Validation of Data Maturity Criteria for Small and Medium-Sized Enterprises

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Data is a fundamental source for any business to operate and to develop. Inefficient data management can lead to lack or a flood of data and consequently non-optimal business decisions. This is particularly evident in small and medium-sized enterprises (SMEs), which often lag behind due to limited resources (financial, human, time, knowledge). To support SMEs in understanding how to manage and utilize data effectively we propose a data maturity assessment multiple-cirteria model. Important criteria were identified from the literature and have been validated through semi-structured interviews with seven Slovenian SMEs. The results suggest some new criteria to describe the data maturity, relevant to Slovenian SMEs.

1   Introduction

In today's society, there is an increasing focus on the transition from traditional to digital business, dictated by rapid and constant changes in the business environment and in society in general. The driving force of these changes is digital transformation, which leads organizations to a new way of doing business, changes in business processes, development of new products and services, and new business models (Kraus et al., 2021). An important part of digital transformation is also the data that the organization creates and captures throughout the business process. Data is the foundation of any information system, and its effective control and management is becoming increasingly important due to its exponential growth. According to the European Commission, organizations that invest in data-driven innovation experience 5% to 10% faster growth (European Commission, 2022). Access to, control and management of data is thus becoming an increasingly important strategic resource and a necessity for the further organizations' development. While large enterprises usually have a clear overview of their data and well-organized data management, small and medium-sized enterprises (SMEs) usually lag behind in this endeavor, as they often have limited human, financial and knowledge resources. To help enterprises assess their level of maturity in data management, a number of data maturity assessment models have been developed and proposed. Current data maturity assessment models are not tailored to SMEs, since they are too extensive or incomplete in the number of criteria proposed, too complex in their structure, or focused on large enterprises. Therefore, there is a need to develop a new data maturity assessment model, that will be tailored to SMEs and will include an appropriate set of criteria that SMEs can use to systematically and comprehensively assess data maturity.

In this paper, we present the results of data maturity criteria validation based on seven Slovenian SMEs. To obtain the results, we followed a design science research approach (Hevner, 2007) and conducted semi-structured interviews (Adams, 2015). Based on the interviews conducted with the SMEs, we will develop a final list of criteria and data maturity assessment scales that will represent the basis for development of a data maturity multi-criteria assessment model for SMEs.

2   Theoretical findings

The previous literature on data maturity models is disperse and focuses on different fields, from data maturity models for the public sector and Open Government (Çaldağ & Gökalp, 2022; Okuyucu & Yavuz, 2020; Rahmatika et al., 2019), to Big Data (Coleman et al., 2016; Comuzzi & Patel, 2016) and data analytics (Mach-Król, 2022), data-driven logistics (Muehlbauer et al., 2022), and data-driven decision making (Nijzink, 2020). Further, we present a few papers that are often cited in the field of data maturity.

(Comuzzi & Patel, 2016) developed a maturity model that would help organizations to generate and appropriate value from Big Data. The proposed model assess the data maturity through five main domains: Strategic alignment (Strategy); Organisation (People and Culture); Governance; Data (management and data analytics) and Information technology (IT infrastructure). The limitation of the proposed model is that it does not provide specific suggestions on what steps an organization should take to improve Big Data maturity and the capabilities mentioned above. The model also lacks some of the criteria for a comprehensive assessment of data maturity, such as data quality, data security, use of data to support decision making, etc.

(Coleman et al., 2016) proposed a Big Data maturity model specifically for SMEs to advance in data maturity and also proposed recommendations. The model assess the data maturity through seven domains: business strategy; data management; people and analytical skills; technological infrastructure; enterprise adoption (engagement in data-centric management) and data governance. Although the proposed model is intended for SMEs, it focuses on data analytics, which is only one of the elements needed for a comprehensive data maturity assessment. (Peña et al., 2018) proposed a data maturity model for the SMEs in a healthcare sector, using the ELECTRE methodology, based on the ISO 15504. The assessment of data maturity is based on the four data maturity domains: people (human resources), processes, technology and data. The structure of the model is more difficult for SMEs to understand, since it is based on the set of mathematical expressions and operations. It is also not clear how SMEs have organized data storage, whether there is organized any training in the data management field and what is the level of awareness and mindset of

employees related to data management, which represent an important part of organizational culture and a basis for a comprehensive data maturity assessment.

