudinal study, to gain insights into the changes of behaviour caused by diverse activities, calls and actual data exposing the problem of climate change and general sustainability issues.

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mHealth Business Model Framework for the Maternal and Baby Segment: A Design Science Research Approach

CHRISTIANA MUELLER

Abstract mHealth applications are increasingly used to track, evaluate and store health data. Besides technological developments and acceptance of such mHealth services, a holistic understanding of the business model is required. A business model framework specific to the context of such mHealth services will support companies in developing holistic business models. In this research in progress, we present the development of a business model framework for mHealth services in the context of maternal and baby healthcare. The development of the framework is based on the design science research approach that supports the rigorous development of the framework. The initial business model framework as well as future steps are discussed. With the aid of the business model framework, companies will be able to design, evaluate and classify mHealth business models.

Keywords: • Business Model Framework • Mobile Health • Design Science Research • mHealth • Maternal and Baby Segment •

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1 Introduction

With technologies such as smartphones, wearables or mobile apps, digitization has made its way into the healthcare sector. EHealth and mobile Health (mHealth) applications and services can revolutionize the entire system of health and treatment. Young people are growing up with digital technologies and use apps for tracking and sharing information. This rising trend has led to 325,000 mHealth applications available in known App Stores in 2017 (Research2Guidance, 2017).

The World Health Organization (2011) classifies mHealth as sub-segment of eHealth and defines it as "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices". A large market has emerged in the health and fitness segment. mHealth interventions are used to track, store and evaluate data such as weight or eating habits (Gentner *et al.*, 2017). With the aid of these services, the patient takes a participatory role in diagnosis and treatment.

Companies that offer mHealth services emerge from diverse areas - from the classic medical and health sector, but also companies operating in the consumer goods industry. The latter in particular are entering the market with products in the health, wellness and fitness sectors. For the development of mHealth services and business models it is necessary to consider the context in which the services are operating (van Limburg *et al.,* 2011). That is why we have decided to examine mHealth business models specifically in the maternal and baby healthcare segment as a fast-growing market. MHealth interventions support pregnant women and young mothers in handling and caring for their babies. They tend to use various applications like specific apps, blogs or social media (Wallwiener *et al.,* 2016) to gain information, record different data or track babies' vital functions with the aid of a wearable device. It provides parents and parents to be with a peace of mind. (Lupton, 2016).

In their study, Nikou and Bouwman (2017) argue that in order to gain economic as well as public health value from mHealth services, companies need to move from the exploration phase (investigation) to an exploitation phase (utilization). Also Cameron *et al.* (2017) revealed that research on mHealth is scattered around topics like change in behavior, adoption of mobile applications in health or how mobile technologies can support prevention, diagnosis or patient care. But "the economic value of a technology remains latent until it is commercialized in some way" (Chesbrough, 2010, p. 354). Thus, more research on the business model of mHealth services is needed (Fielt *et al.*, 2008) in order to utilize such applications in a beneficial way (Nikou & Bouwman, 2017).

For the development of a business model, companies frequently use frameworks and patterns (Osterwalder & Pigneur, 2010; Gassmann *et al.,* 2014) providing a holistic view of the business model and supporting the development process. By now, research on business models of mHealth services neglects such a holistic view. Instead, the focus is on single aspects, like value creation or value capture. Furthermore, the actual value for the customer is also insufficiently emphasized – the value proposition of mHealth services needs to be presented more clearly. (Nikou & Bouwman, 2017). A business model framework with particular characteristics of mHealth services might overcome these issues.

Considering the request that a) more business model research is needed to utilize mHealth services in a beneficial way and b) to provide a holistic view on mHealth business models, the goal of our study is to *develop a business model framework for the design, evaluation and classification of mHealth business models* within the context of the maternal and baby healthcare. This research in progress paper presents the preliminary results of the developed business model framework based on the design science research approach.

2 Design Science Research as Research Method

Design science research (DSR) is increasingly used as a research method in management research (Sprenger & Mettler, 2016; Turber & Smiela, 2017). DSR seemed suitable for our research, as the goal is to develop a useful artefact to design, analyze or classify mHealth business models in the maternal and baby segment. Figure 1 provides an overview of our DSR approach, based on Pfeffers *et al.* (2007).

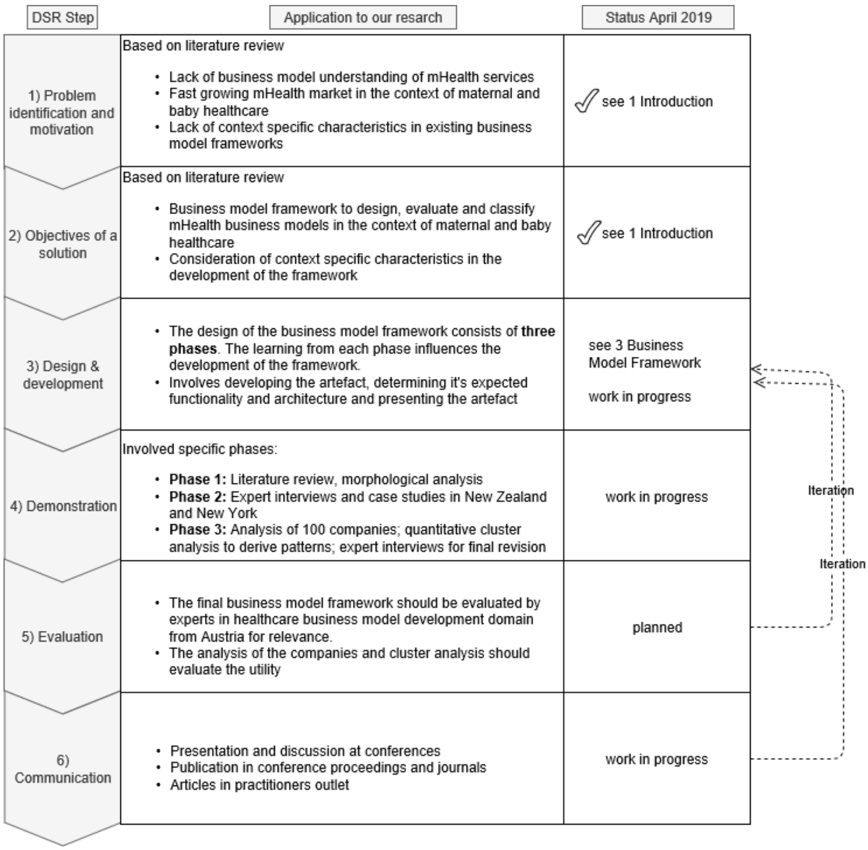

Figure 1: Design Science Research Process based on Pfeffers *et al.* (2007)

The steps one and two of the process were already discussed in the introduction. In the design and development phase, the business model framework is developed in three phases. In phase one, the business model framework, represented as a morphological box (the artefact), was iteratively developed based on literature research. For that reason, the morphological analysis is used as an overall method as it has proven as useful in developing a holistic understanding of business model elements in their specific contexts (e.g. Lee *et al.*, 2013; Peters *et al.*, 2015). The Framework is structured in dimensions consisting of several parameters and their specific characteristics. In phase two, case studies and expert interviews are used to review and adjust the framework if necessary. In phase three, the usability of the framework is demonstrated by applying the framework to 100 companies offering mHealth services in the maternal and baby healthcare segment, drawn from the platform angellist.com. The data of these companies are collected based on secondary sources and analyzed by means of a qualitative content analysis. Based on the outcome of the qualitative content analysis, a quantitative cluster analysis is conducted in order to reveal different business model patterns. To evaluate the final business model, business professionals and researcher experienced in the development of mHealth services are interviewed in order to validate the framework for applicability and integrity. In addition, the framework is communicated continuously. New insights might lead to further revisions of the framework.

3 Business Model Framework for mHealth Services

Although there exists no uniform definition of the business model yet, there is a general consensus that business models are described by different elements (Baden-Fuller & Haefliger, 2013). In general, the business model explains "how the enterprise creates and delivers value to customers, and then converts payments received to profits" (Teece, 2010, p.173). For the development of our morphological box (see table 1), we adopted the business model dimensions proposed by Johnson *et al.*, (2008) as they represent the main dimensions of a business model – customer value proposition, value creation and value capture. Furthermore, we only considered specific business model parameters that characterize mHealth services in the maternal and baby segment.

We based our business model framework on three literature streams: 1) (Digital) business model frameworks and patterns (e.g. Osterwalder & Pigneur, 2010) that provide insights in characteristics of (digital) business models, 2) eHealth and mHealth business models in order to identify market specific characteristics, especially from the maternal and baby healthcare segment, and 3) platform business models, as mHealth services are often based on digital platforms that connect different users, for example to exchange information (Lupton, 2016). In the following, the main aspects of our business model framework are described.

Table 1: mHealth Business Model Framework

<table>
<tr><th>Dimension</th><th>Business Model Parameter</th><th colspan="9">Characteristics</th></tr>
<tr><td rowspan="6">Customer Value Proposition</td><td>Target Customer</td><td colspan="4">B2B</td><td colspan="5">B2C</td></tr>
<tr><td>Market Segment</td><td colspan="3">Hardware</td><td colspan="2">Software</td><td colspan="4">Service</td></tr>
<tr><td>Service Offering</td><td colspan="3">Physical product-based service</td><td colspan="3">Digital product-based service</td><td colspan="3">Pure digital service</td></tr>
<tr><td>Value Proposition</td><td colspan="2">Functional Value</td><td colspan="2">Emotional Value</td><td colspan="2">Social Value</td><td colspan="3">Epistemic Value</td></tr>
<tr><td>mHealth Category</td><td colspan="3">Medical</td><td colspan="2">Healthcare</td><td colspan="4">Wellness/Fitness</td></tr>
<tr><td>Regulation</td><td colspan="4">Yes</td><td colspan="5">No</td></tr>
<tr><td rowspan="3">Value Creation</td><td>mHealth Intervention Point</td><td colspan="2">Conception</td><td colspan="2">Pregnancy</td><td colspan="2">Postnatal</td><td colspan="3">Newborn/Baby</td></tr>
<tr><td>Digital Technology</td><td>Wearable Device</td><td>Mobile App</td><td colspan="2">Social Media</td><td colspan="2">Website</td><td>Video</td><td colspan="2">Private Message</td></tr>
<tr><td>Key Activities</td><td>Dissemination of information</td><td colspan="2">Service Provision and Management</td><td>Education</td><td colspan="2">Community Building</td><td colspan="2">Data Management</td><td>Platform Management</td></tr>
<tr><td rowspan="3">Value Capture</td><td>Key Revenue Stream</td><td>Device Sales</td><td>Freemium</td><td>Advertising</td><td>Sponsorship</td><td>Service Sales</td><td>Subscription</td><td colspan="2">Pay per download</td><td>Licensing</td></tr>
<tr><td>Revenue Source</td><td colspan="2">Health insurance</td><td colspan="2">User/Patient</td><td colspan="2">Third Party</td><td colspan="3">Mixed</td></tr>
<tr><td>Price Mechanism</td><td colspan="2">Fixed Price</td><td colspan="2">Product Feature Dependent</td><td colspan="2">Customer Segment Dependent</td><td colspan="3">None/Other</td></tr>
</table>

The *customer value proposition* explains how the company fulfills an important need or solves a customer problem (Johnson *et al.*, 2008). The parameter considered are the *target customer* segments; the operating *market segments* (Scheel *et al.,* 2013); the *mHealth categories* defining if the application can be designated as medical, healthcare or wellness/fitness (Kamel Boulus *et al.,* 2014; Rose *et al.*, 2017) and if the application is *regulated*; the kind of *service that is offered* as well as the *value* provided to the customer (Sheth *et al.,* 1991; Caridà *et al.*, 2014).

The *value creation* dimension is expressed by processes and resources in order to create the customer value proposition (Johnson *et al.*, 2008). In the case of mHealth services for maternity and baby healthcare, categories defining this dimension are *mHealth intervention points* in the continuum of maternal and baby care (Tamrat & Kachanowski, 2012); *digital technologies* used for these interventions (Free *et al.,* 2010; Lupton, 2016) and the *key activities* performed (Pagliari *et al.*, 2005; Osterwalder & Pigneur, 2010; Mettler & Eurich, 2012; Chen *et al.*, 2013).

The *value capture* dimension, also known as profit formula (Johnson *et al.*, 2008) explains how the company creates value for themselves when providing value to the customer. The parameters considered in are *revenue streams* (Parente, 2000; Mettler & Eurich, 2012); *price mechanism options* (Osterwalder & Pigneur, 2010) and *revenue sources* (Peters *et al.,* 2015).

4 Conclusion and Outlook

Existing business model frameworks predominantly do not consider the specific context of the operating business model, which is especially important in the area of healthcare. Our framework presented in this paper might overcome this lack and supports companies in developing mHealth business models especially in the context of maternal and baby healthcare. By doing so, our research contributes to the request by Nikou and Bouwman (2017) to investigate in mHealth business models in order to use technologies in a beneficial way (Chesbrough, 2010).

As this is a research in progress paper, we are currently entering phase two and conduct expert interviews and case studies. Although DSR is not commonly used in management research, it has proven as useful in developing the business model artefact in a structured way. Our research at its completion will provide a business model framework that can be used to design, evaluate or classify business models of mHealth services in the maternal and baby healthcare segment. It provides companies a holistic view of the business model. Moreover, we will contribute to the current business model research with a field-tested business model framework for mHealth services that can be used for more intensive research on business models in that field.

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Exploring the Willingness-to-Share Data of Digitized Products in B2B Manufacturing Industries

MANUEL HOLLER, HELEN VOGT & LINARD BARTH

Abstract In the digital age, physical products of all kind become infiltrated by technology. Especially for the sophisticated manufacturing industries manifold opportunities, yet in the same way defiances originate. While academia and practice on the one hand show that the value of digitized products for an ecosystem participant increases with the access to data from the surrounding ecosystem, on the other hand research to understand and manage this willingness-to-share data is limited. Accordingly, the Research-in-Progress Paper at hand explores the willingness-to-share data of digitized products in B2B manufacturing industries. In particular, an exploratory case study research design in the Swiss B2B manufacturing industries is carved out. Considering the inherent limitations of this qualitative research approach, preliminary findings show that highly different aspects influence the willingness-to-share data of digitized products in these environments.

Keywords: • Willingness-to-Share Data • Digitized Product • B2B • Manufacturing Industries • Case Study Research • Research-in-Progress •

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1 Introduction

In the digital age, physical products of all kind become infiltrated by technology (Yoo et al. 2010, Yoo et al. 2012). Recent forecasts by corporate consultancy McKinsey & Company (2018) value the annual economic potential of this digital product innovation (Yoo et al. 2010, Yoo et al. 2012) up to 11 trillion USD by 2025.

Especially for the sophisticated manufacturing industries manifold opportunities, yet in the same way defiances originate (Herterich et al. 2016a, Herterich et al. 2016b). While academia and practice on the one hand show that the value of digitized products for an ecosystem participant (e.g., manufacturer, supplier, or customer) increases with the access to data from the surrounding ecosystem (Porter & Heppelmann 2014, Porter & Heppelmann 2015), on the other hand research to understand and manage this willingness-to-share data is limited (Jernigan et al. 2016).

Accordingly, the Research-in-Progress Paper at hand explores the willingness-to-share data of digitized products in B2B manufacturing industries. Thereby, the following research question is addressed: *[RQ] What are the relevant factors that influence the willingness-to-share data?* To proceed with this leading question, this paper develops an empirical research approach (Yin 2003) based on literature review (Webster & Watson 2002, vom Brocke et al. 2009). In particular, an exploratory case study research design (Yin 2003) in the Swiss B2B manufacturing industries is carved out.

The overall structure of this paper takes the form of four sections: Section 2 continues by outlining the background in terms of digitized products and willingness-to-share data. Section 3 develops a research methodology with an overview, case description, acquisition and analysis of research data. Section 4 finally serves as conclusion pointing towards preliminary findings, contributions to research and practice, limitations as well as an outlook.

2 Literature Review

Digitized products. Throughout publications, various concepts related to digitized products can be found. These novel characteristics are described as intelligent (Terzi et al. 2010), smart, connected (Porter & Heppelmann 2014), or digitized (Herterich et al. 2016a). We aim to build on and contribute to the IS domain, hence we consistently use the herein dominant concept digitized product (Novales et al. 2016). In this sense, digitized products are artifacts "containing sensing, memory, data processing, reasoning, and communication capabilities" (Yoo et al. 2010, p.725). Congruent to traditional physical products, their digitized versions comprise a lifecycle where they are developed and produced, used and maintained, and – for example – recycled (Terzi et al. 2010).

In their seminal article, Porter and Heppelmann (2014) describe the evolution towards these digitized products in five steps: Step 1 represents the pure physical product, for example a tractor. In step 2 this product becomes smart – equipped with embedded systems – and in step 3 connectivity is added to create a smart connected product. By integrating adjacent products (such as planters or tillers) a farm equipment system with the possibility for overarching management emerges in step 4. In step 5, complementing this farm equipment system with further systems (e.g., seed optimization system), a farm management system – or more generally a system-of-systems – emerges (Porter & Heppelmann 2014). Particularly from an IS perspective, Herterich et al. (2016a, 2016b) describe the technology affordances and corresponding obstacles of digitized products in manufacturing industries.

Willingness-to-share data. As a matter of principle, the area of willingness-to-share data represents a highly interdisciplinary field involving domains such as management, law, and psychology (Hart & Saunders 1997). As socio-technical question, this field can be considered as emerging in the IS domain (Du et al. 2012). To work up the current knowledge, we reviewed literature following established guidelines (Webster & Watson 2002, vom Brocke et al. 2009).

In a wider sense, within the increasing diffusion of IT into organizations, data sharing has been studied in traditional functions of the value chain such as electronic data interchange (e.g., Hart & Saunders 1997) or supply chain management (e.g., Eurich et al. 2010). Recent research has also looked more deeply into more modern IS fields such as social media (e.g., Lee et al. 2013, Morey et al. 2015). In a narrower sense, particularly for the context of digitized products, not many researchers are engaging these days (Jernigan et al. 2016). Whereas in the business-to-consumer (B2C) context such as smart watches or fitness wrists (Chen et al. 2016, Seifert et al. 2018) some initial scientific insights are available, the business-to-business (B2B) setting is scarcely studied (Jernigan et al. 2016). To condense the review, environmental uncertainty (e.g., customer, supplier), intra-organizational facilitators (e.g., top management support, IT enablers), and inter-organizational relationships (e.g., trust, shared vision) have been identified as relevant factors (Li & Lin 2006, Fawcett et al. 2007).

Based on this analysis, the following methodical research gap (Müller-Bloch & Kranz 2015) can be summarized: Less empirical data – in particular no valuable, context-rich qualitative research – from the mainly hidden corporate contexts is available (Jernigan et al. 2016).

3 Research Methodology

Overview. Our phenomenon targeted is the willingness-to-share data of digitized products in B2B manufacturing industries. Hence, case study research understood as "empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (Yin 2003, p.13) can be regarded as sound research method. More precisely, to explore the factors influencing the willingness-to-share, an in-depth single-case study approach with multiple embedded units of analysis is applicable (Yin 2003). Thereby, the case is represented by a manufacturing company with its different customers operating different products as units of analysis.

Case description. B2BComp is a Swiss small to mid-sized enterprise developing, manufacturing, and maintaining heavy equipment for mining. Its product portfolio encompasses a range of heavy equipment from rather basic to high-end machinery which are mostly marketed abroad in B2B markets. With some customers also in Europe, main application fields are in Asia, Africa, and the United States. Driven by the competitive market environment as well as specific customer needs, the company is moving towards making their equipment digitized and offering additional product-related services such as predictive maintenance. For these services different sensors need to be installed at the mining equipment and the customers have to consent to share this data basis. Thereby, the data can range from simple discrete data (e.g., periodic monitoring of operating hours) to complex real-time data (e.g., continuous logging from shock sensors).

Acquisition of research data. Upon the recommendation by Yin (2003), we aim for several sources of evidence to study the willingness-to-share factors. From a sampling perspective, a purposeful sampling strategy (Coyne 1997) is intended performing semi-structured interviews (Schultze & Avital 2011) and focus groups (Morgan 1988) at the interface between B2BComp and its different customers operating the different products. By the support of B2BComp unique access (Yin 2003) to internal experts as well as customer executives is given. For rich insights relevant departments such as management, marketing, R&D, IT, and legal are included. Interviews and workshops will be conducted until information saturation (Coyne 1997). More specifically, both data acquisition methods comprise the following steps: (1) Introduction of the project, (2) contextual questions referring to the participant and its organizational entity, (3) initial examination of current practices on willingness-to-share data, (4) detailed working out of relevant factors leveraging wh-questions, and (4) conclusion. For the sake of scientific rigor, we seek to records all events (Yin 2003).

Analysis of research data. For further processing, qualitative data will be brought to written form by transcription (interviews) and memos (focus groups) (Sinkovics et al. 2005). The research stream of grounded theory (Strauss & Corbin 1990, Strauss & Corbin 1997) has yielded a set of structured methods to aggregate data. Accordingly, the acquired data are analyzed in the steps open, axial, and selective coding (Strauss & Corbin 1990, Strauss & Corbin 1997). Operatively, the texts are loaded into the qualitative data analysis software "NVIVO" by QSR International annotating all passages addressing the willingness-to-share factors. Then, these codes are iteratively pooled and lastly re-organized around the emerging categories (Strauss & Corbin 1990, Strauss & Corbin 1997). Qualitative research is often confronted with reluctances (Yin 2013, Keutel et al. 2014). Thus, to ensure scientific quality, we apply case study guidelines like audio recording, multi-coder data analysis, and continuous sense making (Yin 2003, Yin 2013).

4 Preliminary Findings and Conclusion

Preliminary findings. This Research-in-Progress Paper aims to set the stage for exploring the willingness-to-share data of digitized products in B2B manufacturing industries. For this objective an exploratory case study research design in the Swiss B2B manufacturing industries was proposed. So far, initial interviews and focus groups (sales and product manager interview in February 2019, focus group with board of management in May 2018, interdisciplinary focus group in February 2019) were conducted and analyzed. Preliminary findings show that highly different aspects influence the willingness-to-share data of digitized products in B2B manufacturing industries. In detail, main drivers can be detected, complemented by a range of mediating factors. The drivers in turn can be distinguished into willingness-to-share factors that can be influenced (e.g., trust and established relationship, type and frequency of product data, and data security practices) and factors that cannot be affected (e.g., dominance in the market, degree of innovation, and data privacy regulations). Beyond, factors such as received benefits, the design of contracts, and implementation efforts act mediating.

Conclusion. For the scholarly community, the expected findings offer initial empirical evidence from a real-world case in the manufacturing industries as inquired by research (Jernigan et al. 2016). In the profound upheaval by digital product innovation (Shim et al. 2019), this research generates valuable insights referring to the foundations of data-driven innovations. For the industrial application, the results represent a base to understand and shape partnerships to realize efficiency increase as well as novel value-adding services. Upon the strategic character and long-term impact of decisions on digital product innovation in manufacturing industries, these insights are relevant to guide investments.

The authors are aware of the inherent limitations of this qualitative research approach. Case study research cannot generate representative insights (Yin 2003, Yin 2013), hence the expected findings are in some way bound to B2BComp, its products, and customers.

A future avenue of research could follow on the one hand a quantitative validation of the identified factors in further B2B manufacturing industries. On the other hand, more complex multi-tier relationships need to be addressed in the future as well.

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Taking Action: Extending Participatory Action Design Research with Design Thinking

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Abstract Digital transformation adds new possibilities but also more complexity to people's everyday life. To address complex problems within the field of Information System Research, it is advisable to include a variety of stakeholders into the research and design process. Therefore, it is not only necessary to locate the problem solution within the realm where the problem occurs, but also to get the input of the people who have the appropriate insights. In this paper, we propose to use Design Thinking as a course of action for the conduction of particaptory Action Design Research projects.

Keywords: • Participatory Action Design Research • Participation • Design Thinking • Research Methodology • IS Research •

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1 Introduction

The digital transformation brings great changes not only to businesses but to whole societies. With new technologies for social interaction, teamwork and participation, this ongoing process yields a lot of improvements. At the same time the world we are living in gets more and more complex. If we want to improve people's lifes in a world of high complexity by technological innovation and benefit from the new possibilities digital transformation has to offer, it is a good idea to let the actual users be part of the design and development of new and innovativ information systems. Otherwise it is questionable whether the user's needs are first really understood and second actually met.

In business contexts, this concept is called co-creation (Zwass, 2010). The advantage co-creation provides, is the specific knowledge end-users can contribute to the design process. Outside of business contexts, this idea is referred to as Participatory Design (PD) (Kensing & Blomberg, 1998).

In Information System Research, the idea of designing better solutions for business problems as the key concept of a research project is Design Science Research (DSR) (Hevner, March, Park, & Ram, 2004). DSR is critized, as it does not consider the context in which the problem occurs. To approach this, Sein et al. (2011) suggested to conduct DSR including elements from Action Research (AR), where researchers take an active part in the research process and try to come up with solutions within the problem context (Iivari, 2005). In conclusion Action Design Research (ADR) was introduced.

However, ADR focusses on organizational and business needs and is lacking the integration of a larger variety of stakeholders into the design process, which has been identified as highly beneficial, similar as co-creation concepts. Ongoing research addresses this issue by carrying out ADR in a participatory manner (Bilandzic & Venable, 2011; Haj-Bolouri, Bernhardsson & Rossi, 2016). Derived from PD (Kensing & Blomberg, 1998), participatory ADR refers to the paradigm of letting developers, practioners and end-users take part in every single step of the research process instead of solely including them as survey participants or for experimental observations (Haj-Bolouri et al., 2016). Even though, participatory ADR-frameworks are rigoursly derived and developed from theory and address an important aspect, they lack in providing a clear, easy to follow and structured process model which inhibits their practical applicability. A clear methodology could foster not only the understanding of the problem and cohesion among research participants, but also support the development of new and innovative solutions for the proposed research questions.

In this paper we introduce a structured framework for an adapted Design Thinking (DT) workshop as a course of action, to carry out the *Action Taking* part of participatory ADR projects (see Figure 1). The DT mindset is ideally suited to work on innovative solutions for complex problems in diverse teams (Buchanan, 1992). Therefore, we first give an introduction into the basic ADR concepts as well as the particpatory ADR advancements by Haj-Bolouri, Bernhardsson & Rossi (2016) and Bilandzic & Venable (2011). After that, we focus on the DT procedure in detail and give an explanation, why we think it is ideally suited for *Action Taking* in participatory ADR projects (see Figure 2). We close with a description of our proposed research methodology as well as a description of how we plan to proceed in order to evaluate and validate our approach. In Table 1 we provided an overview of the research paradigms and concepts we used.

2 Related Research

2.1 Action Design Research

To understand the specifics of ADR, it is important to know what its origin is. ADR is a combined method of AR and DSR. AR itself is a change-oriented approach, with which social processes can be studied by researcher guided changes, of which effects are then monitored (Baskerville et al., 2018). DSR combines behavioral science and design science and adds rigor and theory to the design of artifacts (Hevner et al., 2004). Within DSR, an existing knowledge base with applicable theories contributes to the development of the artifact and an assessment of the artifact with existing methods from the knowledge base, ensures a rigorous justification of the results and demonstration of the artifact (Hevner et al., 2004). Pefferset al. (2008) further developed a nominal DSR process model that aims to integrate a systematic process, practices and principles for implementing a consistent DSR project. This model aims to strengthen the recognition and legitimacy of DSR and provides guidance to researchers in the execution and presentation of DSR. In contrast, ADR was first introduced by Iivari (2005) and further seminally investigated by Sein et al. (2011). Compared to DSR's problem and theory-based approach, ADR considers organizational and practical activities and problems (Hevner et al., 2004; Sein et al., 2011) to better understand the values, interests and assumptions of an organization (Orlikowski & Baroudi, 1991). The design of the artifact is iterative and in close collaboration with the organization. Sein et al. criticize the separation of design and evaluation and the sequential process models in DSR and argue that a closer link between these two aspects is necessary, which can be achieved by the researchers' intervention.

This interplay of design and evaluation is important for a comprehensively ensembled artifact, that is iteratively developed between the researcher and the organization. Combining AR with DSR has been proven to be beneficial to situate the problem in real life contexts (Iivari & Venable, 2009; Sein et al., 2011). Sein et al. describe the concept itself as "[...] a research method for generating prescriptive design knowledge through building and evaluating ensemble IT artifacts in an organizational setting.".

2.2 Participatory Action Design Research and Citizen Science

In 2011, Bilandzic and Venable presented an advance of the ADR methodology to adapt the research paradigm to the field of Urban Informatics (UI). The objective of UI is in strong contrast with the objective of the original DSR paradigm, which focuses on generating innovative solutions for business needs (Hevner et al., 2004). Bilandzic and Venable state that in order to meet the requirements of the field of UI, namely improving people's everyday life, one should include citizens into the development and design of innovative (software) artifacts. In general, the integration of ordinary citizens in academic research processes is called Citizen Science (CS) (European Union, 2013). The aspect of involving non-scientific stakeholders links both research paradigms, CS and participatory ADR. Subsequently, CS and participatory ADR stand for the same idea, with CS describing the paradigm and participatory ADR describing the specific approach.

One main advantage of integrating stakeholders in the design process is the problem-related knowledge they can provide. This is even more important since ADR projects are situated in the same environment as the problem to be solved. To meet these preconditions, Bilandzic and Venable suggest „[…] that suitable techniques be borrowed from other Action Research approaches […].“ (Bilandzic & Venable, 2011 p. 9).

Another suggestion to open the research process to co-researchers is the PADRE-framework. Haj-Bolouri et al. (2016) describe their concept as an „[…] elaborate version of the ADR method […].“. Instead of conducting a reflection and learning process within the stakeholder group solely at the end of the research process (Bilandzic & Venable, 2011) (see Figure 2), Haj-Bolouri et al. suggest to integrate a reflection and learning process in each and every step of the participatory ADR project. However, both approaches stress the importance of integrating external stakeholders, but lack a specific methodology and process on how this integration can be achieved. Therefore, we suggest to use the DT approach for the conduction of participatory ADR projects.