3   Problem definition

The fundamental problem is that the majority of SMEs do not exploit the potential of data for decision-making, which translates in a lower responsiveness to the dynamic demands of the environment and lower competitiveness. Although various software solutions are available to organizations (enterprise software solutions (ERP and CRM), human resource management (HRM) solutions, document systems) that allow them to manage the data generated during the execution of business processes, the implementation of such solutions is still low (SURS, 2021). The implementation and use of business software solutions is the basis for being able to capture, manage, share and store data. This ensures the entire lifecycle of data management, otherwise a comprehensive approach to data management is not possible. Since SMEs usually lack resources (financial, human, time, skills), they need a comprehensive, systematic and easy-to-use tool to help them assess the state of their data and understand the next steps to data maturity. For a comprehensive assessment of an organization's data maturity, several criteria must be considered: Use of digital technologies and software solutions, data quality, data security, organizational culture, human resources, strategy, data lifecycle, use of data for decision making and others. Therefore, we need to consider data maturity as a multi-criteria problem.

4   Methodology

As a research approach, we followed a design science research (DSR) (Hevner et al., 2004) (Figure 1). The final solution will be a developed IT artifact – in our case, a data maturity assessment model for SMEs. Design science research refers to the iterative sequence of expert activities, to produce an innovative product (artifact).
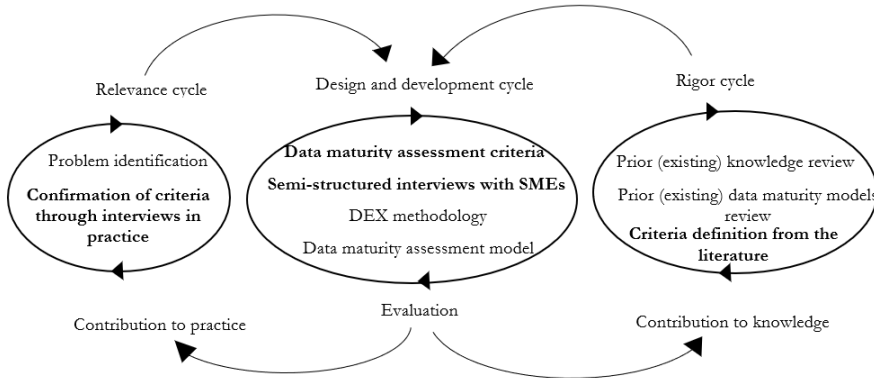
Figure 1: Methodology process - adapted from
(Hevner, 2007)

Based on the literature review, we defined a preliminary list of criteria to be used to assess the data maturity of SMEs (rigor cycle). After formulating a preliminary list of criteria, we prepared the interview questions. We used a semi-structured interview, as this allowed us to include additional questions that were initially not planned. Based on the literature reviewed that addressed the data maturity assessment of the SMEs and the prepared preliminary list of criteria, we defined the interview questions and conducted the semi-structured interviews with a total of seven SMEs. Before conducting the interviews, we obtained information about each SME from the SME website, such as the their business area, number of employees, and whether they had a social media presence, which helped us to define the final list of interview questions for the criteria validation. After interviewing the SMEs, we prepared a transcript of each interview and analyzed the results. The findings obtained from the interviews represent the results of the validation of the data maturity criteria and the feedback to our existing knowledge and literature (relevance cycle).

5   Preliminary/Expected results and future developments

5.1   Preliminary results

In the following, we present the results of data maturity criteria validation of the 7 interviewed SMEs (SMEs A to G), of which one is micro-sized (SME A), three are

small (SMEs E, F, and G) and three are medium-sized enterprises (SMEs B, C, and D). The interviewed SMEs operate in different business sectors – telecommunication (SMEs A and B), manufacturing (SMEs C, E, F and G) and healthcare sector (SME D). The results of the criteria validation are presented in Tables 1 through 7. The (X*) in Tables (1-7) indicates that the SMEs are either using only partial solutions (i.e. Internet of Things only) or the implementation of solution (i.e. e-business implementation) is still in the planning phase.

Validation of criteria presented in Table 1 shows that criteria related to the implementation of Microsoft solutions (e.g. Office 365) and e-signing proved irrelevant for assessing the data maturity of SMEs. Since all interviewed SMEs use the Microsoft Office software, we can not identify any significant differences that would indicate how data mature each of the interviewed SME is based on the use of the Microsoft solutions. In this context this criterion is irrelevant and will be removed for data maturity assessment. Similarly, the criterion of e-signing implementation is irrelevant as it can be integrated as part of e-business and also does not help us to differentiate the data maturity level of the SMEs.

Table 1: Use of digital technologies and software solutions by SMEs

Technologies & software solutions	SMEs						
	A	B	C	D	E	F	G
Accounting programs	X	X	X	X	X	X	X
Human resource (HR) management software solutions		X	X	X	X	X	X
Enterprise software solutions (ERP, CRM)		X	X	X*	X	X*	X*
Microsoft Office – i.e. Office 365, Office 2019	X*	X	X	X*	X	X	X
Document system		X	X	X	X	X	
Sales and marketing programs		X	X	X	X		
Basic programs for data analysis - Excel		X	X		X	X	X
Programs for data analysis - internal program (own solution)				X		X	
Advanced data analytic programs – i.e. Microsoft Power BI, Tableau, SAS BI, Qlik Sense			X		X		
Social media (i.e. Facebook, LinkedIn, Instagram …)	X	X	X	X	X	X	X
Advanced technologies (Artificial intelligence, high performance computing (HPC), digital twin, Internet of Things, robotics)		X*	X*		X*	X*	
Implementation of E-business	X*	X	X	X*	X*	X	X*
Implementation of E-signing		X	X	X	X	X	

The interview results related to data lifecycle criteria (Table 2) show that SMEs are not yet fully exploiting the potential and value of the data they have. One of the most relevant criterion to assess the data maturity of SMEs is data innovation, but the results show that the main use of data is still focused on supporting the day-to-day business operations. Innovation based on data or data-driven innovation (Babu et al., 2021) refers to the new value creation based on data, such as conducting market analyses for particular products, adaptation to the market and to customers,

development, upgrade and introduction of new products and services, improving the competitive nature of organization. Therefore, data innovation is most important criterion to include for data maturity assessment.

During the SME interviews, we found that SMEs prefer to store their data within the company, and are less willing to use cloud services to store their data. Nevertheless, the criterion of data storage is important in assessing SMEs' data maturity, as it can show different maturity levels of SMEs, from those that still store their data on paper or only on their computers, to those that are more mature and also use cloud solutions. The validation also revealed that an SME that has a document system may also have electronic archiving. Despite the fact that electronic archiving is part of the document system, it is important to consider it as an independent criterion. The distinction according to the level of archiving (paper archiving, digital archiving, certified digital archiving) shows how mature an SME is in this context and is therefore a relevant criterion for evaluating the data maturity of SMEs.

Table 2: Data lifecycle by SMEs

Data lifecycle	SMEs						
	A	**B**	**C**	**D**	**E**	**F**	**G**
Internal data capture	X	X	X	X	X	X	X
External data capture (publicly available data)	X*	X	X	X*	X*	X	X*
Data Capture - Social Media					X		
Data storage - company servers	X	X	X	X	X	X	
Data storage - NAS server	X	X		X		X	
Data storage - cloud		X	X		X		
Data analysis - Excel		X	X		X	X	X
Data analysis - internal program				X		X	
Data analysis - advanced tools (e.g. PowerBI)			X		X		
Data analysis - Social networks (Facebook, LinkedIn, Instagram)					X		
Data use - support of business and daily activities	X	X	X	X	X	X	X
Data use - development of new products and services					X	X	
Data use - market trends predictions				X		X	
Data use - strategic level		X	X			X	
E-archiving			X	X	X*	X	

The reporting of data is another criterion to consider as it differentiates the SMEs from those who only report on data that is mandatory by the legislation, such as report on packaging and financial data (taxes, financial records) and those who alredy report data related to sustainability. The case of SME F has shown a need to include an additional criterion related to regulation and the sustainability aspect (i.e. reporting on CO_2 consumption), that we need to consider for a comprehensive data maturity assessment of SMEs.

Table 3: Data security implementation by SMEs

		SMEs						
		A	B	C	D	E	F	G
Data security	Care for data security - each individual							X
	Care for data security - own IT department							
	Care for data security - person (administrator)		X		X	X	X	
	Care for data security - external contractors (outsourcing)		X	X	X*		X	
	Security mechanisms - backup copies of data and documents	X	X		X		X	X*
	Data access - granted appropriate rights to access data		X		X	X	X	
	Information security policy			X	X	X	X	

Regarding data security (Table 3), none of the SMEs have an employee or IT security expert specifically responsible for data security, and the majority of SMEs prefer external contractors (outsourcing). The results of the criteria validation showed that the first criterion related to care for data security (care for data security - each individual) seem to be not relevant, as only one SME (SME G) stated that it has no one to take care of data security and that is the responsibility of each individual. But from the view of assessing the data maturity of SMEs, it can show the differences in the organization and appointment of the roles (i.e. each individual, data security administrator, IT department, data steward).