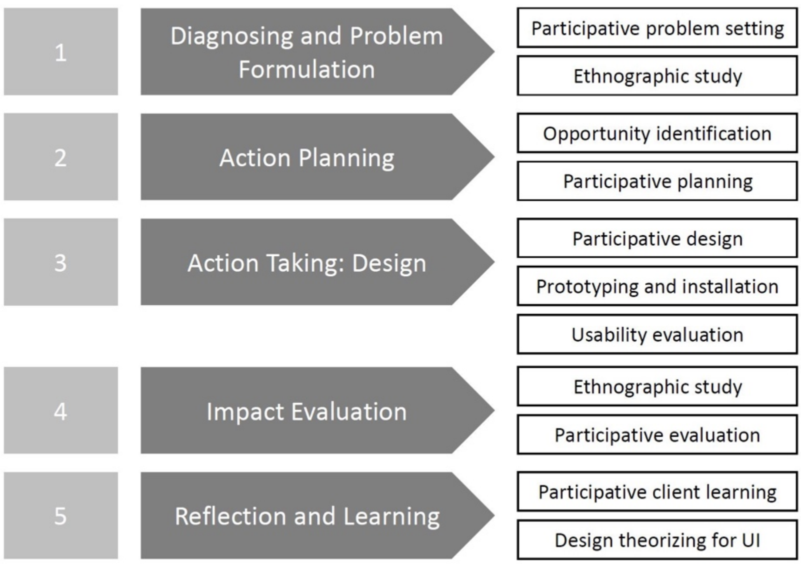

Figure 8: PADR Framework (Bilandzic & Venable, 2011)

Table 3: Overview of research paradigms and frameworks

Concept/Paradigm	Key characteristics	Reference
Design Science Research (DSR)	Theory driven design approach for business needs	Hevner et al., 2004
Participatory Design (PD)	Inclusion of (non-scientific) stakeholders into the design process	Kensing & Blomberg, 1998
Action Design Research (ADR)	Design orientied research approach but with the researcher as active participant	Iivari & Venable, 2009; Sein et al., 2011
Citizen Science (CS)	Inclusion of citizens into every aspect of the research process from topic selection to presentation of results	Dickinson et al., 2012; European Union, 2013
Participatory Action Design Research (participatory ADR)	Combination of DSR, PD, ADR and CS to form an integrated framework for research working together with a variety of stakeholders on design solutions for business and public problems	Bilandzic & Venable, 2011; Haj-Bolouri et al., 2016
Design Thinking (DT)	User-centric and structured collection of methods for working on innovative solutions for complex problems with the integration of a broad variety of stakeholders	Hasso Plattner Institute, n.d.; Lindberg, Meinel & Wagner, 2011

3 Approaching Participatory ADR with a Design Thinking Procedure

In the following section, we propose a process model for integrating participtory ADR research through the use of a structured DT procedure for Information Systems Research.

3.1 Design Thinking

DT-Workshops are ideally suited for generating innovative ideas targeting complex problems (Johansson-Sköldberg, Woodilla & Çetinkaya, 2013). With their high level of inclusion, the focus on solving complex problems and the objection to create innovative artifacts as well as to evaluate the idea's effectiveness, DT-Workshops are a perfect fit for participatory research endeavors. Therefore, we would like to explain in detail the steps we suggest for this process. DT is a customer-centered, participatory, problem-solving method, which contains various steps and iterations (Brown, 2008). Regular DT is carried out in form of workshops and includes a heterogenic group of people. The duration and extent of these workshops differ, as there are many different versions of DT processes. Some interpretations of the process are based on a three-step process, while others are more detailed and show themselves as a nine-step process. Several adaptions of the basic DT-process exist for specific contexts like e.g. innovation processes for industrial services providing specific steps for instance for the development of detailed business models (Redlich et al., 2018).

For our approach, we decided to follow the process of the Hasso-Plattner-Institute of Design at Stanford University in California, where DT was first developed. It is an easy to follow, well documented version of the DT-process, which offers enough flexibility to be used for a large number of research topics. The steps included in this process are *Empathize*, *Define*, *Ideate*, *Prototype* and *Test* (Harris, 2016; Lindberg et al., 2011). Each DT workshop starts with a design challenge. These challenges are expressed by a so called *How Might We* question (Siemon, Becker & Robra-Bissantz, 2018).

In the *Empathize* step, it is necessary to build up an understanding of the human being behind the problem. Therefore, possible activities are general research, interviews and observations to get to know the customer and his or her problems. After gathering enough customer information, an aggregation of this information takes place. This task is followed in the step *Define*. The objective of this step is the definition of the problem, respectively the problem space, to be worked on. This is very important, because all following steps will build on the correct framing of the problem. Finally, the *Ideate* step aims at the generation of many ideas. Typical tasks in this phase are for most of the time brainstorming techniques in various forms. The participants of the DT-process are encouraged to think in all directions and without boundaries like costs or feasibility (Hasso Plattner Institute, 2019). After that, the workshop participants select and transfer the most promising ideas into the *Prototype* step.

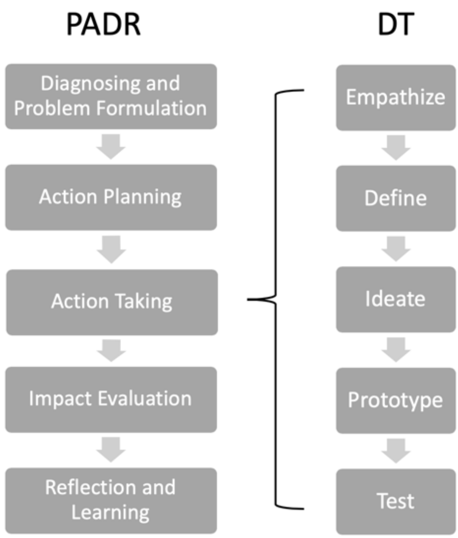

Figure 2: Integrating Design Thinking in the participatory ADR process of Bilandzic & Venable (2011)

Here, the DT-workshop participants themselves build prototypes of various complexity. The goal for the prototype is that the functionality behind the innovative idea can be tested in the last process step; *Test*. DT processes and even specific methods for each step are diverse but very well documented online[1],

[1] https://dschool.stanford.edu/resources

which allows for the workshops to be conducted not only by qualified DT-trainers but also researchers, practioners or anyone interested in collaborattive problem-solving.

3.2 Design Thinking characteristics

To understand why we think conducting DT-workshops is the logical process to follow for participatory ADR workshops, we want to explicitly look at the advantages the process has to offer. Besides generating innovations, DT-workshops have a strong focus on dealing with and understanding the actual problem before any efforts towards a solution are made. The first three steps of the process, as described above, focus on comprehending the underlying problem of the stakeholders. This is necessary to overcome alleged problem causes. In these steps, the workshop participants intensively learn about the perspective of other stakeholders and the design challenge in general. This learning would not be possible if only a certain group of stakehodlers would participate in the workshops. Therefore, it is inevitable to have a diverse group of participants for the workshops to be successful. For every non-organisational design challenge, this calls for the integration of citizens following the CS-paradigm as mentioned above. The different points of view on the design challenge are what makes participatory research and the DT process model so unique and beneficial.

Table 4: Examples for Design Thinking Methods, see footnote 77.

Design Thinking Phase	Possible Methods (selection)
Emphasize	Persona, Service Blueprint, Interview for Empathy,
Define	How Might We-Question, SWOT-Analysis
Ideate	Brainstorming, 6 Thinking Hats, Gut Check, Voting, 6-3-5 Method
Prototype	Business Plan, Story Board, Rapid Prototyping, Ways to Grow Framework, Paper Prototype
Test	Role Play, World Café, UX-Testing, Elevator Pitch

https://designthinking-methoden.de

4 Conclusion and Future Research Agenda

In this paper we have given an overview of existing approaches to combine participation paradigms with design orientied research in Information System Research or respectively UI. We suggest advancing these approaches with a well described and established methodology for particpative innovation workshops. With this contribution we provide a straight forward and easy to follow process model for researchers and practioners alike, who want to include stakeholders into their design-orientied research processes. The main advantage of DT is the well documented workshop structure with enough flexibility and room for adaptation to fit a wide variety of research scenarios. A comparison between the different approaches can be found in Table 3. Beyond that, an easy to follow and coherent research model could hold the possibility to narrow the gap and foster the understanding between research and society.

Table 5: Compariosn of research paradigms and frameworks

	AR	DSR	ADR	Participatory ADR	Participatory ADR with DT
Social and Behavioral Aspects	✓	✓	✓	✓	✓
Design Research		✓	✓	✓	✓
Contextual Aspects			✓	✓	✓
Stakeholder Involvement				✓	✓
Pratical Applicability					✓

Therefore, the research questions we want to adress with the case study and its evaluation are as follows:

1. Does the proposed approach create a valueable framework for generating innovativ solutions for design challenges within the field of UI?
2. Does the proposed approach reach the goal of enhancing the participants relationship and also empower a vast number of stakeholders?

The next step on our research agenda is to host a series of participatory ADR workshops conducted with DT as a process model. The evaluation of this case study will generate insights on the apllicability and usefulness of the proposed process as well as meaningful input for the adaption and improvement of participatory ADR processes in general.

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Is Facebook A Ride-Sharing Platform? Exploration Through Affordance Theory

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Abstract Peer-to-peer ride-sharing is one of the most complex archetypes of the sharing economy. As a result, dedicated digital platforms, designed specifically to handle this complexity, have emerged. However, there are practices where Facebook is used to organise the ride-sharing, although it lacks features that can handle the complexity of ride-sharing. In this research-in-progress paper we demonstrate the importance for researching these practices. We justify the appropriateness for using the Affordance - actualisation lens for analysing the practices. We present the preliminary results from the first case study research.

Keywords: • Facebook • Sharing economy • Ride-sharing • Affordance theory • Platform •

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1 Introduction

Peer-to-peer ride-sharing is one of the most complex archetypes of the sharing economy. This is because of the requirements for "highly coordinated arrangement of resources in a tightly defined timeframe" and "ephemeral and interactive nature of the exchange" (Andersson et al., 2013, p. 3). The provider and consumer need to agree on pick-up and drop-off points, waiting time, music playing, smoking policy, compensation, etc. (Teodorović and Orco, 2008). As a result, dedicated digital platforms, designed specifically to handle this complexity, have emerged. Most prominent examples being Uber, Lyft, Blablacar and others. They are identified as the face of the ride-sharing economy. However, there are ride-sharing practices that are done through non-dedicated digital platforms, like the peer-to-peer Facebook group "Arcade City Austin / Request A Ride" (Tepper, 2016). This is interesting because Facebook significantly lacks the technical features necessary to meet the challenges of ride-sharing complexity, but again there are more than 38000 members in the "Arcade City Austin / Request A Ride" group. Practices of using Facebook for ride-sharing are also present in other countries (Andersson et al., 2013), however it seems that research of these type of ride-sharing practices is somehow 'off our patch'. Thus, we have yet to seriously explore how ride-sharing is organised through non-dedicated platforms and what are the socio-technological mechanisms that enable it?

Dedicated peer-to-peer ride sharing platforms, through their intermediary role and features provide mechanisms that support the sharing between the peers (Puschmann and Alt, 2016). Their purpose it to provide sufficient pool of participating peers, minimise the hazards and increase the trustworthiness (Täuscher and Kietzmann, 2017; Weber, 2014). The dedicated platforms use different models (Constantiou et al., 2017) but they all impact the strategy, processes and systems of the sharing economy (Puschmann and Alt, 2016). Therefore, dedicated platforms are the lens we use to explore the sharing economy. On the other hand, dedicated platforms for ride-sharing mainly operate in large cities and in certain countries. For example, Uber primarily operates in big cities in 80 countries (Uber.com, 2018). But sharing is distinct, ancient, fundamental consumer behaviour (Belk, 2010) and analysing it through dedicated platforms' lens may limit the insight we get about the ride-sharing practices.

In the literature it has been identified that in certain countries social networking platforms, like Facebook, are used for organising ride-sharing (Andersson et al., 2013), but they have not been analysed. Analysing peers' practices of ride-sharing organised through Facebook can provide an additional insight in the sharing economy. Affordance theory provides an appropriate lens because it claims that "actor perceives an object in the environment in terms how it can be used and not as a set of characteristics or features that are inherent to the object and independent of the actor"(Gibson, 1977, 1979 in Volkoff and Strong, 2017). Thus, the focus is to downplay the characteristics or features of the object (in our case dedicated ride-sharing platform) and to focus what the actor could do with the object (in our case general purpose social media platform i.e. Facebook) (Bygstad et al., 2015). In sharing economy context this will mean focusing not on the platforms' features, but on the actions of the actors and their interpretation of available technology through their goals for action (Leonardi, 2011). To date there is no research about affordances in sharing economy. Thus, using affordance theory as a lens can provide novel insight on how the sharing economy is organised.

The purpose of this short paper is to explore how Facebook is used to organise inter-city ride-sharing in a developing country. We present how affordance theory can be used as a lens to achieve this and its appropriateness for theorising the empirical findings by paying attention to "socio-technical" dimension of affordances (Robey et al., 2013). To demonstrate this, we present our initial research outcomes. The paper is structured as follows. First, we present the theoretical context of sharing economy and platforms. This is followed, by justification of affordance theory usage for this research. Then, we explicate the research methodology and the empirical context where the research is performed. Finally, we present our preliminary results and the avenues for further research.

2 Sharing economy and digital platforms

Interest in what is and how the sharing economy is organised and realised is rapidly growing among practitioners and academics (Barnes and Mattsson, 2016; Schor and Fitzmaurice, 2015). This interest is fuelled by the impact and the heterogeneity of sharing economy. The sharing economy, although emerging field, impacts diverse aspects such as the practice on the economy (Zervas et al., 2017), pollution (Möhlmann, 2015), labour and employment (Codagnone and Martens, 2016) etc. Furthermore, the sharing economy presents its self in different forms, levels, approaches due to the heterogeneity in terms of subject of exchange (Schor and Fitzmaurice, 2015), whether they are profit-or not-for profit oriented (Schor and Fitzmaurice, 2015), variety of sectors involved (Wosskow, 2014), business models (Cohen and Kietzmann, 2014; Constantiou et al., 2017) and type of platforms used (Andersson et al., 2013).

Andersson and his colleagues (2013) distinguished four archetypes of peer-to-peer sharing platforms based on object of sharing, timing and meeting requirements: peer-to-peer file sharing, peer-to-peer trading, peer-to-peer-goods sharing, and peer-to-peer service sharing platforms. According to them the peer-to-peer service sharing is more complex than the others due to the need of "highly coordinated arrangement of resources in a tightly defined timeframe" and "ephemeral and interactive nature of the exchange" (Andersson et al., 2013, p. 3). Furthermore, there is a need the peer providers and consumers to agree on pick-up and drop-off points, waiting time, music playing, smoking policy, compensation, etc. (Teodorović and Orco, 2008). Thus, a need for specialised peer-to-peer ride-sharing platform was created. The sharing economy start-ups emerged to meet these challenges and provided digital platform and applications to enable the ride-sharing (Cusumano, 2015). They operate using different business models.

Cohen and Kietzmann (2014) analysed three shared mobility business models: carsharing, bikesharing and ridesharing. In this paper we focus on ridesharing. Ridesharing consists of carpooling, flexible carpooling, vanpooling and peer-to-peer ridesharing (Chan and Shaheen, 2012). Although, historically, all these models have been present for a long time, it is the development of the technologies that fuelled the massiveness and globalisation of the commercial peer-to-peer ridesharing model. The result is large number of intermediaries that own specialised/dedicated digital platform and provide services that facilitate the ridesharing like Uber, Lyft, Blablacar and other. These specialised/dedicated platforms are in the focus of academic research on the sharing economy. However, peer-to-peer ridesharing also exists outside these dedicated platforms. For example, Andersson and his colleagues (2013) identified Skjutsgruppen, a public Facebook group existing from 2007 with more than 50000 members that supports the organisation of peer-to-peer ridesharing in Sweden. In our country we have also identified more than ten public Facebook groups that facilitate the organisation of inter-city ride sharing. As identified by Andersson and his colleagues (2013) Facebook does not provide features that will enable ridesharing and meet the challenges of peer-to-peer ride sharing complexities. Thus, the question is how is this possible? We try to answer this question through the affordance theory. In the next section we provide the justification for using affordance theory as a lens.

3 Affordances

Affordance theory provides a fresh look at the familiar topic of IS adoption and adaptation (Volkoff and Strong, 2017). The main element in the affordance theory is the affordance. An affordance is the potential for behaviours associated with achieving an immediate concrete outcome and arising from the relation between an object (e.g., an IT artefact) and a goal-oriented actor or actors (Bygstad et al., 2015). Affordances have several characteristics: first, they are relational; they are relations between the abilities of the human and features of the object. Second, they are possibilities for action. Affordances exist even if they are not realised or actualised. Third, affordances are not only enabling, but also constraining. Forth, the potential behaviour behaviours of an actor are goal directed (Strong et al., 2014). However, the realisation of the affordances depends on the presence of appropriate enabling, stimulating, and realising conditions (Volkoff and Strong, 2013). It is the particular concatenation of different affordance strands/mechanisms is what leads to the observed phenomenon (Gambetta, 1998 through Volkoff and Strong, 2013). Furthermore, the affordances can be multilevel. Leonardi (2013) differentiates between individual, shared, and collective affordances. Thus, it is necessary to have more contextual approach in the research. To achieve this, we will look on the empirical context through the usage of affordance - actualisation (AA) lens.

Affordance - actualisation (AA) lens highlights the importance of theorising both affordances and the actualisation process, and the context of both (Strong et al., 2014). Actualisation process has been defined as "the actions taken by actors as they take advantage of one or more affordances through their use of the technology to achieve immediate concrete outcomes in support of organisational goals" (Strong et al., 2014). AA lens provides a level of granularity that is specific with respect to the technology while also providing some generality beyond individual case examples (Volkoff and Strong, 2013). Thus, it enables IS researchers to build theoretically sound mid-range theories by focusing on explaining, at a sufficiently detailed level, how and why outcomes occur (Burton-Jones and Volkoff, 2017; Volkoff and Strong, 2017). Affordance theory as a lens have been successfully used for research of IS adoption, adaptation and organisational change (Volkoff and Strong, 2017) and generation of new theories (Leonardi, 2011).

Using the affordances to think about the artefact/user relationship can be useful for generating not only new socio-technical theories (Volkoff and Strong, 2017), but also to create a contextualised theory for effective use (Burton-Jones and Volkoff, 2017). According to Burton-Jones and Volkoff (2017) effective use refers to that type of use that helps users attain desired goals. The effective use can be decomposed by identifying the "immediate concrete outcome", a specific expected outcome from actualisation useful for achieving the organisational goals (Strong et al., 2014). This enables us to identify the affordance network i.e. a linked set of more immediate concrete outcomes (Burton-Jones and Volkoff, 2017). To contextualise the theory means to "discover the specific affordance network and specific actualisation most relevant in that setting" (Burton-Jones and Volkoff, 2017). We use this approach to develop a context-specific theory about organising ride sharing through Facebook in developing country. How we performed this is presented in the next section.

4 Methods and data

To explore Facebook as non-dedicated ride sharing platform, we will use case study research. The distinctive need for the case study comes from the need to understand complex phenomena and to retain the holistic and meaningful characteristics of this phenomena (Yin, 2009, p. 4). More specifically, the case study has a distinctive advantage when questions of why or how are asked for contemporary set of events over which the investigator has little or no control (Yin, 2009, p. 13). As data collection techniques within the case study interviews and observation techniques were used.

First, observation was performed to get insight into the way of operation of Facebook as a ride-sharing platform. Facebook search engine was used to find a pool of potential Facebook groups for analysis. We limited the search results to

Groups only, excluding the pages or people using the search phrase "ridesharing Skopje" (in local language). We identified 10 groups and further examined the information sections of these groups. Based on the information about the number of group members, we selected and focus our attention on two of them i.e. (Facebook group: Veles-Skopje-Veles and Facebook group: Bitola-Skopje-Bitola). Then, we requested to become members of these groups. As group members we have access to all the posts, therefore, consent to analyse the posts from administrator or group users was not required given that all the posts are public and visible to all group members. We analysed the interactions on the Wall section (where group members post messages and information) in the period of February to December 2018. Posts were analysed in a way that the content was categorized according to its source (i.e. who initiated the post - driver versus passenger). Also, content was analysed for distinct themes and concepts.

Second, in order to analyse the process of communication after the posts have been published on Facebook groups, we conducted semi-structured interviews with 4 respondents. We had a list of predetermined questions that leaded the interview, nonetheless, based on the answers of the interviewees additional questions were asked during the interview process. Through in-depth interviews we aimed to understand the experience of the individuals and the meaning they make from using Facebook as a platform for organising ride sharing (Seidman, 2006) Interviews although identified as a separate research category are typically part of other methodologies, such as case studies (Palvia et al., 2003). The four respondents were users of the analysed Facebook's groups for ridesharing. One has participated only in the role of car driver, two only in the role of passengers and one had a dual role of trip organiser and passenger. One individual is employed and three were students. The interviews were performed within the premises of our Faculty and both of the researchers were present on each interview. Interviews were not voice recorded because the interviewees were reluctant to participate in tape recorded face-to-face interviews. Thus, one of the researchers took extensive notes during each interview. Before starting the interview, the researchers introduced themselves, explained the purpose of the interview, stressing the confidentiality issue, options to withdraw, and explained the use and scope of the results. Preliminary questions were based on previously designed interview guide focused on asking participants about their perceptions and experiences with ridesharing. This interview guide allowed the researcher freedom with follow-up questions. All the preliminary questions were divided in five groups: what, where, how, why and other questions. Each interview lasted approximately 90 minutes.

As a result of the Facebook groups Wall post analysis, three primary themes emerged: Theme1; Making ridesharing offer by the drivers, Theme 2: Making car seat request by the passengers and Theme 3: Other information (shared by both drivers and passengers). From the analysis of all posts that belong to Theme 1, we concluded that the intent of the posts is dominantly information giving with differences in type of information provided. For example, users may express an offer providing minimum information about the destination and time of departure such as "Free place to City X around 10:00 (Friday)" or additional information (specific destination point and pick-up location, phone number and name of the driver) such as "Free seat to city X Place Y pick-up from location Z between 13:00 and 13.15 (Friday) [phone number] [driver name]. The posts within the second theme "Making car request" are generally in form of questions in which limited information are given (destination point and departure time) such as "For city X somebody going now?" or in form of statements where information about the phone number of the passenger and/or passenger name are provided such as "I need 2 seats to Place Y after 14:00 [phone number] [passenger name]" or about the exact desired destination/drop-off point such as "I need a seat to City X tomorrow [date] Departure at [time] from Place Z, Destination: Suburb A spot B [phone number] [driver name]). The third theme refers to other traveling route information shared by both drivers and passengers such as "Be careful, rockfalls on the road" or "Radar control at spot X".

Since comments are rare to the published posts, in order to reveal the whole process of communication we conducted interviews with 4 respondents.

For each interview the notes were read and through coding we aimed to identify a pattern that could be used as a base for theorizing (Charmaz, 2006).

5 Preliminary results

The desired goal of the Facebook group's participants is "to arrive at point B at time X". To achieve this the participants, use an affordance network consisting of affordances resulting from the relations between Facebook, mobile phones and the participants as goal-oriented actors. Each identified affordance is named as a gerund associated with the actions that would be taken to actualise that affordance (Strong et al., 2014). In Table 1 we present the affordances and the immediate concrete outcomes.

Table 1: Affordances and Immediate Concrete Outcome.

Affordance	Immediate concrete outcome
Making car offer/car request for ride-sharing	Need for ride-sharing published. Relevant information presented.
Evaluating peer that made offer/request for ride sharing	The person behind the offer/request identified.
Bidding on an offer/request for ride-sharing	Relevant information presented.
Matching values of variables between offer/request and a bid.	The best available ride-sharing combination determined. Achieved agreement between peers.
Arranging pick-up place	Determined point on ride-sharing path. Determined ride-sharing path.

The elements that gave rise to these affordances can be identified through the Facebook features (software object), mobile phones characteristics (hardware object) and characteristics of the participants (actors). They are presented in Table 2.

Table 2: Elements giving rise to affordances

Facebook features	Mobile phones characteristics	Characteristics of the participants
- Publish posts in a group - Send and receive messages through messenger - Add Photos	- smart telephone able to browse internet or install apps - Ability to access to wireless internet	- Individuals have the skills to use facebook on mobile phones - Individuals know the geographical area from/to where they travel

The links among the affordances and outcomes by explicating the goal-directed actions of the participants are presented below. This is the base for creating the affordances network and identifying the emerging dimensions of effective use.

The starting point for using Facebook as a platform for organising ride-sharing is publishing a post in the group. From the posts analysis we concluded that the posts at minimum contain e information about the destination place and departure time. However, there are also more informative posts

From the interviews we identified that when a phone number is provided, the communication continues over telephone, otherwise the communication is done through Facebook messenger. One of the interviewees identified that before engaging in the bidding process it visits the Facebook profile of the person who made the ridesharing offer/request and sees the pictures to identify who is making the offer/request. "You can see from the pictures what kind of a person it is, normal or…" female respondent. The other interviewees do not do this. Through Facebook messenger or telephone, the peers bid for the car offer/request. This is usually done fast, and additional information is provided about the pick-up place. This is where the usage of Facebook, as a platform for organising ride-sharing, stops.

By reflecting of what we observe in the Facebook groups and interview information we preliminary found that key dimensions for effective use of affordances are sufficient, trust and multiple exit points. Sufficient means that the information provided are adequate in quality and quantity for the actors' needs. The participant can have different extend to which they provide information in the post for car offer/ car request. Furthermore, Facebook post features are not constraining the number of words or type of information you add, but again participants publish information that is sufficient for the other participants to make a decision to bid or not to bid for the ride-sharing. Trust is the strong believe in the reliability of the group. We could see a community trust that what is published in the posts or shared through the messenger will be realised. During the interview's interviewees had hard time to identify when something which was agreed was not delivered. Finally, multiple exit points mean that you can leave Facebook at different points and continue the organisation of the ride-sharing through mobile conversations. For example, first exit point could be if the post contains the mobile phone, the second is if you're not satisfied with the profile of the person behind the offer/request and third when the mobile phone's number is exchanged through messenger.

What we identified that is not done through Facebook, at this stage of analysis, is: i) arranging the price for the trip. In none of the post there is information about the price. The price is socially constructed, no one knows when, but "“everybody knows it so you do not need to share it”. ii) Facebook is not involved in the transfer of money. This is done on site, in cash at the drop-off point. iii) There is no review of the drivers and the passengers. The features like “Like” are only sporadically used and mainly to promote the post, but not to review the driver or passengers after the ride-sharing. Some incidents are discussed in the group, but this is also very sporadically.

6 Discussion

This research-in-progress paper explores the practice of ride-sharing that is realised through Facebook although Facebook is general social media platform lacking features for organising ride-sharing. We think that this is a non-usual case and as such it can help us to better understand the mechanisms behind the sharing economy where there are non-dedicated platforms. On a theoretical aspect, we make contribution by demonstrating the usability of the affordance theory for developing context-based theories of effective use (Burton-Jones and Volkoff, 2017) and the benefits of using affordance-actualisation lens (Strong et al., 2014). Finally, we demonstrate that the affordance theory can be also used in a community setting with no dedicated platform.

To improve and validate the results we will continue the interviews and increase the number of interviewees. We will extend to nethnographic research and will become participants in the ride-sharing. During the preliminary research we have identified that one of the groups is most active and we will focus our research on it.

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Internationalization of students' learning using online technology: Lessons learned

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Abstract The global nature of business has increased the importance of students' international experience during their studies at the university. Using interactive technologies the projects investigated ways to increase students' motivation to take responsibility for the learning process by creating "real" international co-creation experience online. This paper presents learnings from two consecutive international collaborative teaching between Edith Cowan University, Australia, and Umeå University, Sweden, in 2017 and Edith Cowan University and the University of Rijeka, Croatia, in 2018. Feedback from the students showed they enjoyed working across cultures and academic discipline on simulated products and marketing campaigns. Issues raised included: the need to explicitly explain how all parts of project is going to work and how the students execute their role. Incorporation of a formal introduction process for the students in each location so all students have the same knowledge about each other. Furthermore, the provision of real-time opportunities to collaborate in lectures and the setting joint deadlines between the units are of importance. Despite some of the shortcomings of the project, it has provided a firm foundation for the refinement of ongoing collaborative teaching.

Keywords: • Higher education • Online technologies • International collaboration • Learning experience • International •

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1 Introduction

The global nature of business has increased the importance of students' international experience during their studies at the university (Guillotin, 2018). Even though students, most often, have the option to study part of their education abroad, this is not possible for all students. However, the proliferation of interactive technologies now allows for international virtual collaboration. This paper gives insights and from a project with the aim to give students international experience without going on exchange studies. The projects were designed to investigate the possibility of increasing students' motivation to take responsibility for the learning process by creating "real" situations (DuHadway & Dreyfus, 2017), in this case including international co-creation experience without having to travel abroad.

Over the past 5 years, there has been an increasing number of on online collaborative tools introduced into the business environment with a range of specialty functions such as file sharing, video conferencing, and communication. Products such as Slack; Yammer; Dropbox; Google drive; Skype and Zoom have become commonplace. There has also been a spill over from personal social media into the business realm with social platforms, such as WhatsApp, WeChat, Facebook Messenger, LinkedIn and Viber now becoming commonplace. The use of online virtual collaborative technology has become central to current business practices especially in Australia due to its physical isolation. While most students are familiar with the array of social media channels for personal interactions, they are less skilled in using online collaborative tools in a professional business setting. Online collaborative tools are now used in the workplace to interacting with colleagues; crowdsource ideas; create innovative marketing content; and engage potential customers (De-Marcos et al., 2016).

In order to improve students' skills a professional and international context the students participated in an international online collaboration through digital platforms to provide students with a globally relevant and transformative social learning experience (Cela, Sicilia, & Sánchez, 2015). The project was devised to exposed students to the business practices of collaboration, co-creation and crowdsourcing to improve their career readiness. Involving students in an international collaboration was designed to increase students' exposure for different cultures and business practices by working with students from another country. It was also structured to improve students technical skills in the use of online collaborative tools in a business setting, which it was hoped, would develop their employability through the co-creation of a product and digital marketing content for an international audience. Furthermore, in one of the collaborative projects describes below, the students also were exposed to interdisciplinary collaboration.

2 Collaborative Project 1: Umeå University - ECU collaboration

A collaborative curriculum was developed combining a Marketing unit (Current Issues in Marketing) at Edith Cowan University (ECU) and an engineering unit (Prototyping for Mobile Applications) at Umeå University. The project incorporated a number of steps that interwove between the two units, with information being exchanged over the semester. As the semesters between the two Universities did not coincide, the ECU students commenced work on the project four weeks before the Umea students.

The challenge in the design of this collaborative curriculum was that the students must be able to finish their unit in case of collaborative problems. Hence, there was no total dependence between the two units and the lecturers used ad hoc flexibility over the course of the collaboration. It was also decided not to give the students all information about the project at the start of the units but rather on a need-to-know basis.

Collaboration process entailed the ECU students forming teams and created an online public blogs containing information drawn from academic and industry literature relating areas of marketing innovation such as smart home technology, connected devices, online media, gamification and environmental sustainability. The blog post formed part the ECU students' assessment for the unit. Then the students at Umeå University students reviewed the blog posts as part of their preliminary research for which they developed their Mobile apps. ECU and Umeå University students used Slack to exchange information and ideas about the app that are being prototyped by the Umeå University students. Umeå University students created a video about their proposed apps in English and posted it on Slack for the ECU students. Using information supplied by the Umeå University students the ECU students develop an informational marketing video around one of the app prototype they select from those present by the students from Umeå University in Sweden. These presentations form part of the Umeå University students' assessment and was marked by the teaching staff at Umeå University. The ECU students created marketing collateral including a product Facebook page, promotional video and linked back to their and a post on their blog announcing the launch the product. These marketing material formed part the ECU students' assessment for the unit and their processional portfolio.

2.1 Assessment of the collaborative project

The student review of the project showed that they liked the idea of the project but a more structured approach would be beneficial. Students on both sides of dyad often struggled with the unknowns, as they were reliant on students half a world away. However, from the communication platform it could be observed that the students exhibited skills in finding solutions and workarounds to complete their assessments.

Experiences and learnings from the project include:

1. The need to explicitly explain how all parts of project is going to work and how the students execute their role,
2. Supervise a formal introduction of the students in each location so all students have the same knowledge about each other,
3. Provide real-time opportunities by setting Swedish lectures in the morning and Australia lectures in the afternoon, and
4. Set joint deadlines between the two units and make clear the consequences of failing to meet deadlines.

Challenges during the collaborative project included, stilted exchanges on issues due to time differences, differing understandings of cultural priorities and aligning the timing of assessment of the units' requirements. However, benefits to the students included, experience to give and receive feedback, experiencing a new business culture and technologies, development of online media skills and having to solve real world problems. For the Australian students an added benefit was the visit to Perth of one of the Swedish teachers, which supplement their online experience. This may have contributed to a greater positivity toward the project reflected in their unit evaluation.

3 Collaborative Project 2: ECU-University of Rijeka Collaboration

As part of the implementation of new marketing unit called Social Media Marketing at ECU in 2018, a collaborative teaching project was established with the University of Rijeka, Croatia, related to Faculty of Economics and Business and the course Business to Business Marketing.

To assist with the local and international collaboration the "Social Studio Digital Hub" Facebook page was established to facilitate information and cultural exchange. The ECU students wrote marketing blogs about the Kvarner Region of Croatia, in which the University of Rijeka is located. Some of the ECU students posted their blogs on the Social Studio Digital Hub Facebook page, where some ECU and University of Rijeka students have commented on the content of the blogs.

It was originally intended that the University of Rijeka students would also view and comment on the ECU students' posts on the Facebook page however once again the students required a an assessment to motivate them to comment on the ECU blogs. To facilitate feedback on the ECU blogs, the University of Rijeka students participated in a workshop where they reviewed over 50 ECU blogs. As part of the process the University of Rijeka students developed a rating system for marketing blogs, which they applied to the ECU blogs. Rating criteria focused on blog appearance, information provided and perceived effort authors put in creating content. The main feedback was related to the poor user design of the blogs and lack of detailed information on the blogs.

In their second assessment in the Social Media Marketing unit, the ECU students had to create a social media marketing plan for a company from the Kvarner region. As part of this assessment, the ECU students need to read and incorporate all relevant feedback from the University of Rijeka students. Through SalesForce, ECU students viewed the marketing analytics on their posts and improve their campaigns, thus having a 360-degree view of digital marketing. The marketing insights gained from SalesForce enabled the students to create a more targeted and measurable social media marketing plan for a company on which the students had selected. This online collaboration exposes the ECU students to feedback from peers half a world away. It also designed to illustrate the complexity of online and international interactions, which are part of the globalized economy in which our students will work.

The outcomes of this project include providing students with the opportunity to develop digital marketing skills that will make them more competitive in the industry as they graduate. Additionally, the online collaboration exposed the ECU students to feedback from peers from another country and illustrates the complexity of online and international interactions that are part of the globalized economy. Most of the ECU students were very engaged in the project and enjoyed having feedback form peers form another country and the opportunity to take on the persona of a travel blogger. However, some of the ECU students questioned why they had to focus on an international location rather than a domestic market.

3.1 Assessment of the collaborative project

The University of Rijeka students evaluate their collaborative experience as moderately satisfied. But they are willing to participate in similar collaborative project again due to exposure to different cultures, communicating with students from another university as well as this activity was for them fun and refreshing in their curriculum. This activity was rated as interesting and exchange of information between different countries as well as because of being exposed to innovative way of teaching. They pointed out "the university should always come up with new projects and make things different than usual".

Benefits from this collaborative project from the students' perspective include internationalizing their learning experience, improving their English language skills, being involved in new way of teaching, communicating with other students and teamwork. They also pointed out that "it was cool to see that your student get tasks that are really based on practical work and not just theoretical". One student pointed out as positive that at the end they got the chance to meet one of the professors from ECU.

Most of the University of students did not perceived this collaboration to be frustrating. But some students pointed out "language barriers" that made him/her slightly frustrated about collaborative project. Still, they proposed some interesting improvements like video calls, more feedback, interpersonal communication between students or making it more complex task with aim to learn more. Some, elements that they suggested were planned but due to time zone difference they were demanding to actually implement them. Video reflection from an ECU professor was included in class lectures but one students pointed out that video should have been of higher quality and that sound was not quite understandable. All students pointed out that task was clear, understandable and could really evaluate effort that ECU students invested in creating Kvarner region blogs.

Experience and learnings from the collaborative project include:

1. Activity is perceived as interesting, fun and new perspective in teaching
2. Innovative approaches that include new ways of teaching and/or international collaboration are welcomed
3. More feedback is needed and students would appreciate more contacts with ECU students either video communication or through more extensive collaboration with ECU students
4. Have to think how to solve time difference to have more personal communication between students in classes.

Outcomes from this collaborative project included students' benefits like more international exposure, more exposure to different culture and improved language skills. Criteria they developed to evaluate blogs helped them to consistently evaluate more than 50 different blogs about Kvarner region that ECU students wrote. At the end students were satisfied with this project and would participate again in a similar project with more real-time collaboration between the students.

4 Conclusion

Analyzing the project among teachers involved, revealed some challenges, however all teachers consider that this type of international collaborative curriculum can benefit the students (cf. Chang & Lee, 2013). Challenges during the collaborative project included, stilted exchanges on issues due to time differences, differing understandings of cultural priorities and aligning the timing of assessment of the units' requirements. However, benefits to the students included, experience to give and receive feedback, experiencing a new business culture and technologies, development of online media skills and having to solve real world problems. To further strengthen the collaboration between the teachers in the collaborative project between Umeå University and ECU, a face-to-face meeting and collaboration was also arranged in Perth in addition to the virtual collaboration (cf. Lin, Hu, Hu & Liu, 2016). This was also an added benefit for the Australian students since the last feedback could be given on site. This may have contributed to a greater positivity toward the project reflected in their unit evaluation. For the students from University of Rijeka, a visit from one of the ECU teachers was perceived as added benefit.

Universities that focus on collaboration (Srikanthan & Dalrymple, 2002) and internationalization, solving real-life problems like case studies (Damnjanovic & Novcic, 2011) is positively influencing perceived quality from student perspective. This could influence not just future enrolment of students but also perception of the University's quality among other stakeholders, such as the industry. Hence, implementing collaborative real-life projects in teaching process influences not just students' curriculum but also marketing environment as well and consequently helps universities to acquire a better position in the educational landscape.

This project is ongoing and during spring 2019, the Umeå University-ECU collaboration will have a second try with another collaboration between an engineering unit in Sweden and a marketing unit in Australia. The overall aim during this project is further refine the process and find better touch points between the students that provides both short-term value (perceived by the students within the timespan of the unit) and long-term value (perceived by the students in their future profession) for the two different student groups. Also, for assessing collaboration project in future the same evaluation criteria will be applied in Australia, Sweden and Croatia.

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An Approach for Secure Data Transmission in a Distributed Production Environment

MATEJ VUKOVIĆ, CHRISTIAN KITTL, JÜRGEN MANGLER & STEFAN THALMANN

Abstract The exchange of data along the supply chain can be viewed as one of the key characteristics of advanced manufacturing concepts, frequently labeled as industry 4.0 . Intelligent products produced in shorter life cycles, increasing cost and quality pressures from global supply chains, increasingly complex regulatory requirements, as well as decreasing costs of advanced sensors are major drivers for this trend. Large amounts of data generated as a by-product of this trend represents an opportunity for advanced data analytics. However, the exchange of data across organizational boundaries bears also the risks of being in the focus of cyber-attacks. In this paper, we tackle the challenge of securing the data transfer in an Industry 4.0 environment. We first identify the security requirements within our use case. Based on these requirements, we present an approach for secure data transmission and discuss how our solution meets the identified requirements.

Keywords: • Digitalization • Secure architecture • Data transmission • Production environment • Encryption •

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1 Introduction

The exchange of data along the supply chain can be viewed as one of the key characteristics of advanced manufacturing concepts, e.g. industry 4.0 (Kagermann, 2015). Intelligent products produced in shorter life cycles, increasing cost and quality pressures from global supply chains and increasingly complex regulatory requirements are major drivers for this trend (Kache & Seuring, 2017). Additionally, inexpensive sensors enable companies to collect more and more data about even more diverse aspects of their production lines and affordable cloud-based services to store or compute these data. This however leads to big data sets which cannot be processed by human experts anymore. For this purpose, data analytics promise huge advantages. However, the exchange of data across organizational boundaries bears also the risks of being in the focus of cyber-attacks (Stjepandić, Liese & Trappey, 2015) or the risks of losing competitive knowledge or of revealing business insights to other companies or even to competitors (Ilvonen et al., 2018). Both threats (1) to be a possible target of a cyber-attack and (2) not to know which business insights or critical knowledge an external part can derive from shared data are major concerns of organizations in general (North et al., 2019).

To allow digital innovations by fostering digitization, companies have to balance the benefits expected from digitization and the risks may arising from those technologies (Thalmann & Ilvonen, 2018). As manufacturing data is the core of manufacturing companies' competitive advantage, security systems need to be developed to prevent unauthorized access to data and thus to reduce the risk of digitization (Thoben, Stefan, & Wuest, 2017). The challenge in this regard is, that data comes from different types of Internet of Things (IOT) devices and sensors and all of these devices need to be connected but often they are not designed with security in mind. As a result of this situation, the connection between these heterogeneous systems is often vulnerable, especially in a cross-plant scenario.

In the work of (Priller et al., 2014) migration of the existing industrial devices into the world of Smart Services was discussed and initial guide was developed for establishing efficient and secure interaction between different production subsystems. (Maritsch et al., 2015) show the superiority of MQTT over other protocols for the secure device connection in the context of smart factories. In the work of (Lesjak et al., 2015) a connection between devices on the field and the message broker was discussed. After it was shown how to securely connect and authenticate devices, an approach for data encryption on a single device was proposed in (Lesjak et al., 2016). (Maritsch et al., 2016) propose different message broker architectures. However, neither of them can be applied in our use case for various reasons (existing data transmission mechanisms in place, customer owns the data storage, etc.). Hence, we want to investigate how a system architecture can look like enabling easy integration into an already running shop floor.

2 Methodology

In our research we are following a Design Science Research Methodology (Hevner et al., 2004) (Clarke, 2017) (K. Peffers et al., 2007). In the relevance cycle we have identified the challenge of securing the data transmission within the Industry 4.0 use-case. Specifically, we investigated the case of the Smart Factory Vienna and first identified the security requirements. In our design cycle, we defined the requirements and the objectives of the new solution in the Use-Case section of this paper. In our rigor cycle, we researched the literature for existing solutions and approaches suitable for our identified design problem.

The current architectural solutions did not satisfy the requirements and objectives of the current use-case. Hence, we designed and developed a new architectural solution for the secure data transfer that is described in detail in The Proposed Solution section. This solution is then demonstrated in the "Pilotfabrik Industrie 4.0" and will be evaluated in the future work.

3 Use-Case

The "Pilotfabrik Industrie 4.0" in Vienna is a demonstrator plant that also produces parts for customers. Artefacts to exemplify production in the context of this paper are:

- EMCO MaxxTurn 45 lathe, integrated OPCUA server.
- ABB IRB 2600 industrial robot, ABB specific interface.
- Neobotics AGV, proprietary REST interface.

- UI to enter part measurements running on a Raspberry PI 3B+, proprietary REST interface.
- Inateck QR Code Scanner connected to a Raspberry PI 3B+, proprietary REST interface.

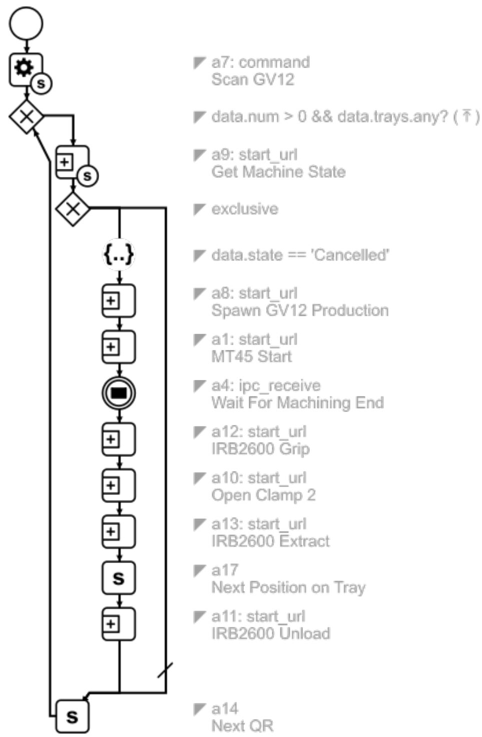

Figure 1

Artefacts consist of hardware and software that either produces data streams, or can be polled for data points. Each Artefact is wrapped by an adapter that pushes the data stream to an Extensible Messaging and Presence Protocol (XMPP) server, where it is available for consumption. The individual artefacts are independent, they do not know anything of each other. All logic how the machines interact are handled by a cloud based cell orchestration solution, in this case by centurio.work (Pauker, 2018). Centurio.work instantiates and executes process models, in order to (1) produce a specific part, (2) collect data from all participated artefacts during production, and (3) ensure that all artefacts work correctly together during production. On the left-hand side an example process is depicted. In the example process an operator scans a QR code, which results in the production of a batch of products, which are loaded on to a tray on top of an AGV. The AGV the delivers the batch of parts to the operator which can measure the compliance with tolerances, and separate good from bad parts.

The network inside the Pilotfabrik is in a demilitarized zone (DMZ) and deemed problematic, as many parties share same network / have access to network ports.

Based on this setting the following requirements can been elicited:

- Low Latency / high performance: the collected data is used to coordinate Machines, and to show real-time data about the production. The machines produce up to 2 MiB per second.
- Tamperproof Data Flow: the customers demand a detailed protocol about production for long-time warranty issues. Furthermore, tampering with data could lead to potentially fatal decisions for the interaction between the machines.
- Quality of service has to be ensured.
- Identity spoofing / man in the middle attacks should be prohibited by introducing transport layer security, and end-to-end encryption.

All the machines are configured so that the above-mentioned wrapper is the only means of accessing the machine. The wrapper is thus necessary to (1) deny access to potentially insecure resources, (2) deal with no-routable protocols.

4 The Proposed Solution

In this section we describe our proposed architecture of our approach and how it satisfies the requirements defined in the use case. In the following text our approach is described in a single tenant context. However, multi-tenant application is possible with minimal extensions to the proposed architecture. Overview of the architecture of our approach is shown in the figure 2.

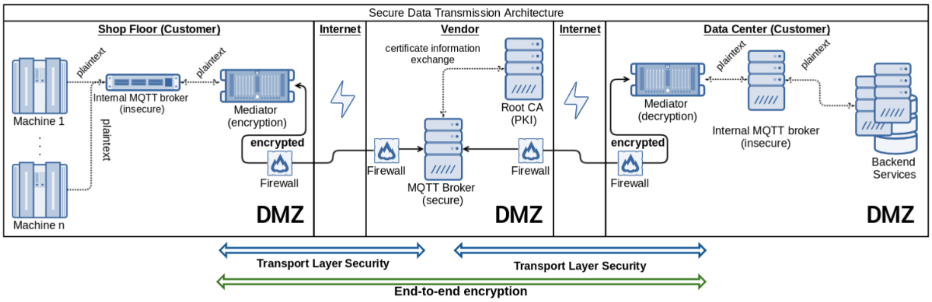

Figure 2 Architecture of the proposed approach

To satisfy the requirements defined in the use case we developed a secure data transmission infrastructure based on Message Queuing Telemetry Transport (MQTT). MQTT is providing a lightweight publish/subscribe message transport (Lampkin et al., 2012). We base our work on top of solutions proposed in (Lesjak et al., 2016), (Maritsch et al., 2016), (Priller et al., 2014) and (Lesjak et al., 2015). Selection of this technology reflected on other elements of the proposed architecture. Aside from the selection of MQTT as a base communication technology, architecture was designed around non-intrusiveness and ease of integration into the currently running system. In this sense customer sends and receives the data in non-encrypted, plain text form and message encryption, message decryption, message integrity, client authorization and other security tasks are handled by the subsystems of the secure data transmission architecture. Data exchange is secured in two layers.

In the first layer data is secured using Transport Layer Security (TLS). This protocol provides data encryption, data integrity checks and client authentication on the transport layer. Client authentication is required whenever one of the clients initiates a connection to the message broker. Using this mechanism, we make sure that the subsystems on both endpoints are authenticated and only selected subsystems can send or receive the data. However, this layer only secures single connections, as single connections are secured, by using only TLS data is decrypted when received by the broker and encrypted again when establishing the connection with the subscriber. To prevent from data being exposed in the scenario of the broker being compromised we introduce second security layer to the architecture.

Second security layer in the proposed approach is end-to-end encryption. In this layer devices that publish the data have predefined set of recipients and their public keys which they use to encrypt the data and create a so-called envelope. For each of the recipients, data is encrypted with their public key and upon receiving the data they can decrypt it using their private key. This approach creates a reasonable overhead that is a result of the multiplication of the encrypted data. Multiplication of data is happening because the encrypted message is created for each of the recipients defined on the side of the devices that publish the data. In our use case this overhead is avoided by using only one recipient that is the processing backend.
Our approach consists of several subsystems and in the following subsections these subsystems are described.

4.1 Message Broker

Message broker is a central component of our approach. Based on (Maritsch et al., 2016), we propose a new broker architecture making the integration as non-intrusive as possible and to leverage the advantages of the currently implemented infrastructure. The hybrid architecture uses one main message broker that contains a root Certificate Authority and two message brokers on the sending and the receiving end of the data transmission pipeline. Devices on the sending and receiving end of the architecture are located onsite in the DMZ. Message broker has two roles. On the one hand it mediates communication between MQTT clients (Lampkin et al., 2012) and is responsible for receiving messages, filtering and sending messages to the clients that are subscribed to them. On the other hand, within the infrastructure that message broker is running on, a Public Key Infrastructure (PKI) is created and it contains a root Certificate Authority. Root Certificate Authority signs all other generated certificates for each of the devices and clients in the data transmission pipeline. This results in a secure and trusting architecture where all of the clients must be authenticated by the certificate signed by the root Certificate Authority. If the client is not authenticated the connection to the message broker cannot be established.

With these mechanisms in place this approach allows only predefined clients to connect to the message broker and only predefined message receivers to decrypt the data. To make the integration efforts low no topics were defined in the message broker.

4.2 MQTT Clients

In our approach MQTT Clients represent subsystems that are in charge of sending the data (publishers) and receiving the data (subscribers). Both are single-board computers that have enough processing power for the tasks of encryption and decryption and running a Linux distribution.

For the devices that are sending the data we use a concept called Mediator (Priller et al., 2014). A Mediator is a gateway device that provides a modular extension to existing machines. It includes necessary computation and communication resources and can be connected with the machines via several interfaces. Usage of the Mediator addresses the legacy aspect of the machines by extending their functionality by enabling them to connect to the internet and encrypting the data. It also addresses the transparency aspect by enabling the customers to filter the data and select what do they want to transmit. Mediator device aggregates the production data produced by the machine, encrypts it, establishes the connection with the message broker and sends the aggregated data to the message broker.

5 Conclusion and outlook

Within this design science project we tackled the challenge of securing the data transfer in an Industry 4.0 use-case. We have developed an design artefact that satisfies the identified requirements. In our use case four requirements were defined: (1) low latency and high performance, (2) tamperproof data flow, (3) quality of service, (4) prevention of identity spoofing and man in the middle attacks. First requirement, (1) low latency and high performance, is addressed in related work (Lesjak et al., 2016) and proposed architecture and mediator devices provide reasonable and acceptable overhead. Second requirement, (2) tamperproof data flow, is addressed from several aspects. One aspect is TLS encryption and client authentication which ensures that only defined clients publish and subscribe to messages. Furthermore, end-to-end encryption ensures that data is transferred in the original state and no changes can be made to it without detection. Finally, mediator devices are connected to the machines via non-routable protocols and in the case of this devices being compromised, attacker is not able to penetrate the network. Requirement (3) quality of service is addressed by-design as a part of the MQTT protocol. Last requirement, (4) prevention of identity spoofing and man in the middle attack is addressed with the usage of TLS and client authentication and end-to-end encryption. Client authentication enables connection establishment to only those clients that have certificates signed by the root Certificate Authority. TLS on the other hand secures the connection to the message broker and from the message broker and encrypting and enveloping the data from sending end to the receiving end ensures that only receiving client can decrypt the data.

In future work we want to evaluate and benchmark the architecture in the pilot factory "Pilotfabrik Industrie 4.0", starting in June 2019. The system evaluation will be based on measuring the impact of securing the data transmission infrastructure compared to the insecure data transmission. Especially impact on the data velocity, volume and latency.

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The Integration of Data Science into State-of-the-Art- and Future- Business-Information-Management Concepts

ANDREAS JÜRGENS

Abstract The goal of this submission is to review my research approach regarding the Data Science discipline, present preliminary results and discuss the sensibility and next steps. This work mainly focusses on the problems arising from recent development of the Data Science discipline. The value and potential of data analysis is evident, but many companies and organizations struggle establishing new methods and technologies in existing structures. It seems to be obvious, that the immense speed of technological development is challenging. But besides the technological aspect, the organizations must adopt new working modes for more intensive cooperation and interaction. To formulate a possible future attempt to face those problems, it is not sufficient to only focus on technological concepts. The information management hand handling must be reviewed and adjusted as well. This leads to the preliminary title of my PhD thesis: The Integration of Data Science into State-of-the-Art- and Future- Business-Information-Management Concepts.

Keywords: • Doctoral Consortium • Data Science • Information Management • Big Data • Data Analytics • Text Mining •

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1 Introduction

The volume and variety of data have grown rapidly in recent decades and tools and methods have been developed accordingly.(Gandomi & Haider, 2015; Larson & Chang, 2016; Sirin & Karacan, 2017) Today we are faced with an overwhelming zoo of tools and methods to utilize the potential of data. Numerous articles have been published in scientific journals explaining and discussing terms, technologies and applications.(Buchkremer, 2015; Davenport & Patil, 2012; Gampfer, Jürgens, Müller, & Buchkremer, 2018; Hayashi, 1998) Today you can find various different visualizations, naming different topics and showing their development and relationship. It is noticeable that the representations differ greatly and that there does not seem to be a uniform definition. Rather, different topics mix, which are differently pronounced depending on the context and focus of the author or the paper.(Chee et al., 2009; Provost & Fawcett, 2013)

Besides this overwhelming technological side, many institutions seem to be unable to adopt the new technologies and implement it permanently in their daily business. Many authors indicate the benefits, but it seems to be challenging, to integrate new technologies in existing organizations.(I. J. Chen & Popovich, 2003; Ngai, Xiu, & Chau, 2009a; Phan & Vogel, 2010) This leads to the hypothesis, that the integration of technology is not sufficient to develop to a data centric organization.

Reviewing the recent changes in the recent decades, the technological landscape of data analytics has changed radically. Organizations doesn't seem to be able to adopt this technologies in their information management concepts.

In my PhD thesis, I want to develop an integration concept for data science architectures in current and future business information management concepts.

2 Problem definition

The development of Data Science has been an immense evolutionary step within the recent years. It brought a zoo of tools and services, offering and mixing applications and services and indicating new inventions with new names and terms. Today we face Big Data, Cognitive Services, Artificial Intelligence, Advanced Analytics and Deep Learning Systems without being able to name the differences.(Bhardwaj & Singh, 2017; Larson & Chang, 2016; Lavalle, Lesser, Shockley, Hopkins, & Kruschwitz, 2011; Sirin & Karacan, 2017) Besides this brand names and commercial definitions of technologies and services, people don't have a proper understanding about the scientific development of the recent years.

Without a proper understanding the integration into current and future organizations and business information management concepts will not be easy or even possible.

My PhD thesis therefore is divided into THREE empirical parts, each contributing to the respective topic to a certain extend. The first aspect is the Data Science discipline. Several different definitions can be found and all of them differ to a certain extend. Most mix different disciplines and bring in new or combined terms often motivated by companies bringing up a unique name like a trademark. This leads to misleading information, confusions and issues naming and identifying the scope and focus of this discipline. There as several review papers, providing a limited view on a certain discipline, but all of them only handle a few papers and a limited point in time. In order to obtain a clear picture of the scope, the derivation and the future orientation of this field of research, a comprehensive literature research is carried out in the first empirical part including all available literature. The aim of this literature research is to obtain a conclusive picture of the origins, current situation and future orientation of this field of research, so that in the further course of this work a link with the field of information management can be demonstrated. This holistic and general review on literature has not been provided ever and summarizes all available papers on a high level.

The second empirical part focusses on the Information Management Concepts. Many companies find it difficult to make information in their internal structures accessible in such a way that all employees who need and are likely to use information can do so. Many projects and processes are already limited in their beginnings and can therefore only achieve a limited result or deliver it later than would be desirable and possible. In the second empirical part of this paper we will examine to what extent information management is considered in research and whether scientific findings correctly address the problems in companies. In a comparative analysis, it is determined to what extent the topics of the scientific publications differ from those discussed in the business community or business associations. This is to support the fact that the research is able to examine actual problem definitions and to supply with appropriate solutions. Such comparative literature searches could not be found at present and represent an extension of the scientific knowledge on this level.

In the third part of this thesis, it will be examined to what extent there are already process models according to which data analysis processes can be carried out in a structured manner. It is questionable which models already exist, which strengths and weaknesses they have and whether they are actually applied. If certain models are preferred to others, this indicates a good problem-solving competence of the corresponding model. It is possible, however, that no known model will be used in reality. Then it would be important to understand whether it is due to the lack of knowledge of the users or to shortcomings in the models. If there is no model that can be successfully applied, a new model might have to be developed to meet the requirements of the users and to implement the methods coherently and sustainably. This analysis is only partially carried out by a literature analysis. The focus is on a survey addressed to project managers who already have experience in managing data analysis projects. This contribution will help researchers to identify the problems that arise in practical use. Depending on the findings of this empirical chapter, a proposal will also be developed that could solve the identified problems. The evaluation of such an adapted method could be done in further research.

The overall result of this work is expected to be a concept that addresses and solves the current and future problems of information management in an appropriate data science infrastructure. For this purpose, adapted process models will be developed, if necessary, with which researchers and users will be able to use analysis methods better and more reliably in the future. This contribution is also an important gain for the scientific community and industrial users.

3 Methodology

Various scientific methods are used to address the various problems.

In order to describe the origin of the term data science, a classical literature analysis is first carried out, which is primarily based on review papers, since these already focus on the historical development and linkage with other subject areas. Subsequently, a systemic literature search is carried out. This is realized with the support of modern data analysis methods, as the expected amount of several thousand scientific publications cannot be efficiently read and evaluated manually. Methodically, this chapter therefore focuses on manual and systemic literature research. To this end, it draws on methods that have been developed, evaluated and published as a by-product of this work. The STIRL method, which describes a complex analysis of texts and documents, should be mentioned here.

In order to define the scientific scope of the topic Information Management, a comparative literature search is carried out. This is only partly based on the methods discussed in the previous topic area. The focus here is on the comparison of topic development in scientific research and practical application. The main topics in the real application are extracted from publications of the industry associations. The main aim is to identify different topics.

In the third part, the analysis of the procedure models, the focus is on the survey of experts in the form of a survey after an introductory literature search. This survey is aimed at project managers who already have experience in the field of data analysis projects. The identification of these experts is problematic as there are currently only limited numbers of experts.

The structure of this research work was visualized in the following diagram to further illustrate it table 1:

Table 6: Structure of the PhD Thesis

Chapter	Topic
1	**Introduction**
2	**2. UNDERSTANDING DATA SCIENCE DISCIPLINE** 2.1 Historic development of Data Science 2.2 A systematic literature on 20 years of scientific literature 2.3 Reporting the Review 2.4 Focus Changes of Data Science related topic within the recent 20 years 2.5 Future Development of Data Science Disciplines
3	**3. INFORMATION MANAGEMENT** 3.1 Understanding Information Management in scientific literature and business context 3.2 Evaluation of gaps in research and application of information management 3.3 Development of a future outlook to information management
4	**4. DATA SCIENCE PROCESS MODELS** 4.1 Overview about current Data Science Process Models 4.2 Evaluation of the potentials and challenges of Data Science Process Models 4.3 Results and Discussion 4.4. Summary and identification of gaps
5	**5. INTEGRATION OF DATA SCIENCE ARCHITECTURE IN CURRENT AND FUTURE INFORMATION MANAGEMENT CONCEPTS** 5.1 Summary of gaps in former disciplines 5.2 Approach to fill the gaps 5.3 Results and Discussion 4.4. Summary and identification of gaps
6	**Conclusion and outlook**

4 Preliminary/Expected results

To understand the Data Science discipline, the systematic literature review was performed, analyzing ~50.000 documents. The first result is a map of the terms and categories, which came up and developed over time. Founded on a classical literature review, the core topics could be identified, which formed the basis for creating the document set – the corpus.