Table 4: Data quality strategy and data quality review results by SMEs

		SMEs						
		A	**B**	**C**	**D**	**E**	**F**	**G**
Data quality	Establishment of a data quality strategy			X		X	X	
	A formally written strategy for data quality					X	X	
	Data quality review			X*	X	X	X	
	Data quality assessment				X	X	X	

Data quality is one of the most important criteria to ensure accurate decisions based on validated data. Although the validation results of the data quality criteria in Table 4 appear to be less relevant to SMEs, all criteria must be included to obtain a comprehensive data maturity assessment.

Table 5: Establishement of data management strategy and investments in data management by SMEs

		A	**B**	**C**	**D**	**E**	**F**	**G**
Data management strategy	Established data management strategy					X		
	A formally written data management strategy					X		
Investments	Information infrastructure investments	X	X	X	X	X	X	X
	Data management investments					X		X

The results in Table 5 show that the criteria related to data management strategy and investment in data management do not seem to be so relevant when assessing SMEs' data maturity, as only one SME (E) indicated that it already has this data aspect in place and attaches high importance to it. Only one other SME (SME G) indicated that they always use part of their investments specifically for improving data management. Despite the fact that the majority of SMEs only invests in information infrastructure, it is important to also consider the investments in data managent and to start implementing a data management strategy, either as part of the business

strategy as this is a fundamental basis for the transition to a data-driven enterprise as indicated by (Davenport & DalleMule, 2017).

Table 6: Organizational culture and human resources by SMEs

		A	B	C	D	E	F	G
Organizational culture	Awareness of efficient data management	X*	X*	X*	X*	X	X	X*
	Spreading the culture of efficient data management among employees		X*	X*		X	X	
Human resources (HR)	Education and training in the field of data management			X	X*	X	X	
	Encouragment of employees for better data management	X	X	X		X	X	X
	Open communication	X	X	X	X	X	X	X
	External contractors - involved		X	X*	X		X	X*
	External contractors - not involved	X				X		

The results of Table 6 show that 4 out of 7 interviewed SMEs organize training and education for their employees so that they can better manage their data and acquire additional skills. This indicates that organizing training and educadion on data management is an important criterion to consider, even though interviewed SMEs currently educate their employees mainly on how to use Excel. The criterion of open communication is highly relevant, as the results in Table 6 show that open communication is present in all 7 interviewed SMEs, and for this reason must be considered when assessing SMEs' data maturity.

From the results in Table 7, SMEs are beginning to consider the use of data at a strategic level as well, but they agree that intuition and experience must also be considered. In the case of SME C, they are particularly committed to basing their decisions on data. The director of SME C stated that 70% of strategic decisions are based on data and the remaining 30% are based on soft factors, reflecting the environment and employee attitudes. The situation is similar in SME F, where the percentage of data-driven decisions is 50%. Other SMEs are not yet ready to adopt this mindset. When we asked SMEs whether they have adequate data when making strategic decisions, the answers were mixed. Three of seven SMEs interviewed (C, D and F) stated that the data are adequate. In the case of SME A and B the adequacy of data for strategic decisionsis is not so relevant. At the moment they are more focused to provide the data to support the operating of the business and then start to build from that point further. Based on this observations the criterion related to the adequacy (relevance) of data for decision-making is important to include for assessing the data maturity of SMEs.

Table 7: Establishment of data-driven decision making on strategic level

		A	B	C	D	E	F	G
Decision making (strategic decisions)	Intuition-driven decision making							
	Intuition-driven + data-driven decision making	X*	X	X	X	X	X	X*
	Data-driven decision making							
	Data sources for decision-making - CRM, ERP			X	X*	X	X	X*
	Data sources for decision-making- (from Excel)	X	X	X	X	X	X	
	Data sources for decision-making (Geographic information systems (GIS)		X					
	Adequacy of data in decision-making	NR	NR	X	X	X	X	X*

NR – Not relevant

5.2   Expected results and future developments

The semi-structured interviews we conducted with the seven SMEs revealed opportunities for the inclusion of new criteria, such as those related to regulation and the sustainability aspect (i.e. reporting on CO_2 consumption, packaging) and the need to remove some of the currently proposed criteria (i.e. e-signing, implementation of Microsoft Office solutions). Since only the results of 7 interviewed SMEs are presented, we expect to add additional criteria or remove some of the currently proposed criteria in future research, as shown by the results of the criteria validation in this paper. In future research, we will focus on formulating the final list of data maturity criteria for SMEs and finalising the definition of the measurement scales, which will help us develop the first version of

a multi-criteria data maturity model for SMEs. We expect that we will need to develop the model in several iterations before the final version.

Acknowledgements

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