The terms were ordered as a tree, showing the relation and development as a growing thing.

The roots of the tree – the foundation of the Data Science discipline, is 'Information Systems', consisting of the terms Management Information Systems (Jourdan, Rainer, & Marshall, 2008), (Negash & Gray, 2008), Management Support Systems (Baars & Kemper, 2008), Decision Support Systems (Chee et al., 2009; Golfarelli, Rizzi, & Castenaso, 2004; Jourdan et al., 2008) and Business Information Systems (Devlin & Murphy, 1988).

The trunk, which is mainly Business Intelligence (Ngai, Xiu, & Chau, 2009b), (H. Chen & Storey, 2012; Gibson, Arnott, & Jagielska, 2004; Waller & Fawcett, 2013), (Golfarelli et al., 2004; Jourdan et al., 2008), (Unger & Kemper, 2008), (Baars & Kemper, 2008; Lönnqvist & Pirttimäki, 2006; Negash & Gray, 2008), (Chee et al., 2009) and reflects the operationalization of the former concepts. Terms like data warehouse, data mining and text mining are related here. Parallel to the term Business Intelligence the term Artificial Intelligence came up. Although this term had its foundations much earlier and was already defined around 1950, the development of this term and its relation to relevant topic blocks only came up later. In the beginning Artificial Intelligence was a concept to reproduce the human brain in a computer. This should enable research on the brain and mental illnesses. In the course of its evolution, the category AI only later received stronger connections to data analysis and machine learning.

For this reason, we have them in the evolution tree parallel to the area of Business Intelligence, which together lead to the new category Big Data. Waller and Fawcett refer in their publication to topics such as Big Data and Predictive Analytics (Waller & Fawcett, 2013). They also refer to topics such as Advanced

Analytics, which were discussed in more detail by Barton and Court (Barton & Court, 2012).

Therefore, we ordered the category Analytics as the branches from Big Data.

In parallel we identified terms like machine learning and deep learning and ordered them in the category learning. We learned, that my authors identified the relation of topics and the interaction so other technologies, but there was no paper providing a holistic overview about the development and interaction of the respective disciplines. The review led us to a good understanding of the development of the terms and categories and allowed us to draw the evolutionary tree of data science in the following figure:

Figure 9: Evolutionary tree of Data Science: relation and development of terms and topics

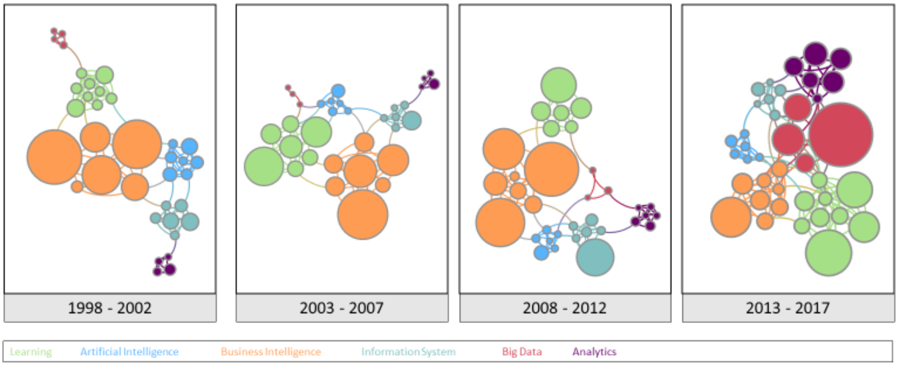
With a complex text analysis, each category was examined to derive the development within each category. In addition, the interaction with other categories was analyzed, by identifying the change of topics over the categories.

Based on these detailed developments of the different subject areas, a unification and generalization of the subject areas and their overlaps could be named. It became apparent which disciplines have developed and described the different focus topics. It also became clear that the definition of the themes has changed over time. This results in new links and focus of the topics. The most striking changes are as follows: The predictions from data were formerly discussed in the context of Analytics, shifted to the Learning area and established themselves in the Business Intelligence area. Big data was initially defined as a problem arising from the sheer volume of information and the associated technological challenges. Today we talk about Big Data in connection with corresponding solutions and potentials. These are interwoven in different topics and show the integration of these solutions and the development of potentials.

Artificial intelligence developed from behavior research to human computer interaction.

The topic Artificial Intelligence changed significantly over the recent years. Formerly this topic focused on understanding the human brain and its interconnections to analyze the human behavior. This changed in the recent years. Computers nowadays shall understand not how the human brain things, but what the thoughts are. The topic highly focusses on the human computer interaction. AI shall help computers to understand humans and interpret their commands in context of the current situation. The terms used vary over time. They start with language interpretation and understanding facts, move to strategic behavior and games and lead to social society and communication. This shows how different the human computer interaction is understood in this category and how it developed.

It can easily be seen, that the topics were connected only very low in 1998-2002. Over the time the topics overlapped and established connections. AI, BI and Learning were the center first, then they included Big Data, Analytics and Information Science. Today all topics are interconnected and are one big group. In future this interconnection will be more intensive and the original category names will become more unimportant. Instead a new discipline covers all aspects and summarizes all topics in one. We suggest naming this overall discipline: Data Science.



Technical topics can be found, covering learning and clustering algorithms, technical models and technologies as well as the basic understanding of BI and decision making. Very interesting is the cluster healthcare, which was interpreted as an issue selecting the documents for the corpus first, but was proven correctly after detailed investigations. (Chawla & Davis, 2013; Onofrei, Hunt, Siemienczuk, Touchette, & Middleton, 2004; Verma et al., 2019; Waller & Fawcett, 2013)

We observed, that the topics changed significantly over time as you can see in figure 11. Former focus on BI understanding shows the early description of the demands and requirements of the business or management perspective. In the 1980's the discussion changed to algorithms and technical topics as well as to the decision-making process, which means the integration in the management processes. Later the focus changes to more technical focus and the attention to more upcoming topics and technologies. E.g. Social Media draws attention starting from 2000, showing the technological orientation matching the social media trend. (Corley et al., 2010; Voytek, 2017; Zeng, Chen, Lusch, & Li, 2010) The focus on more complex learning algorithms supports the demand in artificial intelligence. Security and privacy gains attention in the 2000's. Use cases and applications are discussed more intensively, supporting the fact, that the technology is present in today's environment.

This shows how the data science topic with all related focus point has developed into something new – we call this the metamorphose of data science, starting with specific topics, which develop and interconnect and cannot be individual topics anymore.

5 Future development

The next steps in my PhD thesis are the research in Business Information Management. Are the existing Information Management Concepts adequate for the current needs and requirements? It can be postulated, that there are requirements in business context and solutions offered by scientists. The first aspect to clarify would be: do the solutions, developed and discussed by scientist match the needs and requirements in business context?

I assume, that there are differences and alignment is required.

In addition, the Process Models regarding Data Science shall be evaluated. There are common process models like CRISP-DM, which was developed some years ago. It should be analyzed, if the process model helps to drive Data Science projects and integrate the technology into daily business processes or if adjustments are required, based on technological and organizational developments. This will lead to the core part of my PhD work.

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Intelligent personal assistants in business processes: Evaluation of a Prototype (V-IP-A)

DANIEL HÜSSON & ALEXANDER HOLLAND

Abstract Intelligent Personal Assistants are getting more important in business-processes. To address this requirement the Prototype V-IP-A was developed to work out three different workflows with speech-support in a business context: Briefing, Search, Explanation. As a key finding from previous researches, the task attraction was identified as the most important factor for user-acceptance. Based on this finding and the Prototype a questionnaire for evaluating the user-acceptance of different features was derived and presented in this paper to give an outlook for further research on this topic.

Keywords: • Intelligent Personal Assistant • Human-Computer-Interface • ERP • Machine Learning • Business Process •

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1 Introduction

With the rise of intelligent personal assistants (IPA) like Amazon's Alexa or Google's Assistant a new era of human-computer-interaction (HCI) reached the mainstream. (Pradeep Doss, Ankit Pal, 2018) Applications are empowered to interact via speech, enabling the users to trigger actions by voice-commands or give feedback to the users by speech-synthesis. The private use of IPA promotes the desire to use speech-interaction also in business-context. Business-Applications like ERP-Systems have to account this trend and accompanying research has to figure out, which IPA-Features are recognized as helpful in business processes. (Nishimura, Yamamoto, Uchiya, & Takumi, 2018; Saran, 2018)

Enabled by progress in natural language processing these types of features are accessible through frameworks with pre-trained models for speech-recognition and speech-synthesis, simplify the implementation of speech-interaction for developers and creating new opportunities for business workflows. (Chen, Hakkani-Tur, & He, 2016; Kepuska & Bohouta, 2018; Zeroual & Lakhouaja, 2018) As part of a research-project, an IPA-Prototype (V-IP-A: VEMAS [Vertriebsmanagement und Abrechnungssystem]-Intelligent-Personal-Assistant) for an ERP-System was developed (Hüsson & Holland, 2019). Setting up on this prototype an evaluation of the usage of the IPA will be worked out in this paper, to figure out what type of business processes can be supported by an IPA and what features are affecting the user-acceptance of the new HCI.

The focus will be set to three features in different workflows:

1. Briefing:
   The IPA gives a brief summary of the notes of the day, written by other users of the ERP-System

2. Searching:
   The user searches for Customers via speech-recognition

3. Explanation:
   The user opens a report via speech-recognition, the IPA displays the report and explains the shown data via speech-synthesis

The objective of this paper is to work out a research design to evaluate the IPA-features based on user feedback. To reach that target the current status of the prototype will be explained, the research method for the evaluation will be worked-out and a questionnaire will be derived.

2 Prototype Status

The IPA was realised as an additional add-on to the ERP-System and can be started via mouse-click on the microphone-button. The IPA appears and asks via speech-synthesis how to help the user (Figure 1: Startscreen intelligent personal assistant).

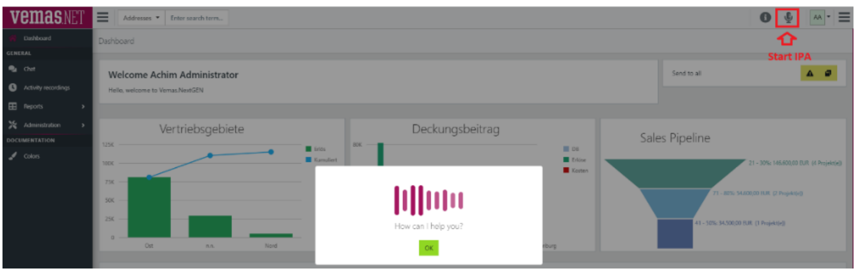


Figure 1: Startscreen intelligent personal assistant

The IPA now listens to the user's voice, records the speech-input and converts the spoken input to text. After that, the IPA proceeds the captured text to the Natural Language Understanding-Layer (NLUL) and the NLUL extracts the keywords. The keywords are being proceeded to the ERP-WebAPI and the command are derived and executed. In Case of a speech-synthesis output, the Natural Language Generation-Layer proceeds the text-output of the ERP-WebAPI and starts the Text-to-Speech output (compare Figure 2: Voice-Command-Handling).

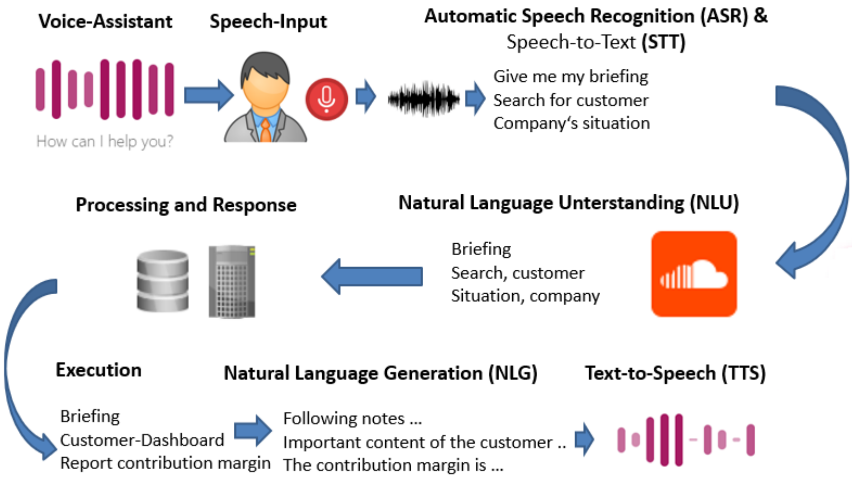


Figure 2: Voice-Command-Handling

In case the recognized keywords are not matching with a defined command, the IPA gives feedback via speech-synthesis and refers to the help for a list of all supported commands. If the triggered command needs a parameter and the IPA was not able to find the parameter in the text, the IPA will ask for specific parameters.

As stated in chapter 1 three features are implemented in the IPA and can be examined in this study-case. We will have a closer look at these functions below.

2.1 Search for Customers

By using the voice command *"search for customer"* followed by a customer's name the IPA is able to search customers by company name. If the search result is unique the System opens the Customers-Dashboard and shows detailed information like the company's address, all contact-data and the content of all notes (see Figure 3: Search with Result).

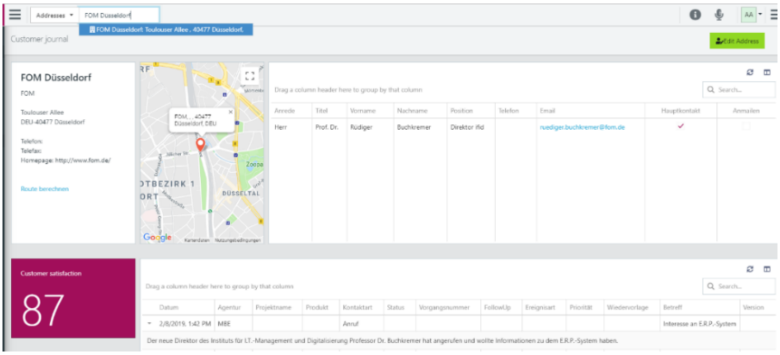


Figure 3: Search with Result

The challenge with searching by customer name is the spelling of the company's name. Usually companies have own names, not following any spelling rules, that makes it hard to validate the result. This issue is part of the research field of named entity recognition (Ertopcu et al., 2017; Zukov-Gregoric, Bachrach, Minkovsky, Coope, & Maksak, 2018).

2.2 Daily Summary

The daily summary can be triggered by the voice-command *"give me my briefing"*. The IPA reads out the notes associated with the (potential) customers, written by the users on the same day. This feature is relevant e.g. for sales representatives, to get an update of their customers at the end of the day. Every entry is being introduced with meta information, starting with the Name of the note's author, the date and time followed by the customer's name and the name of the contact person. After that, the subject is read out followed by the full content of the note.

For Example, a Note created by the fictitious user Melanie Becker on 8th February 2019 at a fictitious Customer FOM Düsseldorf will be read out like that:

> *"Note by Melanie Becker on February, 8 2019 01:42 p.m. at FOM Düsseldorf.*
> *Contact person: Mr. Rüdiger Buchkremer.*
> *Subject: Interest in ERP-System.*
> *Content: The new director of the Institute for IT Management and Digitization Prof. Dr. Buchkremer called and wanted information on the ERP-System."*

All important details are being submitted via speech-synthesis, to get a brief summary about important information about interests and customers.

2.3 Explaining Data

To Support users in interpreting complex reports, the explanation mode of the IPA was implemented. Based on the raw-data provided for reports the IPA summarizes and rates the data. The rating is configured in the ERP-System, giving boarders for judging values in a specific range. With the voice command "*show me the company's current situation*", the IPA opens a graphical report and expounds the displayed data.

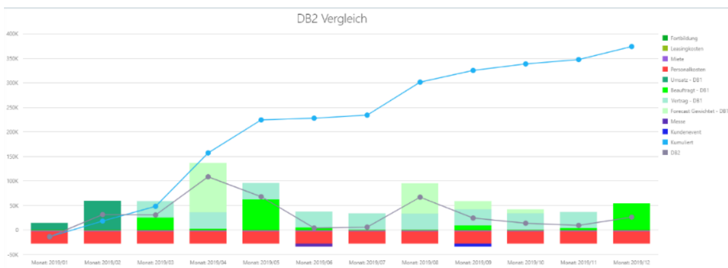


Figure 4: Report contribution margin

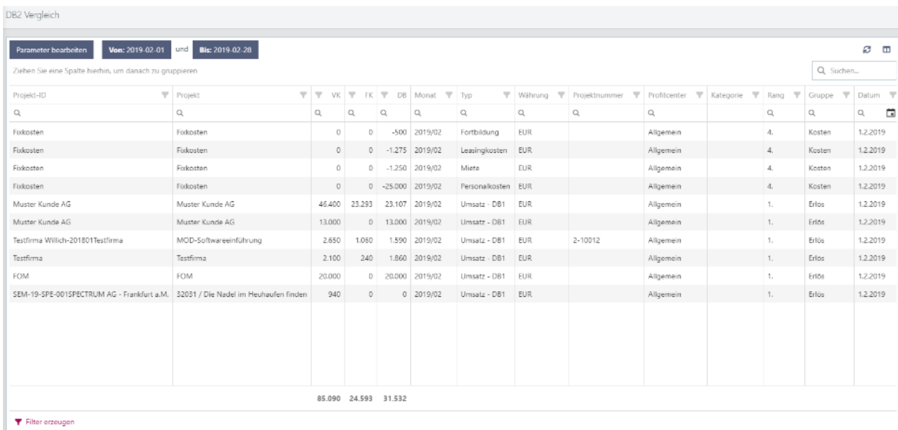
As presented in Figure 4 a graphic Report with bars and lines is showing the contribution margin in a specific timeframe, analysing the current revenues, the sales-forecast and costs. The IPA explains the content with the following readout:

> *"The current situation of the company is as follows:*
> *In the past, the January until February 2019 approx. 17.700 € as contribution margin. For the future March to December 2019 about 251.900 € are expected as Contribution margin. For the entire period January to December 2019 is the expected Contribution margin approx. 269,600 €. The contribution margin is higher than the Shareholder expectations. The highest costs are caused by: Personnel costs: 300.000 €. The Personnel costs are below the planned budget."*

The IPA compares the calculated values with the configured values to assess the company's situation reading the costs and revenues. The highest cost-category is determined and also compared with the configured value range, so the user can classify the result easier.

The user is also able to comprehend the summary with a Drill-Down triggered by the command "Show me Details for", followed by the name of the month, e.g. February.

The IPA shows a grid with detailed information about the costs- and revenues in the requested date span as presented in Figure 5. With the provided details the user is able to form his own opinion and overrule the IPA's interpretation.


DB2 Vergleich

Parameter bearbeiten | Von: 2019-02-01 und Bis: 2019-02-28

Ziehen Sie eine Spalte hierhin, um danach zu gruppieren

Suchen...

Projekt-ID	Projekt	VK	FK	DB	Monat	Typ	Währung	Projektnummer	Profitcenter	Kategorie	Rang	Gruppe	Datum
Fixkosten	Fixkosten	0	0	-500	2019/02	Fortbildung	EUR		Allgemein		4.	Kosten	1.2.2019
Fixkosten	Fixkosten	0	0	-1.275	2019/02	Leasingkosten	EUR		Allgemein		4.	Kosten	1.2.2019
Fixkosten	Fixkosten	0	0	-1.250	2019/02	Miete	EUR		Allgemein		4.	Kosten	1.2.2019
Fixkosten	Fixkosten	0	0	-25.000	2019/02	Personalkosten	EUR		Allgemein		4.	Kosten	1.2.2019
Muster Kunde AG	Muster Kunde AG	46.400	23.293	23.107	2019/02	Umsatz - DB1	EUR		Allgemein		1.	Erlos	1.2.2019
Muster Kunde AG	Muster Kunde AG	13.000	0	13.000	2019/02	Umsatz - DB1	EUR		Allgemein		1.	Erlös	1.2.2019
Testfirma Willich-201801Testfirma	MOD-Softwareeinführung	2.650	1.060	1.590	2019/02	Umsatz - DB1	EUR	2-10012	Allgemein		1.	Erlös	1.2.2019
Testfirma	Testfirma	2.100	240	1.860	2019/02	Umsatz - DB1	EUR		Allgemein		1.	Erlös	1.2.2019
FOM	FOM	20.000	0	20.000	2019/02	Umsatz - DB1	EUR		Allgemein		1.	Erlös	1.2.2019
SEM-19-SPE-001SPECTRUM AG - Frankfurt a.M.	32031 / Die Nadel im Heuhaufen finden	940	0	0	2019/02	Umsatz - DB1	EUR		Allgemein		1.	Erlös	1.2.2019
		85.090	24.593	31.532									

Filter erzeugen

Figure 5: Drill-Down-Function

To evaluate the use of the described Features of the IPA further researches with structured user surveys are necessary. The following chapter will work out a questioner to investigate the attitude of users towards the IPA and the presented features.

3 Research Design

This research is part of an extensive research project, analysing the impact of artificial intelligence on business processes in small- and medium-sized enterprises with a focus on IPA. Later on, questions like:

- Which type of reports and underlying data are explainable with an IPA using speech synthesis?
- What are the user-requirements for an IPA with speech synthesis for support decision in complex business processes like forecasting, controlling or project-management?
- What effects according to process-costs, process-quality and process-transparency does an IPA have?

will be answered, based on the current and following research steps. The first step is the evaluation of specific features of the IPA to work out the importance of the IPA-Support in different use-cases.

The research design is derived from previous researches of Han & Yang (Han & Yang, 2018) who analysed the user-acceptance of IPAs based on an online survey in the USA. The focus of their research was based on seven constructs:

- Task attraction
- Social attraction
- Physical attraction
- Security/Privacy risk
- Parasocial relationship
- Satisfaction
- Continuance intention

As the main result of their study, the task attraction (TA) is a key factor for satisfaction and satisfaction is significantly influencing the continuance intention. Beside the TA other studies are rating the security and privacy risks as an important factor towards the acceptance of an IPA. (Manikonda, Deotale, & Kambhampati, 2018) Due to the fact, that the IPA-Prototype bases on a framework – in our case implemented in Google Chrome (Glen Shires & Philip Jägenstedt, 2018; Wedekind, 2018) - and the limitation of small – and medium-sized enterprises in resources for basic research (Polyakov et al., 2018) the security and privacy risk cannot be influenced in a significant way by the research team.

With that conclusion, the focus of this paper is the evaluation of the TA towards the IPA-Prototype. To analyse the TA several features of the IPA –described in Chapter 2 – will be tested by experimentee. The experimentee are people with work experience and usage of ERP-Systems and will get a short instruction for the usage of the IPA. After these tests, the experimentee will be asked questions about the user-experience during the usage of the IPA to point out the most important features influencing the satisfaction and continuance intention.

3.1 Research Question

Based on the experience during the experiment, the participants are going to rate the three different feature-types (Briefing, Searching and Explanation) according to the usefulness in daily business tasks. To measure the use of the different features a 4-point Likert scale will be used to rate the experience from "meet", "rather", "rather not" to "does not meet". The even scale with no neutral option forces the experimentee to make a decision towards any feature. The participants have the option to write an annotation to add further hints and information to a question-category. The experimentee can also suggest new features for the IPA for later developments.

The main research questions for this study are:

- Which of the three feature-types is most useful all the participant?
- Which of the three feature-types is most useful for executives?
- Which other features are relevant for the use in a business context? Combination of feature types?

The following hypotheses are being evaluated with the questionnaire developed in this paper:

- The explanation-feature is most useful for executives.
- The search-feature is most useful for non-executives.
- The briefing-feature is most useful for all participates.

3.2 Questionnaire

Based on the research questions from chapter 3.1 the following questionnaire was derived:

Item					
GI	**General information**				
GI1	Gender	M/F/D			
GI2	Age	X			
GI3	Executive	Y/N			
GI4	branch of industry	FREETEXT			
GI5	Percentage repetitiv tasks	%			
GI6	Experience with voice assistants (Alexa, Google, Siri, etc.)	Y/N			
GI7	Annotations	FREETEXT			
GQ	**General Questions**	**meet**	**rather**	**rather not**	**does not meet**
GQ1	I am opened for new technologies				
GQ2	I like to try out new Features, even in beta-status				
GQ3	My actual tasks will be affected by new technologies				
GQ4	Annotations	FREETEXT			
FA	**Functional Aspects of the IPA**				
FAS	**Search-Features**				
FAS1	Searching via speech causes faster results				
FAS2	Own-Name-Recognition will improve my working-tasks				
FAS	Annotations	FREETEXT			
FAB	**Briefing-Feature**				
FAB1	My daily briefing gives target orientated information for my tasks				
FAB2	The IPA should condense the notes and give a summarzied briefing with keywords only				
FAB3	The IPA should give Information about the numbers of unsolved and solved tickets and the number of created documents				
FAB	Annotations	FREETEXT			
FAE	**Explaination-Feature**				
FAE1	The combination of speech-interaction in graphical and tabular reports supports a better unterstanig of the displayed content				
FAE2	Highlighting data during the speech-synthesis will improve the unterstanding of the report				
FAE3	The preliminary assessment via speech synthesis affects my decessions				
FAE4	The graphical and tabular views are sufficient for me, I do not need any linguistic processing				
FAE	Annotations	FREETEXT			
FAM	**More functions**				
FAM1	The recording of working hours via voice input would make my job easier				
FAM2	Writing notes via voice input would simplify my work				
FAM3	Voice commands can completely replace navigation using a keyboard, mouse or touchscreen				
FAM	Annotations / Feature-Suggestions	FREETEXT			

Figure 6: Questionnaire

The participants will be clustered in groups regarding the gender (GI1), age (GI2), executives (GI3), attitude towards new technology (GQ1 and GQ2), the ratio of repetitive tasks (GI5) and experience with voice assistants (GI6) to work-out and analyse the different ratings of the features.

4 Discussion and Outlook

As presented in chapter 2, the prototype is ready for a first evaluation. Based on the implemented IPA-features a questionnaire was derived and presented in this paper. The next step is to start the experiment and check the derived hypotheses. With the results of the survey, the prototype will be improved and advanced. Especially possible new features requested by the participants in the survey are in focus of the next steps, to work on a prototype which is matching with the requirements in business-context. At the end of the feedback loop (compare Figure 7) with maximal 3 runs a final Prototype will be available for the final evaluation and measurements.

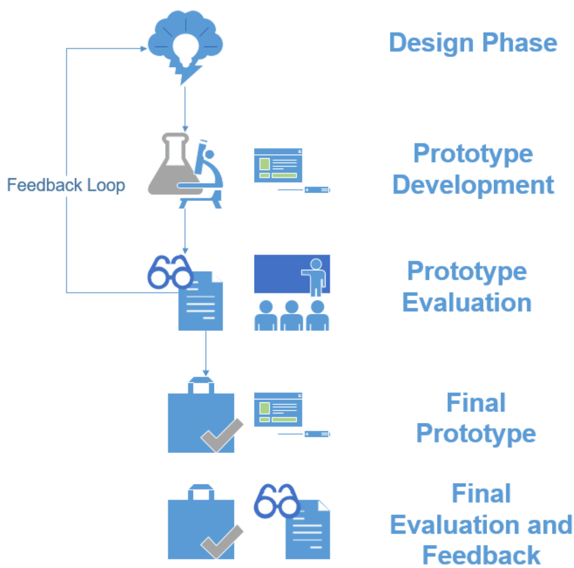


Figure 7: Research plan

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Digital Transformation of Croatian Seaports

MARIJA JOVIĆ

Abstract Maritime transport sector plays an important role in the economic development, and can be divided into three fields: cargo transport, passenger transport and seaport services (loading and unloading processes, storage etc.). It involves numerous stakeholders, from administrative bodies to carriers, shipping agents, freight forwarders, pilot companies, towing companies etc., who exchange large quantities of data. The data is often exchanged in various formats, sometimes even in paper format, which leads to delays and errors. Therefore, closer cooperation between stakeholders is necessary, along with data exchange standardization, to achieve smoother and faster data exchange. Digital transformation affects maritime transport sector and requires the implementation of new methods, models, and tools, and often implies new approaches, business models, and new skills which will help the transport companies and seaport stakeholders to remain competitive in the modern environment, achieve growth, and fend off competitive threats. The author plans to research the role of private and public seaport stakeholders in digital transformation. The problem of data ownership will also be addressed, because it affects the speed of digital transformation in maritime transport sector with an emphasis on seaports. In the second year of PhD research, the author will propose a model of digital transformation of seaports loosely based on the research by Venkatraman, (who devised five levels of digital transformation) and by Heilig, Schwarze and Vos (who followed up on Venkatraman's research). The model will be substantially revised to fit the Croatian seaport context.

Keywords: • Digital transformation • Maritime transport sector • Seaport business • Seaport stakeholders • Croatian Seaports •

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1 Introduction

Digital transformation refers to a business transformation through the adaptation of digital technologies. It can also be viewed as an accelerated transformation of business activities and processes in order to take the full advantage of the possibilities of digital technologies ("Digitization, digitalization and digital transformation: the differences"). The speed of business process, as well as an easy access to data is one of the triggers for achieving a competitive position in the transport sector. A digital transformation refers to a broader process of transforming an organization or a network of organizations on different levels (e.g., strategy, governance, leadership, culture, people, technology, etc.) by making use of digital technologies and concepts, to which we refer to as enablers (Heilig, Schwarze, & Voss, 2017).

Maritime transport sector is composed of the organizations and activities such as maritime transportation, seaports, a wide range of professional services around the maritime activities etc. ("Maritime Sector").

In maritime transport sector, especially in seaports, digitalisation process is slow, and this sector is among the weakest digitalized sectors ("SMART InfoTrend"). On the other hand, it is very interesting that within seaports, Port Community Systems (PCS) are globally widespread as specific digital platforms, and connect all stakeholders in the administrative and commercial part of the business ("SMART InfoTrend"). PCS is a neutral platform for electronic data exchange between public and private participant systems in order to enhance data exchange within the port authorities and to improve the business ("Port Community System").

In the maritime transport sector, especially in seaports, it is important to identify the innovative technologies, business models and policies that will drive change and to establish governance structures at the global and national levels to foster the innovations that our societies will need for a more sustainable and better performing future transport system (Rodrigue, 2010). Unfortunately, most of the Croatian seaport facilities are technologically outdated and at a level of 30% to 50% of utilization (Dundović & Kolanović). Furthermore, the exchange of documents is mainly conducted in paper format, which implies higher costs, the possibility of errors (largely due to multiple entries of the same data), etc. The slowness of the entire process alone should be a significant motivator for the digitalization and the implementation of modern ICT systems (Tijan, Agatić, & Hlača, 2012).

Heilig, Schwarze and Vos, provided an extensive analysis of digital transformations in seaports(Heilig, Schwarze, et al., 2017). They identified three generations and analyzed the stages of respective digital transformations using a Venkatraman's model. According to them, three main generations of digital transformation in seaports are (Heilig, Schwarze, et al., 2017):

- paperless procedures (1980s);
- automated procedures: the integration of terminal equipment and the terminals' IT/IS infrastructure to support automation in terminals (1990s - 2000s);
- smart procedures: the integration of different traffic control centers (road, sea, railway) into a main traffic center of the port that allows decision-making and an on-going interaction with stakeholders being actively involved in transport activities based on real-time data (2010s – today).

In order to enable smooth data exchange and facilitate digital transformation within the seaport environment, an integral ICT system should be established, connecting all seaport stakeholders. In Croatian seaports, stakeholders mostly own and operate separate ICT systems, except in the port of Ploče, where the PCS was implemented in 2012. The PCS implementation is a large infrastructural investment. It should eventually result in substantial savings by reducing the time necessary for coordination and by reducing paper documentation, and it should definitely increase the competitiveness of the Croatian seaports (Tijan et al., 2012). The Croatian Ministry of the Sea, Transport and Infrastructure has ensured the realization of PCS in port of Rijeka from the CEF Fund and the State Budget by 2021 ("Archives | Lučka uprava Ploče"). Afterwards, the plan is to implement the PCS in other Croatian seaports of international significance.

In more advanced seaports, PCSs have existed in various forms for a long time ("PCS / Port Community Systems - IPCSA International,"). Rotterdam was one of the first ports to have an operational Port Community System. The Port of

Rotterdam Authority combined this with tools for Port Call Optimisation and hinterland platforms ("Portinsider"). The Port Community System (PCS) for the Port of Hamburg is operated by DAKOSY and is one of the most advanced port ICT systems in the world ("DAKOSY Datenkommunikationssystem AG - Port Community System"). The digital platforms for import processing (Import-Message-Platform - IMP) and export processing (Export-Message-Platform - EMP) enable all businesses and authorities involved in cargo handling to perform fast, efficient and largely-automated processes in seaports as well as perfectly integrated intermodal hinterland handling of all modes of transport ("DAKOSY Datenkommunikationssystem AG - Port Community System").

In Croatia, starting from 2013, electronic process of announcement and registration of arrivals /departures of ships in international shipping is mandatory. For that purpose, the Croatian Integrated Maritime Information System (CIMIS) was established (*REPUBLIKA HRVATSKA Ministarstvo pomorstva, prometa i infrastrukture Uprava sigurnosti plovidbe*,). In 2015, e-Customs service was established. The Croatian Ministry of the Sea, Transport and Infrastructure has recently recognized the importance of digital transformation by implementing several projects. The first project refers to the establishment of a National Single Window (NSW), an information platform for data exchange and processing through the cooperation of the Ministry of the Sea, Transport and Infrastructure, the Customs Administration of the Ministry of Finance, the Port Authority of Rijeka and the Port Authority of Ploče (Jović, Kavran, Aksentijević, & Tijan, 2019). Besides that, a new service CIMISNet will achieve the following: significantly improve data exchange, reduce administrative procedures among the involved Ministries, all Port authorities, Coastal Liner Service Agency, Croatian Bureau of Statistics etc. Security in cross-border traffic will also be improved in accordance with Schengen rules (Jović et al., 2019). The goal of the CIMISNet system is to establish an XML message / document exchange with a secure and reliable communication channel for all interested users. In order to allow such communication, CIMISNet will be implemented as a web service (SOAP / HTTPS), which will use the Internet as a communication channel with HTTPS protocol and 2-way SSL authentication (*Specifikacija CIMISNet, Ministry of the Sea, Transport and Infrastructure*).

Although the digital technology is already present in different forms and levels of implementation within seaports, certain seaports have not gone through digital transformation for different reasons; the lack of financial resources, the lack of awareness of the importance of digital trends, the regulation that does not encourage digitalization etc. (Kane, Palmer, Phillips, Kiron, & Buckley, 2017) (Knoess Christoph, Doug Palmer, Anh Nguyen Phillips, David Kiron, 2016) (Reich, Mark, Niiya, Wang, & Warschauer, 2015).

In the context of digital transformation, it is important to address the issue of the data ownership, especially the data which is created and stored by administrative bodies, who sometimes consider themselves as "data owners". Undetermined ownership of data can affect the speed of digital transformation, especially in the maritime transport sector in which many stakeholders (private and even public) have their own particular interests and agendas, and keep their own databases. According to Scassa, the complexities of data ownership refer to the challenges with locating ownership and the balancing competing interests in data, as well as the need to establish significant rights of access and use (Scassa, 2018). The rights associated with ownership provide a powerful basis for control. A data owner can provide access to data or can restrict access partially or entirely (Scassa, 2018). Furthermore, data owners can impose conditions on access or use, including charging fees (Scassa, 2018). With all above mentioned in mind, it is necessary that governments envision and articulate future development scenarios, maintain frequent consultation with the stakeholders, and implement public policies that are applied consistently and that enable the stakeholders to invest with confidence in projects ("MODULE 3: Alternative Port Management Structures and Ownership Models: Port Functions, Services, and Administration Models," 2007).

The research will show the current state of digital transformation in Croatian seaports. The factors that improve seaport business will be determined. In the second year of PhD research, the author will propose a model of digital transformation which will not only be applicable in Croatian seaports, but also in the seaports of countries that share similar characteristics. The model will be based on the research by Venkatraman, and updated by Heilig, Schwarze and Vos, and will be substantially revised to fit the Croatian seaport context.

2 Problem definition

The Croatian seaports are currently in the phase of transition from isolated seaports to communicated seaports (Tijan et al., 2012). It should be noted that the Croatian seaports have omitted infrastructure investments during the 1980s, and have been handicapped by the war in the 1990s which diverted cargo from the Croatian seaports (Tijan et al., 2012). Croatian seaport facilities are technologically outdated and at a level of 30% to 50% of utilization. Furthermore, the need of modernizing and optimizing the communication process in Croatian seaports is necessary (Tijan et al., 2012). Slow digital transformation in Croatian seaports is evident, as the first PCS in port of Ploče (third largest Croatian seaport) was established only in 2012, and should be established in the port of Rijeka (the largest Croatian seaport) in 2021.

As mentioned above, starting from 2013, the process of the announcement and registration of arrivals and departures of ships in international navigation is performed by using the CIMIS system (*REPUBLIKA HRVATSKA Ministarstvo pomorstva, prometa i infrastrukture Uprava sigurnosti plovidbe*). In 2015, e-Customs system was established. The main role of e-Customs is to completely replace the paperwork of customs procedures, to create a more efficient and modern customs environment, to improve security at the EU's external borders, to facilitate and accelerate the exchange of goods and services within and outside the borders ("Carinska uprava - e-Carina," 2019).

The Croatian Ministry of the Sea, Transport and Infrastructure has recently recognized the importance of digital transformation by implementing several projects: establishment of a National Single Window (currently on hold), an information platform for data exchange and processing through the cooperation of the Ministry of the Sea, Transport and Infrastructure, the Customs Administration of the Ministry of Finance, the Port Authority of Rijeka and the Port Authority of Ploče; a new service CIMISNet will significantly improve data exchange, reduce administrative procedures among the involved Ministries, all Port authorities, Coastal Liner Service Agency, Croatian Bureau of Statistics etc. Security in cross-border traffic will also be improved in accordance with Schengen rules [8].

Regarding all the above-mentioned issues, it is evident that the level of digitalization in Croatian seaports is definitely insufficient, and sometimes even non-existent. There are various reasons of such "delayed" digital transformation such as: the lack of resources, lack of the desire to intensify their adaptation to digital trends or lack of government or top management support. In the maritime transport sector, customers are increasingly looking for faster and more efficient services (e.g. faster transfer of goods) and turning to service providers offering more convenient solutions and deeper value throughout the supply chain (e.g. the planning of routes, resources and other supplementary services). There is still considerable potential for improvement e.g. a better integration of existing information systems and data sources as well as a more intelligent use of data may help to improve planning, controlling, and management of intra- and inter-organizational operations (Heilig, Lalla-Ruiz, & Voß, 2017). For this reason, companies are forced to change their traditional ways of managing the business.

The second problem includes data ownership and data transparency. The ownership is often unclear, and some data are of the utmost interest of the company (confidential information). The next example will support this statement: Croatian Customs office maintains a database about the cargo flows, but unless otherwise provided by law, the data are considered confidential. The Customs office uses the data for various purposes, for example risk assessment, and is reluctant to distribute such data to other stakeholders. However, these data might be useful to other stakeholders in order to improve the overall seaport business and even the whole Croatian maritime sector. Therefore, concerns about the individual and particular interests with regard to data and data ownership definitely exist.

The final problem encountered while researching this topic is regulations regarding the digitalization (OECD, 2018). These regulations are often specific for each country, sometimes even within the same country, and the question is whether it is possible to introduce a particular technology or business model and how to adopt it with respect to the present regulations. All EU member states have to comply with EU regulations along with the national regulations, which are sometimes not in unison.

In accordance with the above-mentioned research problems, the object of the research will be to research the current state of digital transformation in Croatian seaports, which do not fully utilize the advantages of digital technologies.

Based on the above-mentioned problems and the research object, it is possible to set up a basic working hypothesis: the digitalization of seaport processes enables real-time data availability, better connectivity of stakeholders, the reduction of unnecessary time spent on document transfer, resulting in the reduction of overall business costs.

3 Research questions

In order to solve the research problems, prove the scientific hypothesis and accomplish the purpose and goals of research, it is necessary to provide answer to the following questions in the PhD thesis:

- What is digital transformation?
- Why is digital transformation important in seaports?
- To what extent is the digitalization present in Croatian seaports?
- What is the role of the administrative and regulatory bodies?
- What is the role of seaport stakeholders in successful digital transformation?
- How familiar with the trends are seaport companies/stakeholders?
- What do seaport stakeholders have to change in order to digitally transform their business?

4 Theoretical background

Digital transformation goes beyond technology, requiring new methods, models and tools to put companies into action and it frequently implies new strategies, new business models and new and dynamic capabilities mostly to create data-driven businesses (Mosconi, Packmohr, & Santa-Eulalia, 2019). Barriers which slow its dissemination are: inadequate or overly heterogeneous company structures or cultures, the lack of strategies and ROI (return on investment) visibility; external barriers represent a shortage of skills and a qualified labour force, lacking or insufficient infrastructure, missing or inadequate regulation and consumer protection, and poor access to funding, particularly for small and medium businesses (Ebert & Duarte, 2018).

When an organization seeks to transform from a manual process to a comprehensive digital platform, this requires a successful leadership strategy which can be influential and impactful in advancing this type of change over the long term (Sow & Aborbie, 2018). Many managers do not have technical knowledge or ability to monitor this type of change.

On the one hand, digital transformation is driven by the confluence of technologies such as Internet of Things, 3D printing, Big Data, machine learning and artificial intelligence (AI); on the other hand, digital transformation provides fertile fields for the further development of those technologies, and most importantly, for the growth of new technologies and new digital business, such as digital twins, blockchain, cryptocurrencies, digital archives, and smart contracts (Huang, 2018). Digital transformation is not necessarily about digital technology, but about the fact that technology, which is digital, allows people to solve their traditional problems (Zhaohao Sun, 2018). The main benefits associated with automation and artificial intelligence refers to increasing productivity (50%), reducing production costs (43%) among others. On the other hand, the digital transformation and robotization of various activities using intelligent machines mean that the human-machine interaction becomes even more present and brings new challenges to all organizational levels (Mosconi et al., 2019).

The changes that are the result of the presence of digital transformation are twofold: either voluntary, where the organization is actively shaping its future strategies via optimizations and investments, or reactive, where unplanned and unexpected changes adversely affect the business model and call for restructuring or emergency operations (Kotarba, 2018). If some company chooses not to undertake a digital transformation, it will remain stuck while their competitors successfully advance their businesses. Depending on a current state of technical maturity and culture for change, the path may be easier for one organization than another (Donnelly, 2018).

Transport plays an important role in today's economy and society and has a large impact on growth and employment ("Transport sector economic analysis | EU Science Hub," 2018). Transportation companies can be broken down into three core cargo-centric groups: non-asset cargo companies, offering logistics services, third/ fourth party logistics, and, freight forwarding and broker services; asset-owning cargo companies, providing the movement of goods via railway, air cargo, trucking, and ocean shipping services; and distribution companies, primarily focused on parcel and local delivery (Futurum, 2017). In recent years, transportation companies have conducted several initiatives to explore new digital technologies in order to use their benefits. This frequently involves transformations of key business operations and affects products and processes, as well as organizational structures and management concepts (Matt, Hess, & Benlian, 2015).

FutureNautics Maritime and Ericsson conducted an international survey (2017) to gain the insight into the maritime sector challenges. Herewith the five biggest challenges to digital transformation: the industry is not aware of how digital trends affect their business and the competitiveness of organizations; there is not enough internal leadership for digital projects; the lack of senior management involvement or the desire to change current practices; companies are often insecure over the security of digital operations, cyber security and resilience; no budgets for digital initiatives (Ultimate Software). Only a small number of industry players in the maritime sector consider that digitalization has already changed their business significantly, whereas companies in high-tech and in public transport have already seen greater changes from the pressure of digitalization (Hamburgisches WeltWirtschafts & Institut, 2018). Even for the future, shipping companies rate the importance of digitalization rather modestly for their own industry: comparatively low 15% consider radical industry change to be unavoidable, while 69% feel that there will be significant changes but no revolution in the industry and a sizeable 16% consider the topic to be overrated (Hamburgisches WeltWirtschafts & Institut, 2018).

Seaport is a nodal point between land and sea, or a modal interface between shipping or sea transportation system on the one side, and the land transport network on the other side (Unctad Secretary, 2004). It can also be defined as a multidimensional system combined between economical function, infrastructure system, geographical space and trade (Hlali & Hammami, 2017). Numerous stakeholders cooperate in seaports and exchange large quantities of data. In recent years, the primary focus of many major seaports was on the development of mobile apps to allow a dissemination of relevant information to port actors for performing and assisting job orders, for instance, information on booked appointments, available parking slots in the port, and container locations, and information about the current status to support drayage truck drivers (Heilig, Schwarze, et al., 2017).

According to The Public – Private Infrastructure Advisory Facility (PPIAF), governments, transport ministry and port authorities play an important role in digital transformation of seaports. It is necessary that governments envision and articulate future development scenarios, maintain frequent consultation with the stakeholders, and implement public policies that are applied consistently and that enable the stakeholders to invest with confidence in projects that support the stated public policy objectives ("MODULE 3: Alternative Port Management Structures and Ownership Models□ :: Port Functions, Services, and Administration Models"). In numerous countries, the transport ministry usually drafts and implements transport and port laws, national regulations and it is usually responsible for planning and financing national projects ("MODULE 3: Alternative Port Management Structures and Ownership Models□ :: Port Functions, Services, and Administration Models"). While central governments need to pursue macroeconomic goals through an active seaport policy, the objectives of the port authority should be focused on port financial and operational activities ("MODULE 3: Alternative Port Management Structures and Ownership Models: Port Functions, Services, and Administration Models," 2007). For example, the Port of Rotterdam Authority plays a decisive part in the process of digital transformation through cooperation with clients, chain partners and digital platforms in order to make Rotterdam a hotspot for the development of the most promising digital innovations; investing in new digital infrastructure that can help create the right conditions for extensive digitalisation etc. ("Digital developments").

5 Methodology

During the research, the formulation and presentation of the results, the following methods will be used: an inductive and deductive method, analysis and synthesis methods, a descriptive and compilation method, comparative and statistical methods, survey methods, interview methods, empirical and modelling methods and a method of observation. Through the research, business operations in seaports will be examined. Relevant stakeholders will be surveyed and the level of digitalization in larger Croatian seaports will be investigated, along with the readiness for digital transformation, as well as the awareness of the importance of digitalization.

Venkat Venkatraman has created a model for digital business strategy in the age of cognitive systems and artificial intelligence (Figure 1) (Venkatraman, 2017).

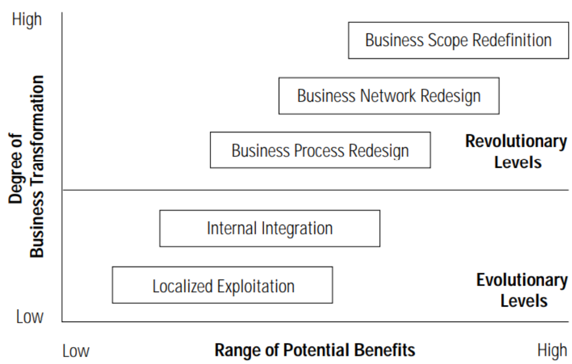

Figure 10: Five Levels of IT-Enabled Business Transformation

Venkatraman demonstrated five different levels of digital transformation (Heilig, Schwarze, et al., 2017):

- Localized exploitation: deployment of standard IT functionality for supporting individual business activities.
- Internal exploitation: technical and organizational integration
- Business process redesign: a redesign of organizational structures and business processes is necessary to fully exploit new IT/IS (information technologies/information systems) capabilities

- Business network redesign: focus on the redesign of business networks from an inter-organizational perspective
- Business scope redefinition: may involve the creation of new strategies, products/services, and partnerships.

Heilig, Schwarze and Vos extended the model of digital transformation of seaports based on the Venkatraman's research (Figure 2).

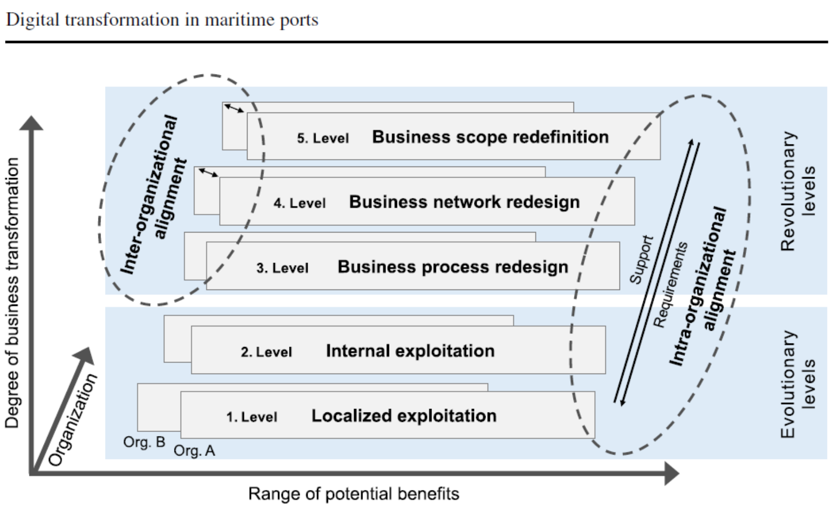

Figure 2: Extended model of IT-enabled business transformation (Heilig, Lalla-Ruiz, et al., 2017)

According to them, the initial Venkatraman's model is restricted to a single business perspective. As the interrelations between those levels in an ecosystem of different actors are particularly interesting, they slightly extend the model by incorporating an additional dimension in order to transform the model from a single to a multi-organizational model (Heilig, Lalla-Ruiz, et al., 2017). That is, a business network redesign of one organization not only requires an internal transformation of structures, processes, and activities, but might promote or have an impact or implications, such as in form of technical requirements, for transformations on different levels in other organizations (e.g., collaborators, partners) (Heilig, Lalla-Ruiz, et al., 2017) . They concluded that "success of digital transformations in a broader context, like in the environment of seaports, is dependent on an inter-organizational alignment of digital strategies and transformation, and may further lead to cross-fertilization potentials, such as in form of competitive advantages".

The research model (which will be devised during the second year of the PhD study) will be based on the above mentioned research by Venkatraman (Hlali & Hammami, 2017) and by Heilig, Schwarze and Vos (Heilig, Lalla-Ruiz, et al., 2017). The model will be adapted to the context of Croatian seaports, with suggestions for further digital transformation.

6 Preliminary/Expected results

The research will present the current state of digital transformation in Croatian maritime transport sector with an emphasis on seaports. The factors that increase the competitiveness of seaports and seaport stakeholders will be defined. The necessity of the digital transformation of Croatian seaports will be outlined. A new model of digital transformation of seaports will be developed according to the preliminary research. Based on the theories and insights on the impact of digital transformation on seaports, the proposed hypothesis (the digitalization of seaport processes enables real-time data availability, better connectivity of stakeholders, the reduction of unnecessary time spent on document transfer, resulting in the reduction of overall business costs) will be proved or disproved.

7 Future development

It is difficult to determine in detail the future development, as the author is currently at the first year of PhD study. The model will not only be applicable to Croatian seaports, but also to the seaports of countries that share similar characteristics. The model could also be used as a basis for future research. By utilising the proposed model, the following should be achieved: better cooperation among stakeholders, timely data with better visibility, simplification of the procedures, reduction of administrative data, and a better use of infrastructure and resources.

8 Conclusion

The speed and easy access to data are one of the triggers for achieving a competitive position in the maritime transport sector. In the context of economic development, maritime transport sector plays an important role and it could be divided into three fields: cargo transport, passenger transport and seaport services. The digitalisation process is slow in the maritime transport sector, especially in seaports. The changes that are the result of the presence of digital transformation are twofold. The first one refers to the seaport stakeholders that actively shape their future strategies by optimizing their business operations and investing in the technology. The second one refers to unplanned and unexpected changes which affect the business model negatively. Therefore, digital transformation is inevitable and necessary, but positive results will only be achieved if digital transformation is properly managed.

Seaports are more than ever dependent on the good networking to achieve the goal of digital transformation. It could be achieved by integrating different control systems supporting seaside, terminal and land operations. To enable digital transformation, coordinated activities are needed and stakeholders have to be involved at an early stage of development.

In Croatia, the insufficient use of digitalization in seaports presents a large problem. The less developed seaports face the lack of resources or lack of the readiness to intensify their adaptation to digital trends.

Governments, transport ministry and port authorities have a significant impact on the maritime sector and digital transformation. The Croatian Ministry of the Sea, Transport and Infrastructure has recognized the importance of digital transformation, and has in this respect initiated the establishment of a National Single Window. National Single Window represents an information platform for data exchange and processing through the cooperation of the Ministry of the Sea, Transport and Infrastructure, the Customs Administration of the Ministry of Finance, the Port Authority of Rijeka and the Port Authority of Ploče. Furthermore, a new service CIMISNet will improve data exchange as well as reduce administrative procedures among the involved Ministries, all Port authorities, Coastal Liner Service Agency, etc.

The author is at the first year of PhD study, and plans to research the role of private and public stakeholders in digital transformation of Croatian seaports. In the second year of the PhD research, the author will propose a model of the digital transformation of seaports. The model will be based on the research by Venkatraman and by Heilig, Schwarze and Vos.

The issue of data ownership will be addressed as well, since data ownership is often unclear and affects the speed of digital transformation in maritime transport sector, which is particularly evident in seaports. The model will be applicable not only to Croatian seaports, but also to seaports in countries with similar characteristics.

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The impact of using digital technologies within the personal sales conversation at the POS on customer satisfaction - A mixed-methods investigation within the retail-industry

DOMINIK RODE & CATHRIN STAMMEN-HEGENER

Abstract Digital transformation and the resulting changes have an immense impact on business, political and social levels (Dirican, 2015); (Andriole, 2016). Also structures of the retail industry will change dramatically as digital technologies gain in influence (Heumann, 2016); (Jones, Brown, Zoltners, & Weitz, 2005); (Lusch, Vargo, & O'Brien, 2007). For stationary retailers, these technologies are a way to create customer satisfaction in a personal conversation at the POS and a meaningful opportunity as a demarcation criterion in times of the pressure of online commerce and the discerning and well-informed cross-channel customers (Heumann, 2016); (Jones, Brown, Zoltners, & Weitz, 2005); (Lusch, Vargo, & O'Brien, 2007); (Sherman & Perlman, 2014); (Giebelhausen, Robinson, Sirianni, & Brady, 2014). This results in benefits for both, retailers and customers (Khare, Kessler, & Wirsam, 2018); (Bruhn & Hadwich, 2017). The difficulty is to select the right digital technologies for generating such a unique selling proposition in order to achieve maximum customer satisfaction (Reiter, 2012); (Kofler, 2018). This application of digital technologies in the sales pitch at the POS within the retail-industry represents an intensively discussed field in previous research work (Taylor, 2016); (Giebelhausen, Robinson, Sirianni, & Brady, 2014); (Spreer & Rauschnabel, 2016); (Watson, 2011). However, previous research has provided insufficient answers to the question of how the use of digital technologies for personal sales interaction at the POS influences customer satisfaction in relation to the various needs of the different sectors of the retail industry (Blazquez, 2014); (Kumar, Reinitz, Simunovic, Sandeep, & Franzon, 2009); (Ryding, 2010). Hence, the author's aim of the planned dissertation is to advance the knowledge and to identify the factors that influence on customer satisfaction, for defining a recommendation action for the management.

Keywords: • Digital Transformation • Digital Technologies • Digital Sales Interaction • Digital Business • Retail •

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1 Introduction

> *"Digital transformation is affecting businesses of all sizes and across all industries."* (Miller, 2017)

Current global development shows that digital transformation is progressing steadily. Digital technologies like big data analytics, cloud technology, internet of things (IoT), mobility devices, augmented reality and artificial intelligence usher in greater automation (Netzer, 2017). The reasons for this dynamic change are that data storage costs decrease as the amount of digitally generated information increases (Walker, 2015). Digital transformation and the resulting changes will have a massive impact on business, political and society level. Increasingly integrating automation into processes will be one of the central challenges of the future (Andriole, 2016); (Dirican, 2015).

The development of digital transformation is also affecting the retail industry. This reinforces existing structural change and leads to high investment requirements for brick-and-mortar retailers to counter the pressure of online commerce and meet the needs of the discerning and well-informed cross-channel customers (Heumann, 2016); (Jones, Brown, Zoltners, & Weitz, 2005); (Lusch, Vargo, & O'Brien, 2007). As a result, stationary retailers need to take action to build face-to-face interaction as a criteria for demarcation (Spreer & Rauschnabel, 2016). This creates the opportunity to improve the personal sales conversation between sellers and customers through digital technologies (Sherman & Perlman, 2014); (Giebelhausen, Robinson, Sirianni, & Brady, 2014).

Digital technologies deliver benefits for both, retailers and customers: on the retail-industry side, this can be done by helping employees in their operations with the goal of efficiency measurement, or by optimizing inventories through intelligent forecasts. In addition, there is a potential for cost savings. Furthermore, digital technologies provide the opportunity to offer new and adapted services, resulting in additional revenue growth. Positive effects are expected from a majority of retailers (78.4%) (Khare, Kessler, & Wirsam, 2018); (Bruhn & Hadwich, 2017).

On the customer side, digital technologies also have many advantages: For example, by using touchscreen displays, customers can find products in stores or provide personalized information about available products. Another advantage comes from mobile applications: they offer automated payment methods that allow consumers to save time and reduce cash register queues (Pantano & Viassone, 2014). For example, virtual mirrors that can be used within the fashion industry can speed up fittings of clothes or help the customer to get feedback through a direct connection to family and friends. Digital technology offers as many opportunities in stores as websites. If retailers use a variety of channels and technologies intelligently, they are far superior to pure digital or point-of-sale strategies (Munzinger & Wenhart, 2012).

Thus, the advantages are obvious: fewer paths for customers and employees, more consultancy skills for the seller and precise customer service lead to increased customer satisfaction (Haderlein, 2012). As a result, if retailers want to differentiate themselves at the point of sale from a pure digital or point-of-sale strategy in order to achieve maximum customer satisfaction, the use of digital technologies is a sensible opportunity (Sherman & Perlman, 2014); (Giebelhausen, Robinson, Sirianni, & Brady, 2014); (Munzinger & Wenhart, 2012). In the personal interaction between sellers and customers, it is possible to achieve a demarcation and to improve the personal sales conversation between sellers and customers through the support of digital technologies (Spreer & Rauschnabel, 2016); (Norris, 2007).

2 Problem Definition

However, with all the benefits that the use of digital technologies can bring, it is important to note: The goal of achieving maximum customer satisfaction within the personal sales interaction at the point of sale is only achieved if the most suitable digital technological support is selected. But with the existing variety of digital technologies available to choose from, this choice is difficult (Kofler, 2018, S. 191 f.); (Kröger, 2018); (Heinemann, 2013); (Kaupp, 2010).

The application of digital technologies in the sales pitch at the POS within the retail-industry represents an intensively discussed field in previous research work (Taylor, 2016); (Giebelhausen, Robinson, Sirianni, & Brady, 2014); (Spreer &

Rauschnabel, 2016); (Watson, 2011). However, previous research has provided insufficient answers to the question of how the use of digital technologies for personal sales interaction at the POS influences customer satisfaction in relation to the various needs of the different sectors of the retail industry (Blazquez, 2014); (Kumar, Reinitz, Simunovic, Sandeep, & Franzon, 2009); (Ryding, 2010). Hence, the author's aim of his work is, on the extension of existing models, to advance the knowledge and to identify the factors that influence on customer satisfaction, for defining a recommendation action for the management.

For this reason, the author has formulated the following research question with the associated sub-questions:

1. How does the use of digital technologies for personal sales interaction at the point of sale influence customer satisfaction?

2. In how differs the level of customer satisfaction when using digital technologies for personal sales interaction at the point of sale concerning the different sectors of the retail industry?

3. To what extent does the use of digital technologies for personal sales interaction at the point of sale impact the customers' repurchase behavior?

4. To what extent does the use of digital technologies for personal sales interaction at the point of sale impact the customers' willingness for cross-buying?

To what extent does the use of digital technologies for personal sales interaction at the point of sale impact the customers' willingness to pay a higher price?

3 Methodology

To analyse empirical evidence in the field there exist various scientific methods that can be used to conclude findings on a research question (Sreejesh, Mohapatra, & Anusree, 2013).

Within the planned dissertation, secondary research is carried out on the basis of a comprehensive literature analysis. Therefore the author will refer to publications, journals, convention proceedings, conferences and recent studies by market research institutes. In addition, publicly available literature on topics such as digital technologies, point-of-sale, sales interaction, marketing, customer satisfaction etc. will form the basis of the literature study. Furthermore, websites of retailers, industrial companies or professionals are included in the research.

On the basis of the secondary research, the author will define the relevant terms. In addition, he will make a conceptual delineation and classification of customer satisfaction, explain the construct of customer satisfaction, and respond to the confirmation / disconfirmation paradigm (Woodruff, Cadotte, & Jenkins, 1983). The author also intends to work out newer approaches to customer satisfaction research in this context.

Furthermore, in order to analyze the effect of the use of digital technologies within personal sales conversations, there exist various theoretical models to identify factors that influence customer satisfaction, which the author currently favors as a foundation (Boslau, 2009):

- Technology Acceptance Model (Davis, Bagozzi, & Warshaw, 1989)
- Innovation Diffusion Theory (Rogers, 1962)
- SERVQUAL-Ansatz (Parasuraman, Zeithaml, & Berry, 1985)
- Transaction-Cost Theory (Williamson, 1979)

An investigation by Song and Letch concerning literature review of assessment methods found that only 5.9% of the studies used multiple analytical methods. In order to increase the knowledge about the research questions within the planned work, this study will combine two analysis methods to increase the knowledge about the research questions (Song & Letch, 2012).

Therefore the primary research is based on a multimethod research (Starr, 2014); (Brewer & Hunter, 1989). Thereby, in order to investigate problems further, to define further parameters and to create a reliable questionnaire for quantitative research, qualitative surveys will be carried out in advance. This happens in the form of expert interviews with specialists in the field of digital technologies for the retail-industry, retailers and customers. The author plans to conduct expert interviews on a semi-standardized interview conducted face-to-face with open questions. This interview technique seems appropriate to keep the answers spontaneous without giving respondents an opportunity to prepare their answers. On this basis, new hypotheses are created, which are then used in the questionnaire. Therefore the author plans a survey, which can be fulfilled analogously or online to obtain results from both, digital affine and less digital affine, participants.

The goal of using this methods, is to follow both, the exploratory (qualitative research approach) and the confirmatory scientific method (quantitative research approach) to reach multiple objectives and to provide a fuller explanation and understanding. Therefore the results of the study will deliver a provision of "subjective insider" and "objective outsider" viewpoints. Another aim of using qualitative and quantitative research methods is to draw from the strengths of the two methods and minimize the weaknesses (Johnson & Christensen, 2013). Summarizing, the following figure 1 illustrates an overview of the planned structure of the work:

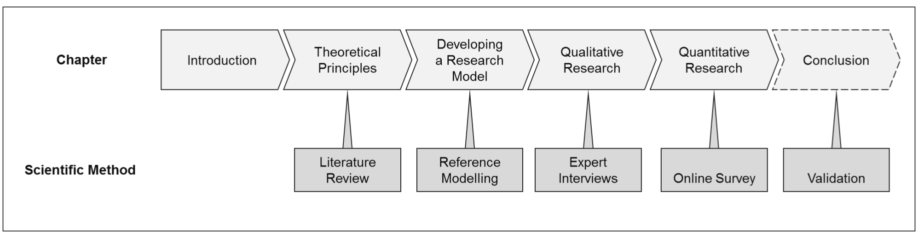

Figure 11: Structure of Dissertation (own representation)

4 Expected results

Digital transformation and the resulting changes have a massive impact on business, political and social levels (Dirican, 2015); (Andriole, 2016). Even structures within the retail industry will change dramatically as digital technologies will gain in influence (Heumann, 2016); (Jones, Brown, Zoltners, & Weitz, 2005); (Lusch, Vargo, & O'Brien, 2007). For brick-and-mortar retailers, these technologies are a way to create customer satisfaction in a personal sales conversation at the POS and a sensible opportunity as a demarcation criterion

(Sherman & Perlman, 2014); (Giebelhausen, Robinson, Sirianni, & Brady, 2014). This results in benefits for both, retailer and customer (Khare, Kessler, & Wirsam, 2018); (Bruhn & Hadwich, 2017). The difficulty is to select the right digital technologies for generating such a unique selling proposition in order to achieve maximum customer satisfaction (Reiter, 2012); (Kofler, 2018).

The goal of the planned dissertation is to elaborate recommendations for the management-level for these challenges. The basis for this is provided by answering the research question "How does the use of digital technologies for personal sales interactions at the point of sale influence customer satisfaction?" and its associated further questions.

The work will be divided into two parts: qualitative research in the form of interviews and quantitative research in the form of surveys. For these two different research methods the author expects the following results:

First, the author conducts interviews with specialists in the field of digital technologies, retailers and customers. The author expects, especially because of the direct implementation with open questions, a very high degree of detail of the answers regarding the creation / achievement of customer satisfaction. The author expects that, above all, the answers of the retailers compared to those of the customers, will differ from the perspective. For this reason, the author of the dissertation assumes that the comparison of the compressed data and evaluation will make an important contribution to research since the two views will certainly be different.

From the surveys, the author of the paper expects that a meticulous evaluation of the results will provide a high added value and important insights that will lead to recommendations for action. This is expected since employees of retail companies and also end customers will be interviewed on the research issues.

In general, the author expects that, especially among younger clients, customer satisfaction increases in a personal conversation due to the use of digital technologies. In addition, the author expects that the use of digital technologies will increase customer satisfaction especially for products requiring explanation and configurable products.

5 Future Development

For the future development of the dissertation, the author is going to work out a comprehensive and meticulous research of all relevant articles to structure them properly. On this basis, an overview in the form of a "state-of-the-art" will be elaborated. Then, a research model will be designed as preparation for the two research approaches of interviews and surveys. Especially for the surveys, the author is going to do a pre-test to ensure the functioning of the chosen method of the poll in advance. This will be followed by data compression, a comparison and an evaluation. Based on this, recommendations for management will be formulated of the findings obtained. Figure 2 gives a detailed overview of the planned timetable of the dissertation.

In addition, the author plans to publish his sub-studies in relevant journals and to present and discuss the results of his research at national and international conferences. This will be an important part of the process because in this way, different aspects of the research can be presented and discussed with experts and professionals so that the topic but above all the research methods and the procedure are always questioned.

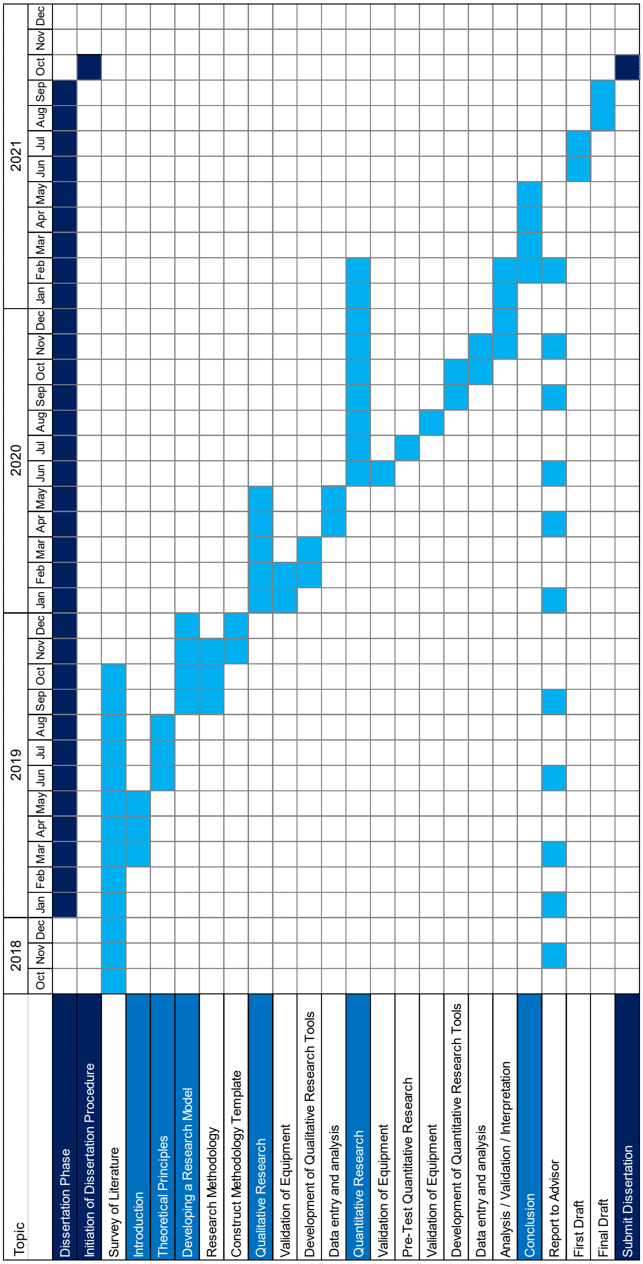

Figure 2: Timetable of Dissertation (own representation)

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Co-Creation of Public Services Literature Review

ROK HRŽICA

Abstract In recent years, increasing competition and desire to stay ahead of the competitions is forcing organizations to give more attentions to the needs of the customers. In order to meet the needs of the customers, organizations, politicians and policy makers should co-create innovative public services. Literature review has revealed that, even though public service co-creation is not a new concept, we could not find any work that would combine decision supports systems, maturity models and public service co-creation. The purpose of the work is to develop a framework that would facilitate the public sector organizations to implement the process of co-creation in the process of renewal or innovation development of the services.

Keywords: • Co-creation • Co-production • Public services • Public administration • Maturity assessment • Decision support system •

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1 Introduction

In a complex competitive world, it is important to be innovative. Increasing competition and desire to stay ahead of the competitions is forcing organizations to give more attentions to the needs of the customers. In order to survive, grow in the market and succeed in their desire, businesses have to innovate and do things differently. They have to encourage customers to take more active roles in producing goods and services. As such, customer participation refers “to the degree to which the customer is involved in producing and delivering the service” (Dabholkar, 1985). According to (Lengnick‐ Hall, 1996) there are five roles of customer: Customer as Resource, Customer as Co-producer, Customer as Buyer, Customer as User and Customer as Product. Not all customers can effectively serve in all five roles capacities.

It is believed, that the term “co-production” was made up in 1970s when Professor Ostrom was asked to explain to the Chicago police why the crime rate went up when the police came off the beat and into patrol cars (New Econcomics Foundation, 2008). In the literature, the concepts of co-creation and co-production are often used as synonyms or interchangeable (W. H. Voorberg, V. J. J. M. Bekkers, & L. G. Tummers, 2015). According to (Constantinides, Wittenberg, & Lorenzo-Romero, 2014) co-creation is also interchangeably used with user innovation or co-innovation. Consumers are involved in new product development where they act as a source of innovation in order to increase the value of the new product or service. In spite of the terminological incoherence of the concept of co-creation and related terms, it is possible to identify the authors' overall agreement on the following: citizens or customers are considered as a valuable partner in public service delivery (e.g. (Baumer, Sueyoshi, & Tomlinson, 2011; Boivard, 2007; Cairns, 2013; Meijer, 2011).

1.1 Co-creation vs. co-production

There are also some authors, that make clear distinction between co-production and co-creation. In goods-dominant logic and production-oriented logic the customer was always a co-producer of value (Vargo & Lusch, 2004), while in service-dominant logic the customer is always a co-creator of value (Vargo & Lusch, 2006). In one the latest attempt to distinguish co-production and co-creation the co-production was defined as “interactive process through which the providers and users of public services apply their different resources and capabilities in its production and delivery." (Torfing, Sørensen, & Røiseland, 2016) On the other hand, they define co-creation as "process through which two or more public and private actors attempt to solve a shared problem, challenge, or task through a constructive exchange of different kinds of knowledge, resources, competences, and ideas that enhance the production of value in terms of visions, plans, policies, strategies, regulatory frameworks, or services, either through a continuous improvement of outputs or outcomes or through innovative step-changes that transform the understanding of the problem or task at hand and lead to new ways of solving it" (Torfing et al., 2016). In line with work of Vargo and Lusch (2004, 2006), the co-creation literature puts more emphasis on co-creation as value (Gebauer, Johnson, & Enquist, 2010). Co-production is rooted in the verb produce which is defined as making or manufacturing from components or raw materials, creating or forming (something) as a part of physical, biological, or chemical process, making (something) using creative skills (Oxford Dictionaries, 2019c). Co-creation is rooted in the verb create, which is defined as bringing something into existence, causing something to happen as a result of one's actions, and in co-, which means together with another or others (Oxford Dictionaries, 2019a). Co-innovation is rooted in the verb innovate which is defined as making changes in something established, especially by introducing new methods, ideas, or products (Oxford Dictionaries, 2019b).

Another definition of co-creation is, that "co-creation is enactment of interactional creation across interactive system environments (afforded by interactive platforms), entailing agencing engagements and structuring organizations" (Ramaswamy & Ozcan, 2018). These interactive platforms can be used not only for the interaction between customers and providers but also for interaction between customers and customers. Some organizations are using social media sites, others are using blogging, just to get the customers online community involved. Blogging is not only a social activity, but it is also a collaborative activity (Nardi, Schiano, & Gumbrecht, 2004) Bloggers and readers are collaboratively involved in the process of co-creating a blog. Blogging is the process of creating a blog, but the creation is in fact a collaboration or interaction between bloggers and readers. Through those interactions blogs are collaboratively co-created (Baumer et al., 2011). Customers or in previous case readers may share ideas, seek advices from other customers, making memories, etc. (Novani & Kijima, 2012). Co-creation refer to any act off collective creativity, that is shared by two or more people (Sanders & Stappers, 2008) and is a collaborative process where players from across different sectors come together to co-design and co-implement new or improved products and services (Mourot & Jefferson, 2014). According to (Prahalad, C.K. and Ramaswamy, 2004) value is co-created by the customer and firm engaged in an innovation process of co-ideation, co-design, co-development and co-creation of new products or services. The role of consumer in the industrial system has changed from isolated, unaware and passive consumer to connected, informed and active consumer. Their contributions can be active (e.g. work, expertise or information) or passive or even unknowing (e.g. behavioral data that is gathered automatically during an activity). Contributions are than aggregated and automatically converted into something useful to others (Cook, 2008).

Public sector innovation derives from the need of governments to boost and enhance the responsiveness of services provided to meet individual and local needs (Alves, 2013). Effective government and public services depend on successful innovation – to develop better ways of meeting needs, solving problems and using resources and technologies. In the private sector, the main motivation for innovation is the need to maintain or increase profitability (cutting costs, improving market share or creating new products and services), while in public sector innovation helps public services to improve performance and increase public value, satisfy the expectations of citizens and adapt to the needs of users, increase service efficiency and lowering costs (Mulgan, G. and Albury, 2003). Enormous economic, environmental and societal challenges, as well as citizens' growing demands puts public administration under severe pressure to be innovative (Albury, 2011; Bommert, 2010; Sandford, 2001). A clear focus, the freedom to experiment and the combination of knowledge of several actors is important, if we want to foster an innovative culture within public administration. Governments have to shift their role from hierarchical, top down steering and self-producing to facilitating and being a co-productive and problem oriented partner (van Duivenboden & Thaens, 2007). Modern public organizations need to become a part of dynamic innovative ecosystem where they co-create value with citizens, government, policy makers, other public and private organizations and institutions (Rychkova & Zdravkovic, 2017).

Some authors have drawn attention to the fact that collaborative interaction between public and private actors can also have adverse consequences, it can lead to co-destruction of public value (Echeverri & Skålén, 2011; Järvi, Kähkönen, & Torvinen, 2018; Plé & Cáceres, 2010). In the context of e-government, for example, Uppström & Lönn (2017) warn that when developing and evaluating e-government initiatives, we should be aware of co-destruction and co-creation outcomes for all the involved communities.

1.2 Co-Creation as Part of Public Governance

In this section we will show how co-creation has changed due to different public governance theories and administrative practices. According to (Garcia Haro, Martinez Ruiz, & Martinez Canas, 2014), co-creation of value is an important business strategy, necessary to support innovation processes and is needed to achieve competitive advantages. Co-creation of value presents the mutual contribution among consumers and a company in an innovative process (Roberts, Hughes, & Kertbo, 2014). Importance of innovation will continuously grow as the business environment is still increasingly uncertain and competitive (Han et al., 2012). In his key speech (Albury, 2011), he is questioning why are governments across the world talking about public service innovation now and not many years ago. Why has this subject become so important in last years? He is talking about "the perfect storm", where long-term challenges are becoming more pressing, increasing pressures and demand on public services, recession, that lead to massive tightening of public finances and persistent issues with unknown pathway to solution. This lead to radical and compelling innovation, that offers significantly better outcomes for significantly lower costs (Albury, 2011). According to (Kovač, 2015) there were four public governance theories Weberian public administration (**WPA**), New Public Management (**NPM**) and **post-NPM**, Neo-Weberian State (**NWS**) and Good Governance (**GG**). In literature we can find GG (OECD, 1995) also as digital-era governance (Dunleavy, Margetts, Bastow, & Tinkler, 2006), network governance (Klijn, 2008), interactive governance (Edelenbos & Van Meerkerk, 2012) or New Public Governance (Osborne, 2006). WPA was in 19th and the beginning of 20th century, NPM and post-NPM was from 1980s on, NWS is from late 1990s to present and GG is from 2000s and on. According to (Randma-Liiv & Drechsler, 2017) were in last three decades in Central and Easter Europe four phases of public administration paradigm. From 1989 to 1996 was NPM, from 1997-2004/07

Post-NPM, from 2004/07 to 2014 NWS and New Public Governance (**NPG**), Joined-up Government (**JUG**) and Whole-of-Government (**WoG**) and from 2014 to today Public Sector Innovation (**PSI**). In addition to traditional model few new governance and hybrid models has emerged Some of these models are New Public Governance (**NPG**), New Public Service (**NPS**), New Weberian State (**NWS**) and Public Value (**PV**) (Lampropoulou & Oikonomou, 2018). To sum up public governance theories, we have Weberian public administration (**WPA**), New Public Management (**NPM**) and **post NPM**, New Weberian State (**WBS**) with New Public Governance (**NPG**), Joined-up Government (**JUG**) and Whole-of-Government (**WoG**), Public Value (**PV**) and Public Sector Innovation (**PSI**).

Table 1 presents the roles of service beneficiary within different public governance models with the stress on collaboration dynamics between government and citizens.

PUBLIC GOVERNANCE MODEL	SERVICE BENEFICIARY
WPA	Citizen as legislation addressee
NPM	Customer, client, user, consumers
POST-NPM	Customer, client, user, consumers
WBS	Citizen, more as a subject
NPG	Active citizen, co-decision maker
JUG	Increased citizen participation, citizen-centered models.
WOG	Public-private cooperation, coordination
PV	Citizen as stakeholder, citizen/customer
PSI	Valuable partners, co-creators

Table 7: Public governance models

Source: Authors own interpretation of: (Christensen & Lægreid, 2007; Katsamunska, 2016; Kovač, 2015; Lampropoulou & Oikonomou, 2018; O'Flynn, 2007; Randma-Liiv & Drechsler, 2017; Suzuki & Demircioglu, 2017; Thapa, Niehaves, Seidel, & Plattfaut, 2015)

1.3 User roles

Citizens can have different roles in co-creation. (Nambisan & Nambisan, 2013) defined four roles in citizen co-creation such as **citizen as explorer, citizen as ideator, citizen as designer and citizen as diffuser**. In work (W. H. Voorberg et al., 2015) identify three types of roles a citizen can have in co-creation/co-production: citizen as a **co-implementer, citizen as a co-designer and citizen as an initiator**. According to (Echeverri & Skålén, 2011), citizen can have four roles: value **co-creator, value co-recover, value co-reducer and value co-destroyer**. Last two roles came from co-destruction, because co-creation and co-destruction are intertwined. Citizen may have different roles based on participation in, for example, smart city project. There were 6 roles for citizens such as **citizens as sensors or data providers, citizens as problem reporters and feedback providers, citizens as hackers, citizens as neighborhood innovators, citizens as idea generators and budgeters and lastly citizens as collaborator and project partners** (Günter, 2016).

With the change of public governance models, citizens are taking new roles – they are becoming more and more active in collaboration with government. Three broad issues have made imperative for government agencies at all levels to change the nature of their relationships and engagement with citizens in problem solving. Fiscal austerity encourages new, less resource-intensive modes of problem solving. Complex problems call out for more collaborative approaches with external partners, including citizens. New information technologies make connecting with citizens easier and reduce the cost of such collaboration (Nambisan & Nambisan, 2013). These three factors have set the context for redefining citizens role in public services. Citizens are not passive anymore, but are valuable partners, co-creators in achieving business goals and main objectives.

The reminder of the paper is organized as follows: section "Methodology of a Literature review" presents literature review on research trends in the field of public services co-creation. In section 3 we present problem definition, section "Methodology and preliminary/expected results" presents our conceptual framework and the last section summarizes our future development beliefs.

2 Methodology of a Literature review

Previous definitions of co-creation share some key points. Co-creation is an activity of process between the company/organization and the consumer/user/citizen/customer. It requires joint collaboration of both sides and the main objective is to create value for both sides (Garcia Haro et al., 2014). Based on these key points, we can sum up, that in the context of public administration, the room for co-creation was created within the New Public Governance and forward.

2.1 Research Trends in the Field of Public Services Co-Creation

Relevant literature in the field of public services co-creation will be searched in the Web of Science and ScienceDirect. We will run few searches in electronic database using different terms:

- [co-creation] or [co-production] or [co-innovation] and [public services] or [public administration] or [public domain] or [local government],
- [co-creation] or [co-production] or [co-innovation] and [maturity model] or [maturity assessment] or [maturity level] and lastly
- [co-creation] or [co-production] or [co-innovation] and [decision model] or [decision support system].

The results of the above presented search strategy are presented in Table 2.

Table 8: Search parameters and results

Search parameters	Results		
	Web of Science	ScienceDirect	Scopus
1. **co-creation** or **co-production** or **co-innovation**	9132	23582	11444
2. (**co-creation** or **co-production** or **co-innovation**) and	269	33	422

	(**public services** or **public administration** or **public domain** or **local government**)			
3.	(**co-creation** or **co-production or co-innovation**) and (**maturity model** or **maturity assessment** or **maturity level**)	3	10	9
4.	(**co-creation** or **co-production or co-innovation**) and (**decision model** or **decision support system**)	10	6	38
5.	(**co-creation** or **co-production** or **co-innovation**) and (**decision model** or **decision support system**) and (**public services** or **public administration** or **public domain** or **local government**)	0	0	1
6.	(**co-creation** or **co-production** or **co-innovation**) and (**public services** or **public administration** or **public domain** or **local government**) and (**maturity model**	0	0	1

or **maturity assessment** or **maturity level**)			
7. (**co-creation** or **co-production** or **co-innovation**) and (**decision model** or **decision support system**) and (**maturity model** or **maturity assessment** or **maturity level**)	0	0	0
8. (**co-creation** or **co-production** or **co-innovation**) and (**decision model** or **decision support system**) and (**maturity model** or **maturity assessment** or **maturity level**) and (**public services** or **public administration** or **public domain** or **local government**)	0	0	0

In our review, we will include records from 3rd, 4th, 5th and 6th search in the Web of Science, ScienceDirect and Scopus. These records include search parameters that are relevant to the topic of research. 3rd search parameter revealed 21 different articles and 4th search parameter 42 different articles. Articles that include the 5th and the 6th search parameters are already part of 3rd and 4th search parameter. In total, without duplicates, we identified 63 different articles to be included in the literature review. We will divide research trends into five categories: subject area, user roles, digital dimension, role of decision support systems and role of maturity models. Figure 1 shows number of articles published per year. As we can see, the trend is growing, indicating that we are addressing a relevant topic. Number of articles for year 2019 is not relevant, because year has just started.

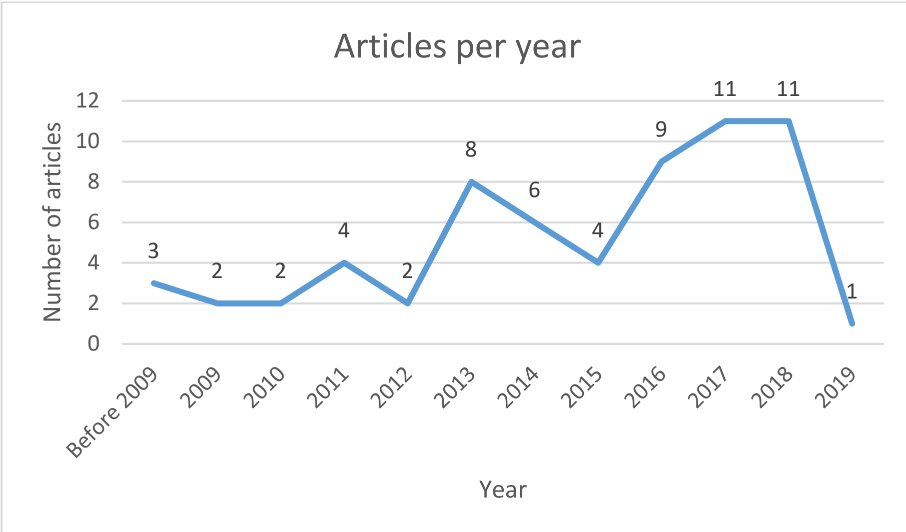

Figure 12: Number of articles per year

2.1.1 Subject area and user roles

Table 3 shows number of articles and references per category. We can see that most of the research in the observed field was made in the field of environment, marketing, computer science, health and industry. These subject areas seem to practice a high level of collaboration between citizens and organizations.

Table 9: Number of articles and references per subject area

Subject area	Number of articles (percentage)	References
Agriculture	2 (3,2 %)	(Eastwood, Dela Rue, & Gray, 2017; Rossi, Salinari, Poni, Caffi, & Bettati, 2014)
Biology	1 (1,6 %)	(Altieri, Di Renzo, & Genovese, 2013)
Business	1 (1,6 %)	(Adrodegari, Saccani, Kowalkowski, & Vilo, 2017)
Car industry	1 (1,6 %)	(Beelaerts van Blokland, van de Koppel, Lodewijks, & Breen, 2018)
Computer science	6 (9,5 %)	(Carroll, 2017; Carroll & Helfert, 2015; González-Rojas, Correal, & Camargo, 2016; Hofmann, Lauber, Haefner, & Lanza, 2018; Hwang, 2010; Zainuddin & Gonzalez, 2011)
Education	3 (4,8 %)	(Basanno, D'Aniello, Gaeta, Perano, & Rarità, 2016; Piroozfar, Adeyeye, Rosenkind, & Winstanley, 2013; Valentin, Hegmans, Emrich, Werth, & Loos, 2013)
Environment	17 (27 %)	(Adem Esmail, Geneletti, & Albert, 2017; Barnhart et al., 2018; Capaz & Seabra, 2016; Conraud, Jammes, Vera Morales, & Cordoba, 2014; Dahl et al., 2018; DeCrappeo, Bisbal, & Meadow, 2018; Dilling & Lemos, 2011; Gebetsroither-Geringer, Stollnberger, & Peters-Anders, 2018; Lobbrecht, Einfalt, Leanne, & Poortinga, 2011; Mann & Schäfer, 2018; Pérez-Fortes, Bojarski, & Puigjaner, 2011; Polese, Carrubbo, Bruni, & Maione, 2017; Rayl, Young, & Brownson, 2013; Rose et al., 2018; Stewart & Bennett, 2017; Wissen Hayek, Teich, Klein, & Grêt-Regamey, 2016; Wood, Stillman, & Goss-Custard, 2015)

Geochemistry	3 (4,8 %)	(Barth, Andresen, Iden, & Johansen, 1996; Fang et al., 2016; Yang, He, Hu, Hu, & Yi, 2017)
Health	5 (7,9 %)	(Freebairn et al., 2017; Horrocks, Michail, Aubeeluck, Wright, & Morriss, 2018; Sawtell et al., 2018; Schalkers, Enthoven, Bunders, & Dedding, 2017; Seymoens, Ongenae, Jacobs, Verstichel, & Ackaert, 2019)
Industrial services	1 (1,6 %)	(Kohtamäki & Helo, 2015)
Industry	5 (7,9 %)	(Caner Taşkin & Tamer Ünal, 2009; Dumetz et al., 2016; Li, Zheng, & Wang, 2013; Ojanen, Kolehmainen, Ahonen, & Tuominen, 2010; Resteanu, Mitan, & Masei, 2001)
Marketing	7 (11,1%)	(Chuang, Lin, Chen, & Chen, 2013; Lee & Lee, 1999; Motamarri, Akter, & Yanamandram, 2017; Mukherjee, 2016; Pantano & Migliarese, 2014; Roser, DeFillippi, & Samson, 2013; Tung, Yuan, & Chi, 2009)
Not specified	5 (7,9 %)	(Chiu, Liang, & Turban, 2014; Constantinescu, Devisch, & Kostov, 2017; Grace, Finnegan, & Butler, 2012; Karmarkar & Roels, 2015; McPhee, 2016)
Other areas	3 (4,8 %)	(Haahr, 2014; Kutsikos & Kontos, 2012; Tonelli, Demartini, Loleo, & Testa, 2016)
Social policy	2 (3,2 %)	(Hildebrandt, 2018; Santos, Tonelli, & Bermejo, 2014)
Space science	1 (1,6 %)	(Sherwood & McCLeese, 2013)

Similarly, user roles as identified in section 1.3 were identified only in one article, where there were four user roles: innovators, differentiators, enablers and coordinators (Motamarri et al., 2017). In other articles, user roles in context of co-creation or co-production were not specified. We can find other roles in the context of decision making, such as stakeholders, experts, decision makers, etc.

2.1.2 Digital dimension

In this section, we show how often a digital dimension is addressed in the co-creation research. From total of 63 articles, 34 articles have digital dimension (54 %) and 29 do not (46 %). In those 34 articles, we can find different tools for decision support systems or maturity models, web-based visualization platforms, SaaS applications, electronic guided decision support systems, different practices on social media platforms, usage of machine learning for decision-making, etc. Many of them could be reused with little or no changes.

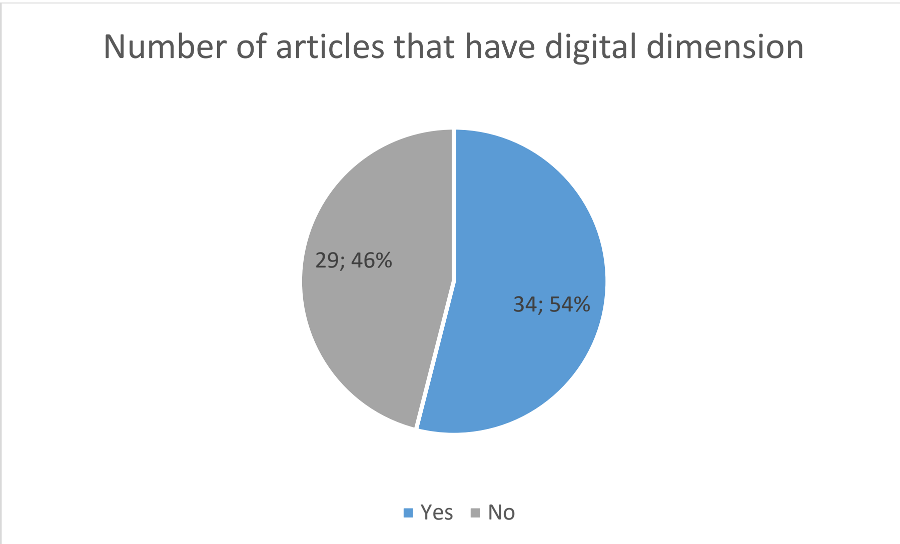

Figure 13: Digital dimension in the co-creation literature

2.1.3 Role of decision support system or decision models

From 63 articles, 42 articles (66,67 %) were found with search parameters "decision support system" or "decision model". Of 42 articles only in 3 articles (7 %) role of decision support system or decision models were not clearly shown. Role of decision support systems can be found in different decision support systems (e.g. spatial DSS, DSS for vineyard managers, DSS for farmers, DSS for seasonal climate forecasting, etc.). In some articles we could find which method was used (e.g. ANP, AHP, Theory-based, Multi-attribute decision making, Pareto frontiers, Machine learning as part of DSS, decision chats, etc.). In some cases, authors wrote about (decision support) tools or decision models for decision making and not decision support systems (e.g. decision support tool for watershed management, dynamic decision support tool for comparing policy options, spectral analysis tools, decision aid tool based on System Perception Analysis, Emergency decision model for distribution plan, Decision analytical model for evaluation of interventions, etc.). Decision models can be also found as part of larger applications, as it is the case in (Lobbrecht et al., 2011; Tung et al., 2009). We can summarize that different authors use different methods for decision making.

2.1.4 Role of maturity models or maturity assessment

From 63 articles, 21 (33,33 %) were found with search parameters that contained "maturity model", "maturity assessment" or "maturity level". Of 21 articles in 7 articles (33,33 %) role of maturity models was not clearly shown. Some authors proposed new or updated maturity models (e.g. Enterprise interoperability framework for assessing maturity level, Inner Source Capability Maturity Model, Stability-value leverage maturity model, Model Predictive Control, etc.). Role of maturity model can be also seen as part of Manufacturing Value Modeling Methodology, that uses Gartner Maturity Model. Nonetheless authors mostly assessed maturity with 3 to 5 Likert Scale, where 1 was the lowest score and 5 was the highest score.

2.2 Mayor Subsections

According to (Urze & Abreu, 2012) if you want to achieve high levels of performance and competitiveness or competitive advantage, you need innovation capacity, which requires access to new knowledge that enterprises usually do not hold. For example, in United Kingdom patient and public involvement in health care research is a requirement in most publically funded researches. Co-production emerged as a critique of the lack of recognition of service users input in the successful delivery of a service. Co-production, as a service delivery model where the service user is an active contributor in the delivery of service, has often been cited in UK health and social care policy as a way forward (Realpe, Wallace, Adams, & Kidd, 2015). Different actors are participating in the process of knowledge production which is becoming more socially accountable (Gillard, Simons, Turner, Lucock, & Edwards, 2012). Lack of accountability, autonomy, capacity, trust, efficiency and legal basis of the modern state are five concepts criticizing public-private partnership (3P model). According to (Puerari, Concilio, & Longo, 2014), a solution might be a public-private-people partnership (4P model). Governance model based on 4P model shows that governance is the result of a learning process that involves knowledge in action, or better action as knowledge. Involved actors in the making of the governance are transforming their own experiences into a cognitive infrastructure of the emerging governance.

According to (Nascimento, Sousa Neto, Milito, & Oliveira Júnior, 2014) there are eight factors contributing to the growth of maturity in project management in public organizations. These factors are Planning and control, Management skills development, Project management environment, Subject Acceptance Project Management, Stimulus for Performance, Evaluation of Projects and Learning, Office of Project Management and Visibility of Project Managers. There are probably also other factors that can be used in maturity model for maturity assessment.

A maturity model is a technique that is valuable in measuring different aspects of a process or an organization and represents a path towards an increasingly organized and systematic way of doing business (Proenca, 2016). According to (Bruin, Freeze, Kaulkarni, & Rosemann, 2005) maturity models have been designed to assess the maturity of a selected domain on more or less comprehensive set of criteria. The most popular way of evaluating maturity is with a five point Likert scale where 5 represent the highest level of maturity. According to (Shih, Zhang, Li, & Bai, 2018) there could also be readiness level scale from 1 to 4. 1 represents new technologies that are still in the research phase and moving toward proof of concept, 2 represents technologies that are in the stages of optimization, system integration, pilot testing and demonstration, 3 represents technologies that are ready for immediate deployment and 4 represents technologies that are mature and well established. This scale could be used after the Likert scale, because first, one would evaluate the maturity of the domain, in order to establish whether it is mature enough to implement new technology; later, with the readiness level scale from 1 to 4, it would be possible to assess the maturity of newly implemented technology. If an organization scores high on both scales, stakeholders would know that this organization is mature enough to implement new innovative technologies, but uses only mature and well established technologies.

When organizations decide to achieve their objectives in co-creating a service or creating a value, they have to manage to co-ordinate different actors in their collaboration. Firstly, organizations have to choose general orientation of their activities in order to secure scheme sustainability on a long-term basis with efficient service maintenance strategy, secondly, planning process should include some safety margins or alternative management rules to allow for unexpected events while the plan is being carried out and making decisions regularly in order to correctly reacting to unforeseen events and reviewing the initial plans (Le Gal & Papy, 1998). In today's organizations, value creation is characterized by intangible drivers like process improvements, innovation, knowledge and people. Decision making is becoming increasingly complicated as a result of the enormous number of alternatives and multiple conflicting goals (Tonelli et al., 2016).

When researching literature in the field of Public Services Co-creation we did not find any article including decision support systems or decision support models and maturity models. In fact, we did not find any article in the field of co-creation where decision support systems and maturity models would be included.

3 Problem definition

Previous research in the field revealed that, despite many co-creation processes, guidelines and instructions, at least to our knowledge, there is no framework supporting public sector organizations in co-creation of public services. Thus, a general research question (RQ) to be addressed in the thesis is: What are the limitations of the existing maturity models for assessment of public services co-creation? This general research questions will be structured in the following ones:

RQ1: Do current co-creation models support evaluating co-creation maturity of services?
RQ2: Is it possible to create a decision making model with which we can measure maturity level of public services co-creation?

> **RQ2.a:** What are key criteria for decision making model for assessing maturity level of co-created service?
> **RQ2.b:** Can decision making model be sensitive enough to differentiate between different levels of maturity?

The purpose of our work is to develop a framework, that would facilitate the public sector organizations to implement the process of co-creation in the renewal or innovation of the service.

The contribution of this research is the development of a framework that guides organizations in public sector in the implementation of process of co-creation.

4 Methodology and preliminary/expected results

Different research methods and models will be used in our research to create proposed framework. Interviews and questionnaires with experts in the domain of co-creation will be used to get proper criteria and weights for our decision making model and maturity model, and case study for testing our framework.
Our framework consists of a few steps. First step is defining the problem. Well-defined problems lead to breakthrough solution. Most organizations are not sufficiently rigorous in defining the problems they are attempting to solve, when developing new products, processes, or even businesses (Dwayne Spradlin, 2012). Usually, finding problems to solve is not a challenge; however, sometimes identifying the exact problem can be a challenge - and thus we sometimes treat the wrong problem (Clemen & Reilly, 2014).

Second step is choosing the right collaboration mode. Complex organizational environment demands effective management not only within but also between organizations (Huxham & MacDonald, 1992). The right leadership is required for successful process of co-creation. Leadership has to navigate in conditions of shared power and voluntary engagement. Participants cannot be ordered to collaborate but must be convinced of the merits of collaboration (Hedensted Lund, 2018). When organizations are increasingly collaborating with outsiders to innovate, they confront critical and complex choices about whom to collaborate and how to share power with them (Pisano & Verganti, 2008). Previous research indicates that collaboration may be necessary and desirable, but it is hardly easy and failures are common (Crosby, Bryson, & Middleton Stone, 2006).

Third step is a design phase. The goal of this step is design of service, which can be used for production of pilot/prototype. Services are essential to human well-being, especially in sectors like health care, education, finance and governmental services (Patrício, 2017). There are three different perspectives to service that have to be taken into account: Goods Dominant Logic (G-D logic), Service Dominant Logic (S-D Logic) and New Service Development (NSD). In G-D Logic is service as an outcome (new kind of service products or attributes), in S-D Logic is service as an experience (valuable, subjective experience) and in NSD is service as a process (a new, well-functioning process). In S-D Logic value is always co-created in interactions among providers and beneficiaries, while in NSD value co-creation is an active, creative and social process based on collaboration between provider and customer (Kijima & Arai, 2016). According to (Bartl, 2009) there are three key questions in co-creation process: "At what stage in the innovation process co-creation should take place? What kind of customer/user is best suited to co-create with? How the course of co-creation should be designated?" In this phase customers and providers try to share and co-define internal model through mutual understanding (Novani & Kijima, 2012). To create optimal settings and conditions for this co-creation design phase is demanding and expensive in terms of time, money and other resources. The right people have to be involved in the right time, both in terms of power and skill and still be sure that progress is being made (Mogstad, Høiseth, & Pettersen, 2018). Not knowing if the project will result in desired outcome or if we are colored by our earlier experiences and past disappointing experiences tends to lead to cynicism and demotivation (Bowen et al., 2013). Better knowledge on the co-creation maturity stage within a firm aims to shed light on potential pitfalls of co-creating offerings and supports practitioners to determine the expected co-creation outcome. A thorough understanding of when and where to leverage co-creation becomes even more important to ensure no co-destruction takes place. (Oertzen, 2018).

Last step is production phase. The goal of this phase is to build working pilot or prototype based on previous research in design phase and then deliver it to market. Service concepts are created, conceptualized and developed to be made ready for delivery. Before delivery, prototype has extensive testing (Mosen Abdel Razek, Husen, Pallot, & Richir, 2017). Tested interactive prototype will be the same as the users will experience when using it after delivery (Boukhris, Fritzsche, & Möslein, 2017). Prototyping is necessary because customers cannot evaluate a service without experiencing it in person (Ko, Jung, Kim, & Keum, 2013). After successful extensive testing of prototype new service or product is ready for delivery.

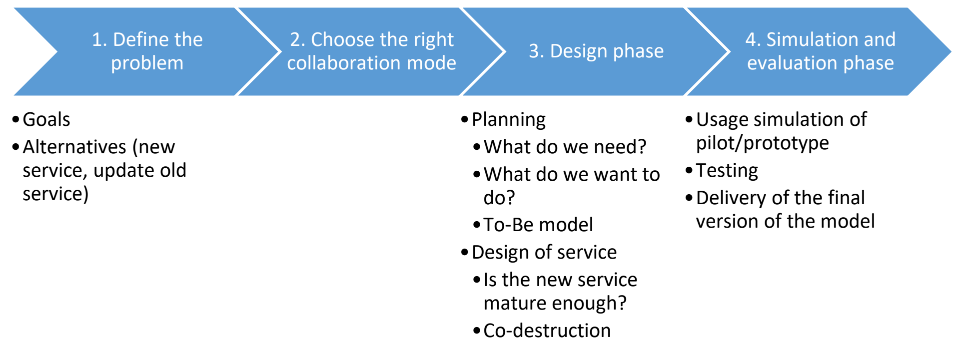

Figure 3: Proposed framework

5 Future development

The purpose of this work was to find literature gap in the field of public services co-creation. Literature review has revealed that even though public service co-creation is not a new concept, we could not find any work that would combine decision support systems, maturity models and public service co-creation. According to (W. H. Voorberg et al., 2015) policy makers and politicians consider co-creation/co-production with citizens as necessary condition to create innovative public services that actually meet the needs of citizens. But what do we actually know about co-creation maturity of these new services? Decision making models for assessing maturity level of co-created services and increasing usage of co-creation practices could help policy makers and politicians get a thorough understanding of when and where to exploit the benefits of co-creation and also ensure that no co-destruction would happen. We believe that our work will also motivate others to start assessing maturity level of their newly innovated services and thus reduce the possibility of co-destruction and failed public services.

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A. Pucihar (ed. et al.)

Building Trust in a Digitizing World

THIES VAN DER LINDE

Abstract Building trust between an organization and customers is a major concern for organizations in a digitizing world. Technology can be a lever for innovation and blockchain technology promises creating immutable trust. How can mechanisms for creating trust be operationalized in blockchain technology and what is the validity of trust-based blockchain solutions for creating trust between an organization and customers?

Keywords: • Trust • Blockchain • Marketing • Digitalization • Trust Mechanisms •

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1 Introduction

Around the world, drivers of taxicabs protest against private hire vehicle companies such as Uber. Uber is a transportation network company that offers services including peer-to-peer ridesharing, ride service hailing, food delivery, and a bicycle-sharing system. It is not a taxi service company since it does not own taxi cars, but it is disruptive for the taxi market (The Economist, 2015). This makes it a good example of blurring organizational boundaries, caused by digitization, globalization, changing labor relations and social media (Management Impact, 2018). Another example is Threadless, a clothing company that fully outsources its core activity, clothing design, to its international online community of customers. It has never invested in advertising and it also employs no professional designers. The customer is the company (Marketing Tribune, 2018).

2 Problem definition: marketing faces trust issues

The blurring of organizational boundaries plays a role in all sectors and within marketing there are three major changes to be seen. Firstly, the rise of the platform economy has led to more stakeholder complexity (Frenken, 2017). Value creation takes place in changing compositions within chains and billions of internet connected objects, devices and robots that will play a role in economic and social traffic are being added rapidly (Marketingfacts, 2016). The technological infrastructure exists, but the social infrastructure with paradigms such as trust, connection, collaboration and development and use of talents are needed and equally important (Korte, 2010). Secondly, the consumer is changing the business. As a result of the macro trend digitization via social media, they are becoming increasingly critical and influential. With one click, they switch to the competitor or share their experiences with the world. They respond via blogs and forums, form (purchasing) collectives and communities such as in the example of Threadless, participate in organizing and implementing organizational processes (open innovation, help desk functions, rates and reviews or influencer marketing). Companies are therefore no longer fully in control of their own products, brands and messages (Vision paper research group MMI, 2016). A problem with this is that consumer communications are not always reliable either. Consumers can threaten with bad reviews in exchange for a free product or service. In the case of Uber, drivers and consumers can agree that they will judge each other well. Something that happens frequently on LinkedIn (Marketingfacts, 2016). Reviews are easily purchased (NOS, 2019) and, according to soon-to-retire Unilever Chief Marketing Officer Keith Weed, many influencers used fake followers, also called computerized bots to inflate viewing figures (Reuters, 2018). Finally, the macro trend sustainability ensures that consumers find it increasingly important which ethical values, such as sustainability, authenticity, honesty, transparency and openness (Nielsen, 2013; World Federation of Advertiser & Edelman, 2013) organizations and brands represent. Marketing is therefore increasingly about values rather than value.

In above mentioned changes, trust plays a central role within the total value creation chain. Carly O'Neill summarizes that consumers find it difficult to trust moral production, with the same reasons why they mistrust mass production. The eco system is too complex due to the increased stakeholder complexity; it is opaque and the chains are long. Consumers do not know which information to trust and have little confidence in the integrity of organizations (Sociologie Magazine, 2013). On a global level, several sources show that organizing and maintaining trust is a major challenge (Gallup, 2018; Weddepohl; Edelman & PwC, 2017). Organizing trust will therefore be the central theme in this research.

Brand expert and neuroscientist Erik Schoppen (2016) states that trust starts with transparency and that organizations must be able to put their promises in order and make them transparent. Bernard Marr (2018) endorses this and adds that in a world of digitization, where 160 million emails are sent every 60 seconds, 98,000 tweets are shared on Twitter, 600 videos are uploaded on Youtube and 1500 blogs are created, organizations must respond with trust and transparency by using technology. Professor Henk Volberda (2015) arrived at four levers for business model innovation of which technology is one: technology, management, organizational forms and co-creation. An example of technology as a lever for innovation is social media, which has been disruptive for many business models.

Blockchain technology claims creating an immutable trust through its characteristics (The Economist, 2015). Ogilvy RED (2017) also concludes that blockchain's immutable trust stems from the following characteristics: safety, transparency, authenticity and credibility. Tapscott (2016) compares blockchain to a general ledger in which transactions are kept. Instead of central control over the general ledger, a blockchain is distributed to blockchain participants. So there is no central database that can be hacked. In addition, the blockchain is in principle transparent for everyone. Finally, the blockchain is cryptographically encrypted which guarantees virtual security. Until now, scalable solutions have not been available and the technology is still in its infancy (Gartner, 2018). This is also evident from research results from the Capgemini Research Institute (2018). This research shows that 3% of 447 blockchain interested companies apply the technology on a large scale and 87% are still in the experimental phase.

A literature research conducted in 2018 towards exploring blockchain in combination with trust and marketing compared to the same research in march 2019 has the following results:

Database: Business Source Elite | EBSCO

Keywords:	Results 2018:	Results 2019:
- Blockchain	3,612	5,174
- Blockchain AND Trust	158	207
- Blockchain AND Marketing	86	135
- Blockchain AND Marketing AND Trust	6	6

The results shown below in figure 1 and 2 indicate that academic research into the claim of blockchain creating immutable trust is increasing in interest. However, if combined with marketing there has not been any new entry and has only two hits in academic journals. Especially one article is relevant to this research: *The limits of trust-free systems: A literature review on blockchain technology and trust in the sharing economy* (Hawlitschek, Notheisen & Teubner, 2018). The authors conclude that de concepts of trust for the sharing economy and for blockchain technology differ substantially. In order to successfully contribute to theory on trust in different contexts it is of utmost importance to agree on a set of common concepts and expressions and to relate those to established work. They proceed stating that it is necessary to critically assess and discuss the "promises" derived from nonacademic literature and media, from a scientific, well-structured and theory-grounded point of view.

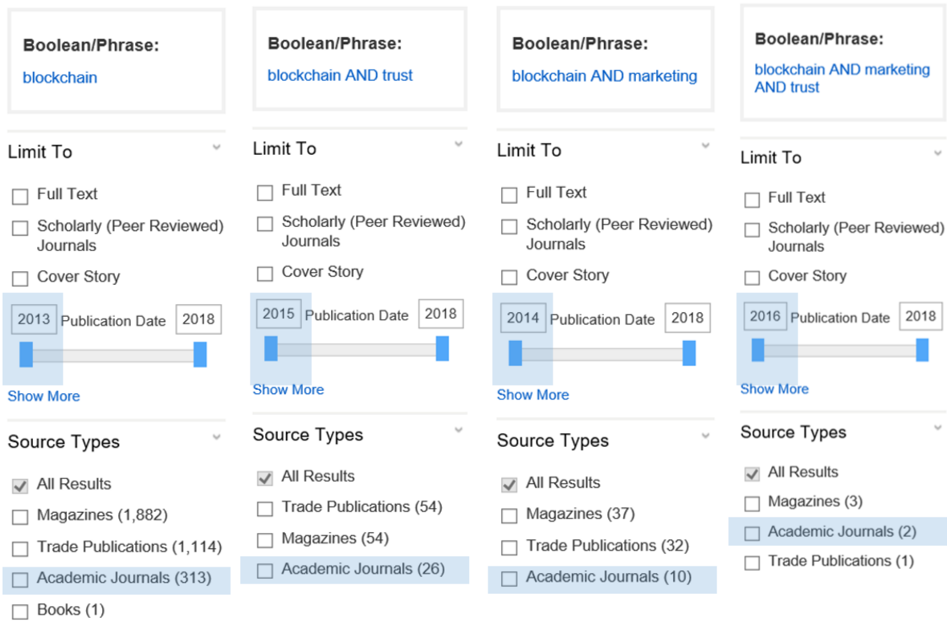

Figure 1: Results 2018

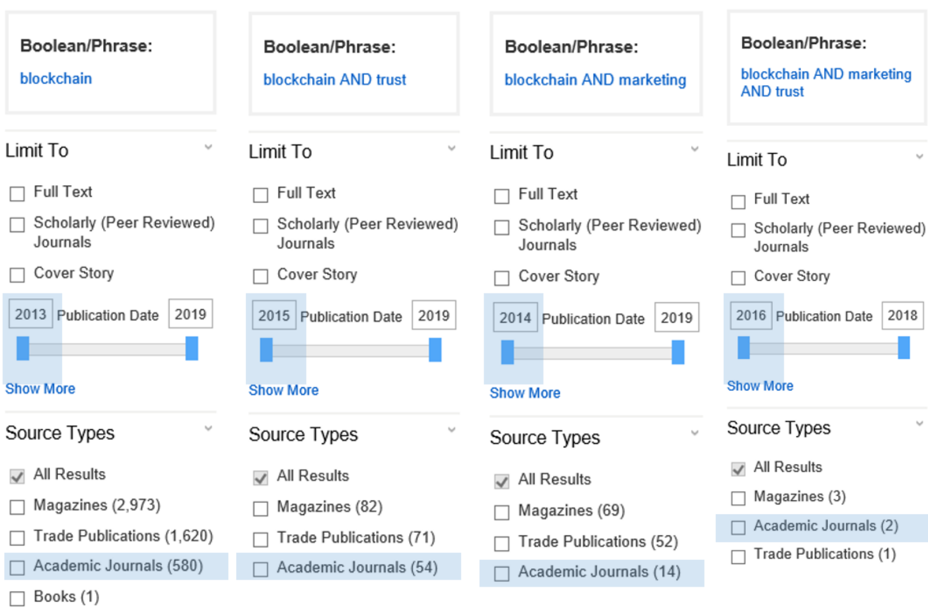

Figure 2: Results 2019

Main Research Question:
How can blockchain technology be set up so that it contributes to organizing trust between an organization and customers in an ecosystem of stakeholders?

The scope of this research will be the food industry since this industry is facing the problem of mistrust between organizations and consumers heavily (Sociologie Magazine, 2013).

"Blockchain technology enables a new era of end-to-end transparency in the global food system. It allows all participants to share information rapidly and with confidence across a strong trusted network. This is critical to ensuring that the global food system remains safe for all."
Frank Yiannas, Vice President, Food Safety at Walmart

Research questions (RQs):

1. What are the concepts of trust in blockchain and in organizing trust between an organization and customers in an ecosystem of stakeholders?
2. What are mechanisms/factors for organizing trust in general and for blockchains specifically?
3. How can these mechanisms/factors (see RQ2) be operationalized in blockchain technology to organize trust between an organization and customers in an ecosystem of stakeholders in the food industry?
4. What is the validity of trust-based blockchain solutions for organizing trust between organizations and consumers?

3 Methodology: design research

The design science paradigm is chosen as research design since it is fundamentally a problem-solving paradigm. It seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artifacts. It is next to behavioral science much used in the Information Systems discipline (Hevner et.al, 2004), especially in the context of addressing so called 'wicked' problems. Therefore it is considered suitable as a design for this research.
The research framework developed by Hevner et al. (2004) is shown in figure 3:

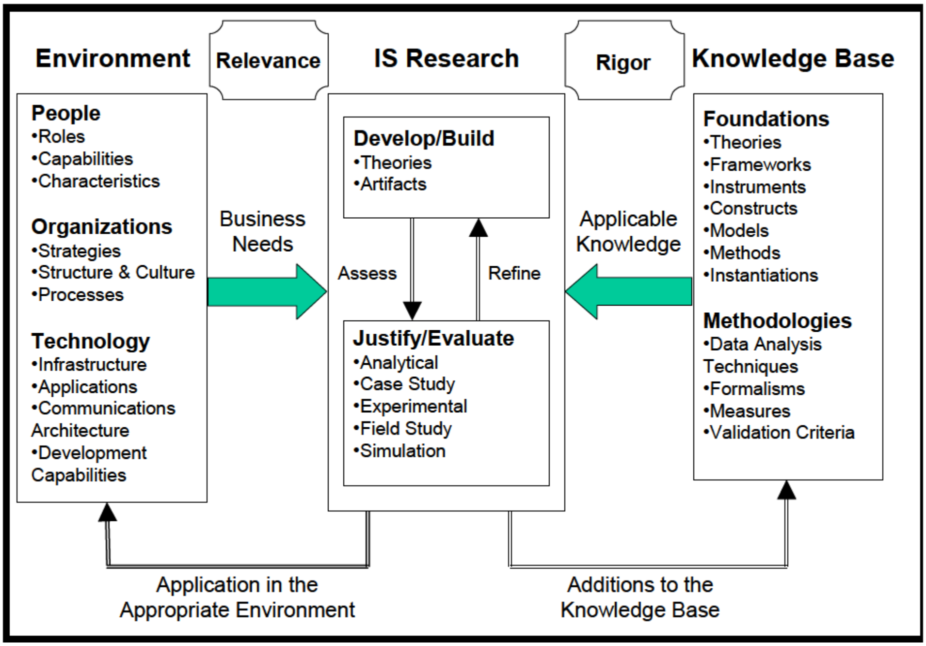

Figure 1: Information Systems Research Framework

There will be three phases in the research covering the research questions as follows:

Exploration phase:

1. What are the concepts of trust in blockchain and in organizing trust between an organization and customers in an ecosystem of stakeholders?

Method: Knowledge Base literature review
A literature review will be conducted to set boundaries for the theoretical foundations and context of the research question, bringing the research question into focus (Okoli & Schabram, 2010).

2. What are mechanisms/factors for organizing trust in general and for blockchains specifically?

Methods: Environment literature review and focus groups resulting in technology-based artifacts, organization based artifacts and people-based artifacts needed for the development phase.

This literature review will focus on instruments and constructs which are in place for organizing trust in all industries. The scope will be within and outside the blockchain as it is relevant to know which factors play a role and can be transferred to building a blockchain setup in the developing phase.

The focus groups aim to further analyze the business needs towards organizing trust. It is more efficient than qualitative interviews and it allows for cross participant communication which achieves more depth in the subject (Morgan, 1996). The participants will be selected on their role and capabilities and there will be a diversity in sectors.

Development phase:

3. How can these mechanisms/factors (see RQ2) be operationalized in blockchain technology to organize trust between an organization and customers in an ecosystem of stakeholders in the food industry?

Method: the blockchain template will be setup following the results of the exploration phase.

Hevner et al. (2004) state that the following artifacts are necessary to address the issue of organizations to overcome the predicted acceptance problems:

- Technology-based artifacts (e.g., system conceptualizations and representations, practices, technical capabilities, interfaces, etc.);
- Organization-based artifacts (e.g., structures, compensation, reporting relationships, social systems, etc.);
- People-based artifacts (e.g., training, consensus building, etc.).

Justifying/Evaluation phase:

4. What is the validity of trust-based blockchain solutions for organizing trust between organizations and customers?

Method: to be chosen
Hevner et al. (2004) continue their framework with five design evaluation methods, see figure 4, of which a choice will be made:

1. Observational	Case Study: Study artifact in depth in business environment
	Field Study: Monitor use of artifact in multiple projects
2. Analytical	Static Analysis: Examine structure of artifact for static qualities (e.g., complexity)
	Architecture Analysis: Study fit of artifact into technical IS architecture
	Optimization: Demonstrate inherent optimal properties of artifact or provide optimality bounds on artifact behavior
	Dynamic Analysis: Study artifact in use for dynamic qualities (e.g., performance)
3. Experimental	Controlled Experiment: Study artifact in controlled environment for qualities (e.g., usability)
	Simulation – Execute artifact with artificial data
4. Testing	Functional (Black Box) Testing: Execute artifact interfaces to discover failures and identify defects
	Structural (White Box) Testing: Perform coverage testing of some metric (e.g., execution paths) in the artifact implementation
5. Descriptive	Informed Argument: Use information from the knowledge base (e.g., relevant research) to build a convincing argument for the artifact's utility
	Scenarios: Construct detailed scenarios around the artifact to demonstrate its utility

Figure 4: five design evaluation methods

4 Preliminary/Expected results:

Expected results for practice:

- Monitoring tool for measuring trust in the food industry
- Configuration template for blockchain
- Promotion of expertise of participants

Expected academic results:

- 5 to 6 academic papers of which at least 1 in an ISI Ranked Journal
- Participation at conferences

5 Future development:

The relevance of this research to education is high. Many institutes within the University of Applied Sciences Utrecht focus on digital transformation, operationalized in big data, blockchain and artificial intelligence. For example, the institute for business administration focuses on digital transformation. Teachers at that institute indicate that they would like to include blockchain in the curriculum, but knowledge is lacking. Opportunities lie in embedding the results in the curriculum of both the IBA and IMC institutes and developing a Master's program within these institutes. In addition, this topic provides opportunities for cross-institutional initiatives.

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University of Maribor Press

Development of Governance-Risk-Compliance Framework for Cloud Environment

MARTIN ZBOŘIL

Abstract Cloud technology has become an inseparable part of a vast quantity of nowadays organizations. Cloud services replace the use of traditional on-premise infrastructure and bring many benefits to the organizations, including security benefits. However, as at each technology, many drawbacks are linked to cloud computing as well. Each organization has different priorities in these drawbacks, nevertheless, security risks and the whole governing of the cloud security should never be missed. Moreover, organizations need to be aware of specifics of cloud security, otherwise, a vast amount of decisions, controls and countermeasures might not be effective. The subject of the thesis described in this article is to provide organizations GRC framework (Governance-Risk-Compliance) that focuses on the security of used cloud services.

Keywords: • Cloud computing • Security • Governance • Risk • Compliance • Framework •

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1 Introduction

Cloud technology is a current subject matter in the business world of IT. In the last years, organizations have tended to increase the number of used cloud services every year in comparison to the use of traditional on-premise systems. The increase is proved in many reports that deal with this area. The examples are *Cisco 2018 – Annual Cyber Security Report* (Cisco, 2018), *Cloud Security Report 2018* (Crowd Research Partners, 2018), *RightScale – State of Cloud Report™* (RightScale, 2018), *Oracle and KPMG Cloud Threat Report 2019* (Oracle, 2019), *Cloud Adoption and Risk Report 2019* (McAfee, 2018) and *State of Cloud Security* (Cloud Security Alliance, 2018).

Prior to delving into the security details of cloud computing, it is important to define how this technology differs from traditional on-premise systems. The official definition of cloud computing does not exist; however, the most respected one was published in *The NIST Definition of Cloud Computing* issued by the National Institute of Standards and Technology (Mell & Grance, 2011): *"Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."* In this publication, National Institute of Standards and Technology further defines five essential characteristics that each cloud service needs to fulfil; they include *On-demand self-service, Broad network access, Resource pooling, Rapid elasticity, Measured service*. Moreover, the document contains two fundamental models of cloud services. The first one, deployment model, defines how the services are provisioned and includes four particular types – *public, private, community, and hybrid cloud.* The second one, service model, describes the components that are provisioned within the cloud service; the fundamental types are *Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS) and Software-as-a-Service (SaaS).*

The service model is related to one important concept of cloud services – *shared responsibility* (Simorjay, 2017). With the use of cloud services, there are always some responsibilities on the side of the cloud services provider and some of them on the side of cloud service customer. The question is then who is responsible for. The examples of responsibilities are the configuration of security controls, managing applications, managing operating systems, containment actions in the case of attack, data retention policy, and software versions control. The most important tool for how to manage the shared responsibilities is the contract with the vendor. For that reason, the contract must precisely define the distribution of responsibilities among the provider and client.

The use of cloud services brings organizations many benefits. Their fundamental overview is presented in the report (Catteddu & Hogben, 2009). The examples are more timely, effective and efficient updates (patches), smart scaling of resource and standardized interfaces for managed security services. The author of this thesis sees the main security advantage of cloud services in the benefits of scale. Cloud providers cannot afford to underestimate the security of the services since security is one of the most important market differentiators in the case of cloud computing technologies. For this reason, they employ many security specialists and use advanced security technologies that the clients cannot afford to pay for in the case of local on-premise solutions.

On the contrary, cloud services bring specific risks that have to be always taken into consideration. The examples are again presented in (Catteddu & Hogben, 2009). Among the most critical risks belongs mainly the loss of governance/control. The cloud providers never provide full access to its IT environment to cloud service clients. For that reason, they must always trust the cloud provider that it has the security on a sufficient level. Another risk is lock-in where the clients may be too dependent on one particular cloud service provider and transition to another cloud provider might be sometimes merely impossible. The next significant risk is the compliance with security standards and regulations. Other examples of risks are isolation failure, insider threat, data protection, and incomplete data deletion.

Organizations that use cloud services need to be aware of issues and requirements related to many other areas. The examples of such areas are business continuity, incident response, identity and access management, IT audit, malware protection, and asset management.

2 Problem definition

People responsible for assuring the security related to cloud services in organizations need to take the specifics of cloud computing into account to achieve the desired level of security. For this purpose, they may use GRC framework (Governance, Risk, Compliance) that helps organizations to identify and manage threats, risks, controls and other aspects of security. T. Kontzer pointed out in his publication *GRC in the Cloud* (Kontzer, 2011) that organizations need to maintain all parts of GRC (Governance, Risk, Compliance) for effective protection of the IT environment.

Several publications have already been focusing on GRC frameworks for the cloud environment. All these frameworks, however, were only on a theoretical and too general level. The examples are frameworks published in *Securing the Cloud with GRC* (Securing the Cloud with GRC, 2010) and *Cloud Computing: Security Model Comprising Governance, Risk Management and Compliance* (Al-Anzi, Yadav, & Soni, 2014).

The only framework that includes also directly implemented tools is *GRC Stack* developed by Cloud Security Alliance (Cloud Security Alliance). This framework is composed of three independent tools:

- *Cloud Controls Matrix (CCM)* – overview of controls grouped into 13 domains; relevant security standards, regulations, and frameworks are linked to each control,
- *Consensus Assessments Initiative Questionnaire (CAIQ)* – a questionnaire that contains questions related to each control from CMM,
- *CloudAudit* – supportive tool that helps cloud providers in audit automation.

This framework, however, does not include all necessary parts that the author of this thesis wants to have in his framework. The examples are risk management, compliance-supportive tool, compact governance part and mainly interconnection of all the parts and information to operate together. Nevertheless, the author of this thesis intends to use these tools as the information source for the framework development.

2.1 Thesis objectives

The main objective of the thesis is to develop the GRC framework that focuses on cloud security. This framework will incorporate all the GRC parts together. In the governance part, the framework will aim at implemented policies and controls, data sent to the cloud environment, contracts, business continuity, and other areas. The risk management part will offer mainly unique catalogs, risk scenarios, controls and countermeasures related to specifics of cloud services. The compliance part will include standards and regulations related especially to cloud computing.

The thesis contains several supportive objectives. The first one includes a description of theoretical basis in the areas of cloud computing technology, cloud security, and relevant governance, risk and compliance. The thesis further involves research with the purpose of finding specifics and priorities relevant for each component of GRC framework. The next supportive objectives closely linked to the primary objective are the design of the GRC framework and its verification through a case study.

2.2 Cloud GRC Framework usage

The developed Cloud GRC framework supposed to be used mainly in three particular scenarios where the organizations perform:

- an internal security assessment of cloud services,
- a security assessment of cloud services to external organizations,
- modelling of a security state in the case of transition to cloud services

3 Methodology

The whole thesis is based on the *Design Science Research* method. The method is rather a general concept; the particular method that is used within this thesis is called *Method Framework for Design Science Research* and was published in *An Introduction to Design Science* (Johannesson & Perjons, 2014) by Paul Johannesson and Erik Perjons. The individual parts of the framework and their relations are shown in Figure 1.

The research problem that is the subject of the *Explicit Problem* phase was already outlined in Chapter 2. The *Define Requirements* phase includes mainly the clarification of the requirements what the GRC framework should do. The subject of the next phase, *Design and Develop Artefact*, is to design and develop the framework with artefacts like the GRC tool and its guideline how the tool is supposed to be used. The artefact as the main output of this Design Science Research method is defined in (Johannesson & Perjons, 2014) as follows: *"object made by humans with the intention that it be used to address a practical problem. (...) Methods and guidelines can also be artefacts, for example, a method for designing databases."* Then, the subject of the following phase is to demonstrate the artefact in the real-life or illustrative scenarios (the phase *Demonstrate Artefact*). At the end, the artefact will be verified at the cloud platform of PricewaterhouseCoopers (Czech Republic). This step is a part of the final phase *Evaluate Artefact.*

Each of the phases mentioned in the previous paragraph is influenced by two other parts of *Method Framework for Design Science Research*. The first one*, Knowledge Base*, involves all necessary theory needed for the development of the GRC framework. The examples are the theory to cloud computing and relevant governance, risk management and compliance. The second part is called *Research Strategies and Methods, Creative Methods* and it includes all the research that is done to fulfil the objectives of the thesis. At the whole beginning, literature research with the research of the current GRC frameworks was performed. Along with it, gathering and processing all required theoretical bases relevant for this thesis took its part. The next step involves a quantitative pre-research that focuses on Czech organizations. The pre-research is in the form of a questionnaire and its aim is to discover the level of awareness and specific priorities of the organizations in the area of cloud security. Further, the qualitative research is done for the purpose of the analysis of cloud security specifics with the relevance to particular areas (e.g. governance, risk management, compliance, business continuity, cloud providers, data security). The qualitative research is done in the form of interviews with IT security specialists.

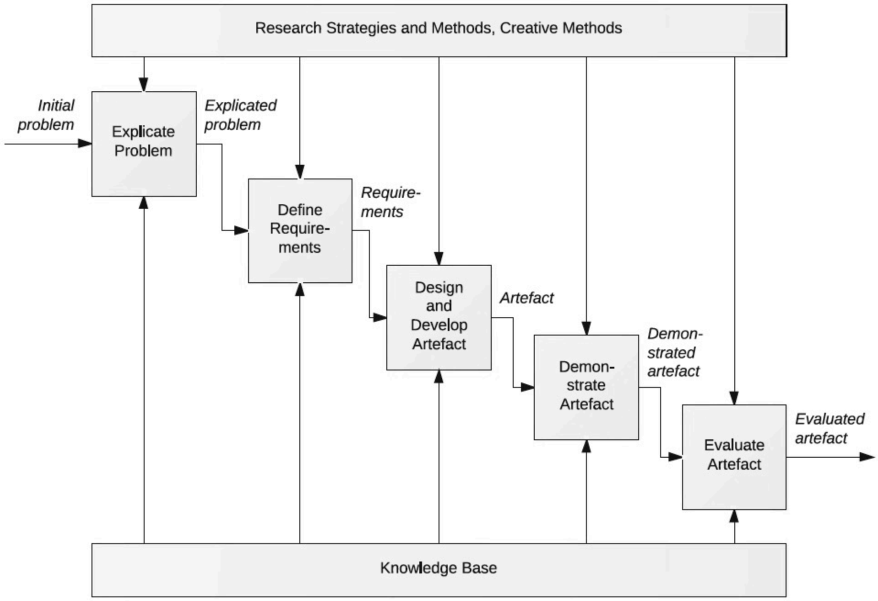

Figure 14 The concept of Method Framework for Design Science Research (Johannesson & Perjons, 2014)

4 Preliminary/Expected results

The research of the relevant literature and the existing GRC frameworks was performed at the whole beginning of the thesis development. Based on it, the objectives of the thesis were adjusted. Then, the required theoretical bases were gathered and the majority of them were already described in the theoretical part of the thesis. Here, the author of this thesis achieved also a certificate in the area of cloud security; the certificate is named *Certificate of Cloud Security Knowledge* issued by *Cloud Security Alliance.*

Based on all the gathered information, the questionnaire for the quantitative pre-research was composed and it contained 27 questions distributed to the following groups:

- governance,
- security, risks,
- security controls, measures,

- compliance,
- National cloud computing.

The pre-research was distributed among 102 representatives of Czech private/public organizations and was performed thank to organizations *PricewaterhouseCoopers (Czech Republic)* and *Tate International.*

Figure 2 shows the exemplary graph with the results of the questions where the respondents were asked on the current and planned state of used cloud services in comparison to traditional on-premise systems within their organizations. At the results, 1 means only on-premise systems used and 10 only cloud services. The numbers in the two boxes at the bottom represent the average values. The examples of the other questions from the quantitative pre-research are:

- What limits and barriers bring adoption of cloud services?
- What do organizations consider as security threats relevant to cloud services?
- How do organizations react to the fact that the providers partly control the security setting?
- What security controls and measurements of cloud services are used in the organizations?

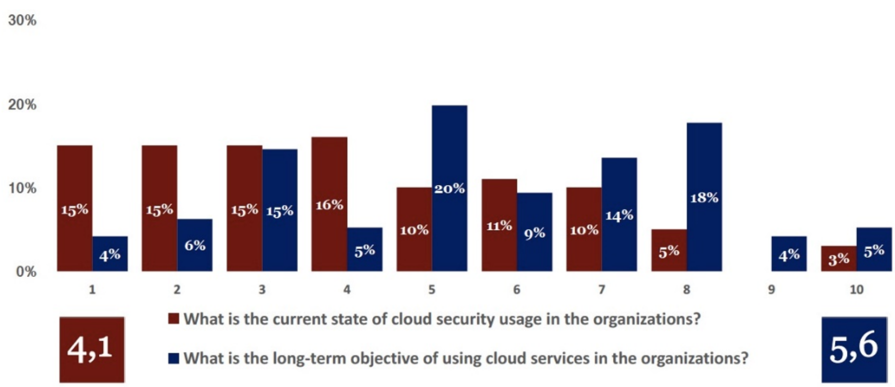

Figure 15 Exemplary graph with results from the quantitative pre-research

The fundamental results of the questionnaire were already presented in the two-part article (Zbořil, Jak na bezpečné zavádění cloudových služeb – část IV, 2018) and (Zbořil & Wojnar, Jak na bezpečné zavádění cloudových služeb – část V., 2019). The author of this thesis further cooperated with Ing. Mgr. Simona Macková to perform more detail analysis of the data. This cooperation is a part of the project called *Support of the cooperation among PhD students of quantitative and informatics programs* at the University of Economics, Prague.

Besides the quantitative pre-research, one interview from the qualitative research was realized. This interview was performed with the IT director of one national bank in the European Union. Although this national bank does not use cloud services, they are currently thinking about the possibilities of its implementation. The interview was focused mainly on the security and vendor's contract issues.

5 Future development

The next step in the thesis development is to complete the interviews. The author of this thesis plan to have from five to ten interviews depending on the sufficiency of information from the realized interviews. The interviews are planned to be finished by autumn 2019.

Then, all necessary information for the complete design of the GRC framework should be gathered. The design and development of the first version of the framework are the next steps after the interviews. After that, the framework will be used on real-life or illustrative use-cases and consulted. Based on the findings, the framework will be adjusted. At the end, the framework will be validated on the cloud platform of PricewaterhouseCoopers.

Besides these activities, criteria for the selection of the right cloud provider will be analyzed. These criteria will be incorporated into the developed GRC framework then.

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A. Pucihar (ed. et al.)

Effects of digital technologies on sustainability performance: business model perspective

DOROTEJA VIDMAR

Abstract Sustainability is becoming a growing need and it is apparent that society won't be able to respond sufficiently without engagement from enterprises. Nowadays business environment is in the midst of two transformations: towards digital and towards sustainable. In order to adapt to the outside pressures, enterprises need to implement changes to different aspects of the business – changes that can be observed through business model. This paper proposes a preliminary research model for research assessing how information technologies (IT) influence sustainability performance through business model (BM) perspective.

Keywords: • Doctoral Consortium Paper • Digital Technologies • IT • Business Model • Sustainability Performance •

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1 Introduction

Sustainability is emerging as a need that has to be urgently addressed by policy makers, enterprises and consumers (Malhotra, Melville, Ross, & Watson, 2013; Ripple et al., 2017). With growing human population, environmental and social degradation is getting more severe and our options are diminishing (Broman & Robert, 2015). There is a growing need for more responsibility from individuals and enterprises around the world. As of 2018 large public-listed enterprises in EU are obliged to report on their environmental and social practices (European Commission, 2017; European Parliament and the Council of the European Union, 2014). Even though current reporting standards are loose and rely heavily on self-assessment, this is important step that will enable policy makers to identify blind spots of existing regulations and researchers to develop appropriate metrics for measuring sustainability of enterprises.

Hildebrandt, Hanelt, & Firk (2018) observed that we are experiencing digital and sustainability transformation at the same time. While our cities are growing and causing environmental pressures, digitalization is creating opportunities to fundamentally change how everything operates. These two continuous processes are developing under internal and external pressures and result in changes of BMs.

The aim of our research is to highlight how enterprises create belief about sustainability and implement changes that lead to improved sustainability performance. Focus of our research is on the role of IT in changes of BM towards sustainability.

Research questions that we aim to address in our research are the following:

- How technological, organizational and environmental factors influence changes in BM?
- How changes to BM influence sustainability performance?

2 Literature review

»Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs« (World Commission on Environment and Development, 1987). This is the most widely used definition of sustainability. It has two underlying concepts; needs and limitations. This concept is vague and challenging to apply – that is why in most cases it is combined with the concept of triple bottom-line (Elkington, 1997). Triple bottom-line means that enterprise needs to perform positively in terms of economic, social and environmental matters to be sustainable –while three bottom lines need to be in equilibrium.

Sustainability is often used inconsistently as financial viability (Lüdeke-Freund & Dembek, 2017), which is nowadays insufficient. Therefore, in our study we adopt the concept of triple bottom-line.

Even though up until now sustainability was more often researched from the environmental perspective, it can be argued that environmental achievements such as lower gas usage and lower carbon emissions caused by lowered car usage and ownership, also cause societal improvements such as lowered pollution, reduction in congestion and noise, improved life quality and with this also improving health and safety of the communal environment (Hildebrandt et al., 2018). This shows that it is not always possible to separate three bottom lines of sustainability, since they often overlap and affect each other.

Recent economic crises raised many questions about appropriateness of profit-normative BMs for fostering sustainability. Profit-normative BMs are considered a default and not-doing-harm a neutral option (Upward & Jones, 2015). Sustainability researchers and practitioners now agree that sustainable development of society is unlikely without sustainable development of organizations (Schaltegger, Hansen, & Lüdeke-Freund, 2016).
As was recently stressed by European Commission (2018), in the future *"competitiveness will be dependent on the ability to move towards sustainability and resource-efficiency and the ability to exploit the advantages of digital technologies"*.
Impact of digital technologies on business is already enormous and growing. Reaching digital maturity through digitalization is imperative for enterprises to ensure competitiveness (Kane, Palmer, Phillips, Kiron, & Buckley, 2017, 2018).

Resource-efficiency can be achieved through the use of digital technologies (Gholami, Sulaiman, Ramayah, & Molla, 2013), but IS sustainability research needs to go beyond Green IT and energy-informatics, that deal primarily with increasing energy-efficiency of technologies (Dao, Langella, & Carbo, 2011).

IT can support green technologies, enable creation of hybrid physical-digital solutions by enhancing the efficiency of business processes through which eco-innovations are deployed and enabling new functionalities, processes and BMs (Hanelt, Busse, & Kolbe, 2017). Not only IT enables the creation of innovative BMs, it also enables their deployment at scale (Hildebrandt et al., 2018).

Pervasive connectivity and IT enable automation and data-driven management of services that users can book, access and pay with the use of applications, all while making the BM more efficient and reliable for the enterprise (Hildebrandt et al., 2018). IT is recognized as a port that provides easily accessible and fitted to customers' needs services with fewer intermediaries (França, Broman, Robert, Basile, & Trygg, 2017).

Some innovative BMs have the potential to alleviate environmental pressure through better utilization of resources (Hildebrandt et al., 2018; Kathan, Matzler, & Veider, 2016), but Hanelt (2018) argues that even though they are showing enormous potential, even innovative BMs are not sustainable by default. They need to be engineered as such and constantly observed, if they are still in-line with their sustainable strategy.

Sustainable business model (SBM) is an emerging field of research building strongly on foundation of business models and corporate sustainability (Lüdeke-Freund & Dembek, 2017). SBMs aim to positively influence not only economic but also environmental and social objectives. It is a promising view that SBMs drive sustainable consumption and production - and if successful, can transform the BMs of incumbents, triggering the transformation of industries or whole economic systems (Bocken, 2019).

Technological advancements were always seen as an important component in SBM research. Technological innovation is seen as one of the factors helping advance environmental sustainability (Lüdeke-Freund, 2010), reduce pollution and waste (Stubbs & Cocklin, 2008). New technologies are seen as a major factor, but are insufficient in changing the system on their own (Boons & Lüdeke-Freund, 2013), they have no value until they are marketed through a particular BM (Chesbrough, 2010).

According to Boons & Lüdeke-Freund (2013) bundle of BM (as a market device) and technological innovation can manifest in three ways: new BM employs existing technology; existing BM employs new technology; new BM that is enabled by new technology or new technology enabled by new BM.

IT can be seen as both a contributor and a solution in the matter of environmental degradation (Seidel, Recker, & vom Brocke, 2013), while demand for sustainability and technological development are external drivers (Hanelt et al., 2017; Heiskala, Jokinen, & Tinnilä, 2016).

IT influences organizational performance. The link might be indirect, through combination of IT, other resources and synergies in business processes. While exploring this, Hanelt et al. (2017) specifically found positive influence of IT use on organizational performance that comes from optimization of business processes and enabling new processes and BMs. They observed that IT creates flexibility in deploying new technologies while enhancing organizational performance.

With increased digitalization, promoting adoption of advanced IT and infrastructure and also growing number of physical-digital solutions, there are enormous opportunities for IT affecting organizational performance (Hanelt et al., 2017), meaning that there are also opportunities for IT at least indirectly affecting sustainability performance of enterprises.

IT enables diffusion of innovative BMs and provides *opportunity* for increased sustainability performance at scale (Hildebrandt et al., 2018), meaning that observing the effects IT has on sustainability performance of enterprises can help us harness and boost its effects.

Seidel et al. (2017) urge IS scholars to view sustainability as the imperative in their research. More research on possible impacts of IT on achieving sustainability is needed (Hanelt et al., 2017; Hedman & Henningsson, 2016; Melville, 2010). The need for inter-disciplinary research on sustainability and IS was already observed by various researchers (Dao et al., 2011; Malhotra et al., 2013; Seidel et al., 2017) and is evident from the practice, where emerging sustainability-oriented BMs are driven by widespread use of digital technologies (Hanelt et al., 2017; Tan, Cahalane, Tan, & Englert, 2017).

According to Boons & Lüdeke-Freund (2013) the link between sustainable innovation and BMs should be better explored. Key areas of research they propose include case studies on how firms connect elements of BM to innovation in practice, to what extent BMs allow innovations towards sustainable and how this translates to business performance. Schaltegger et al. (2016) claim that more research is needed on what enables the transition to SBMs, how can performance and societal impacts be managed and measured on the BM level. Yip & Bocken (2018) argue that research on innovative BMs should be iterative and ongoing while assessment and measurement of triple bottom-line impact of SBMs is an important research topic.

3 Preliminary research model

Based on the literature review we developed preliminary research model. Preliminary research model is composed from 3 parts framed upon BAO (Belief – Action – Outcome) framework (Melville, 2010). BAO framework incorporates social and organizational contexts, linking society, environment and organization (macro level constructs) with individual (micro level construct).

Melville (2010) identified 3 classes of sustainability phenomena from the IS literature:

Belief: emergence of cognitive perception (e.g. perception of opportunities, threats, urgency, ...).

Action: on what ways individuals and organizations foster sustainability through practices and processes.
Outcomes: indicators of environmental and economic performance.

While BAO framework was initially developed to address environmental sustainability, it was framed upon both World Commission on Environment and Development (1987) and triple bottom-line (Elkington, 1997) definitions. To our knowledge, social sustainability in IS literature wasn't addressed until years later. However, in recent years, IS researchers are starting to address social perspective of sustainability as well. Due to recent developments and in line with triple bottom-line, we aim to include social perspective as an important part of sustainability.

BAO framework can be used for framing inter-disciplinary research on IS and organizational sustainability, while it supports diversity of IS research and incorporates both micro and micro level constructs.

As shown in figure 1, societal structure and organizational structure affect individual's belief about sustainability, which leads to individual (including individuals as corporate actors) taking action that translates into outcomes on both social and organizational level.

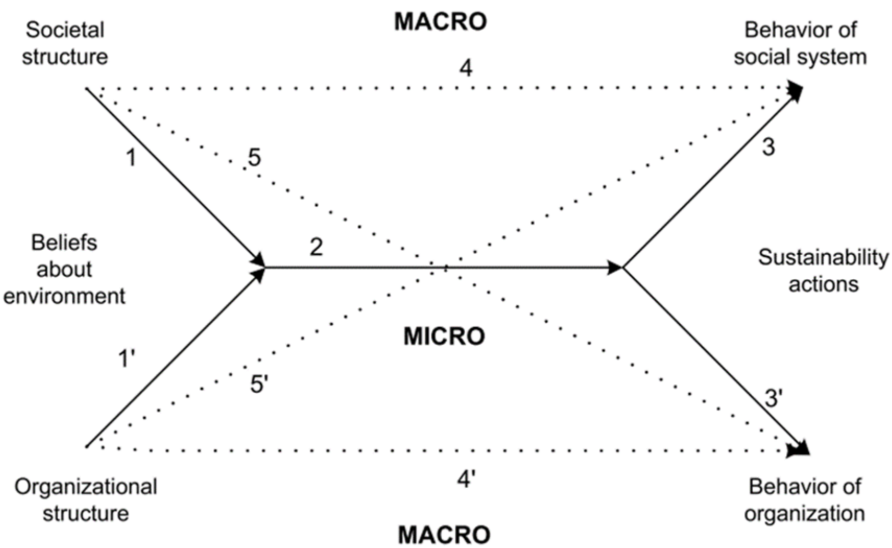

Figure 1: Belief-Action-Outcome framework for IS research on sustainability (Melville, 2010)

Part 1: Forming beliefs through technology, organization and environment

Based on TOE (technology – organization – environment) framework presented in figure 2. technology, organization and environment are defined as constructs that influence organizational decision-making (DePietro, Wiarda, & Fleischer, 1990).

In our model, TOE framework will be used as a first part – forming beliefs about sustainability through technological, organizational and environmental factors. According to TOE framework, these are factors that affect decision making, in our case this applies to making decision about appropriate actions for increasing sustainability performance.

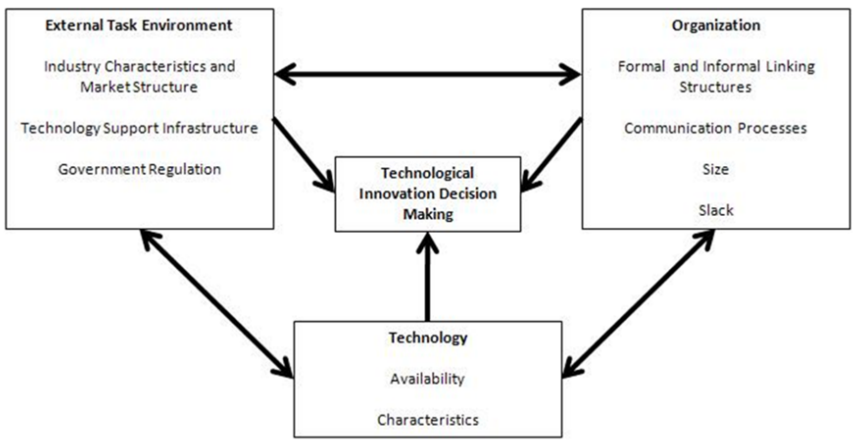

Figure 2: Technology – Organization – Environment framework (DePietro et al., 1990)

Part 2: Observing actions through business model

Based on Business Model Canvas framework (Osterwalder & Pigneur, 2010; Osterwalder, Pigneur, & Tucci, 2005) we will observe changes made to BMs.

Business Model Canvas is composed of 9 parts. Framed around value proposition are key partners, key activities, key resources, channels, customer relationships, customer segments, cost structure and revenue streams. We will observe actions taken to increase sustainability performance through changes made to specific BM building blocks.

Changes made to specific BM building blocks affect organizational performance, meaning changes made to BM possibly affect organizational sustainability performance as well.

Part 3: Assessing the outcomes - sustainability performance of enterprise

Sustainability performance, based on triple bottom-line concept, where questions for assessment of social, environmental and economic performance are taken from GRI reporting standards 101-419 (GRI, 2016) and guidelines on how to use them for disclosure of non-financial and diversity information (European Commission, 2017; GRI, 2017).

3.1 Proposed preliminary research model

Our proposed preliminary research model (figure 3) is composed horizontally according to BAO framework, and it's first part consists of TOE framework. The central part consists of Business Model Canvas elements. Changes in BM leads to outcomes – in our case sustainability performance measures, which are aligned with triple bottom line concept – economic, environmental and social perspective.

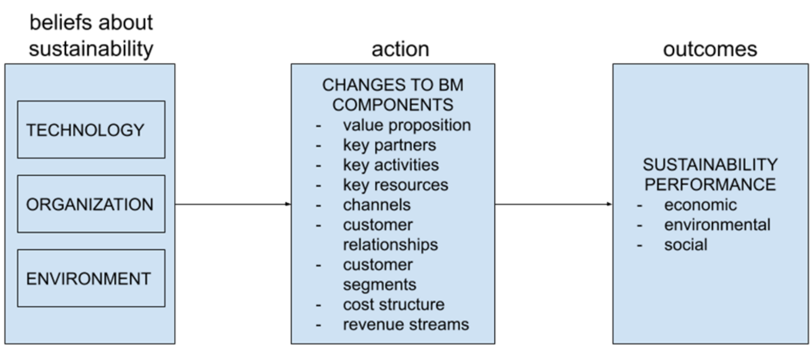

Figure 3: Preliminary research model

4 Methodology

In this research, we will be using mixed methods; combination of qualitative and quantitative approach.

We conducted a literature review in the fields of IS (focusing on IS for sustainability and digitalization), organizational sustainability (particularly the definitions, important concepts and SBMs) and BMs (focusing on emergence of BM concept from organizational and managerial perspective, emergence and evolution of SBMs).

Based on the literature review we constructed preliminary research model, which will be used to develop questionnaire.

Questionnaire will consist of three parts - we will develop first part of the questionnaire based on TOE framework. Second part of the questionnaire will be adapted from large EU Horizon 2020 project Envision (a research project on business model innovation (BMI) practices in small and medium enterprises (SMEs)). Third part of the questionnaire will be based upon GRI standards.

The questionnaire and preliminary research model will be tested and adapted through multiple case-studies in Slovenian enterprises. Adapted questionnaire will be used for survey among Slovenian enterprises. Existing research found differences in how large enterprises and SMEs implement changes. It needs to be considered for study design that successful strategies for changing BM to increase sustainability performance might be very different for large enterprises and SMEs.

Results of our research will be analysed and discussed according to existing body of knowledge. Where possible, findings will be generalized.

5 Expected Results

Through our research, we aim to assess the role of IT in sustainability performance through changes made to BM. We aim to define which technological, organizational and environmental factors influence innovation (changes) of enterprises' BMs and how these changes in BMs influence sustainability performance.

While existing research consists mostly of literature reviews and case-studies, according to Lüdeke-Freund & Dembek (2017) the field is in the phase where theorization is beginning, so the crucial steps that we see for SBM research are:

- More qualitative research;
- Generalization of findings through quantitative studies;
- Development of tools and know-how for enterprises involved in BMI towards sustainability;
- Development of appropriate measures for measuring impact of sustainability-oriented efforts in practice;
- Developing multidisciplinary approach, by including IT perspective in SBM research.

Based on previously stated research gaps and work by other researchers, we believe that exploring the role of IT as one of the factors leading towards SBMs is important.

Results of our research will contribute to better understanding of influence of technological, organizational and environmental factors:

- how technological, organizational and environmental factors influence enterprises' decision making about changes and innovation of BMs
- how changes made to BM influence sustainability performance of enterprises.

Based on our findings we will discuss implications for enterprises (possibly SMEs) and policy makers.

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