

DOCTORAL CONSORTIUM

# AN OPEN ECOSYSTEM OF PLATFORMS ARCHITECTURE TO ACCELERATE INNOVATIONS IN THE 1ST LINE HEALTHCARE

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**Abstract** Whereas open digital platforms drive innovation in many industries, platforms in primary healthcare are still mostly closed. Policymakers have been looking for ways to open up primary healthcare platforms to stimulate collaboration and innovation and do so even more, given the ongoing COVID-19 crisis. Yet, there is more than one way of opening up platforms in primary healthcare, just as it is unclear how different ways of openness can lead to more innovation. An open digital platform is expected to stimulate innovation, flexibility, and interoperability in information systems in first-line healthcare, but how this can be achieved is unclear. The objective of this research is to understand how to develop an open ecosystem of platforms architecture to accelerate innovations in the 1st line HealthCare.

**Keywords:**  
innovation,  
data  
sharing,  
platform,  
ecosystem  
architecture,  
openness,  
healthcare.

## **1 Introduction**

### **1.1 Background**

Professional healthcare in The Netherlands is organized in four domains. The zero-line healthcare denotes preventive care measures and healthcare research. The first-line healthcare concerns all professional care that takes place without a need for a prescription. This domain of care for instance involves general practitioners, dieticians, psychologists, physiotherapists, pharmacists, etc. Furthermore, the second-line healthcare involves healthcare that takes place in hospitals. Finally, the third line refers to specialized care, for instance in clinics.

The COVID-19 crisis has painfully exposed that existing digital platforms fall short at supporting caregivers and patients. When caregivers needed comprehensive and accurate data to diagnose, treat, and identify risk groups, they faced low reliability and information availability (EHRIntelligence, 2020a). Even when patient files were digitalized, caregivers often could not access them due to legal constraints and lack of openness between heterogeneous platforms (Lenert and McSwain, 2020).

Besides the COVID-19 crisis there already were several trends that put pressure on the existing healthcare system. First, there is an increasing demand for healthcare support. Second, costs related to healthcare are escalating. Third, the burden of disease is shifting from short term diseases to long-term chronic conditions. Fourth, there is an increasing call to realize patient-centred care.

### **1.2 Information systems in first-line healthcare in The Netherlands**

There is a wealth of information systems involved with first-line healthcare. This section describes how these systems relate to each other and to professional caregivers in this domain of healthcare.

All caregivers in the first-line care domain use information systems to support them in their daily tasks. For instance, general practitioners use a general practitioner information system (Huisarts informatiesysteem, HIS), a pharmacist uses a pharmacist information system (Apothekers informatiesysteem, AIS), etc. These

systems provide functionalities such as: patient treatment logging, a calendar, a cash register, etc. These systems are the focus of this study.

In addition to these systems, there are other applications and infrastructures that extend the information systems in this domain. One of the most prominent examples is the Personal Health Environment (Persoonlijke Gezondheidsomgeving, PGO). These systems are also important for this study, these are the ones to be disclosed via platforms. They are architectural mechanisms that should achieve openness and innovation.

### **1.3 A digital platform for first-line healthcare**

We argue that a vibrant and dynamic ecosystem of third-party service developers is beneficial to the primary healthcare domain. Leveraging the knowledge of third-party developers is expected to lead to increase in innovation efforts for the primary healthcare domain, developing services that benefit both the side of the care givers as well as the patients. In an example situation for a platform-oriented information system in the primary healthcare domain, the platforms' core contains core functionality that is shared among all participating parties (e.g., logging patient treatments, authorization, identification). Additionally, complementors can offer modules that can be coupled to the platforms' core. These modules may mediate between user groups, adding values to different actors in the ecosystem. In this example, an independent software developer may add an application to the platform by using interfaces and boundary resources, e.g., APIs and SDKs (or boundary resources) that are provided by the platform owner.

#### **Example 1:**

In the example a developer may have the idea for an IoT medicine box that can track what medicine a patient takes in. This exact intake can be monitored. While this is useful for the patient, it may also allow the patient's pharmacist and general practitioner to keep track of the medicine take in and health status of the patient. This way, the caregivers can give accurate support to the patient.

#### **Example 2:**

A patient makes use of his mobile phone camera to keep track of complaints concerning a mole on his/her skin. The picture can be sent to a general practitioner. Simultaneously, this picture may be analyzed through a specific add-on module created by a third-party developer, comparing it to pictures of moles of other patients. Information regarding this analyzed picture can assist the general practitioner in making a decision that he/she can discuss with the patient.

## 2 Theoretical background

### 2.1 Digital platforms in healthcare

Digital platforms may benefit the healthcare domain. For one, they can reduce fragmentation of applications by integrating different IT-services through a platform (Furstenau et al., 2018). Secondly, digital platforms show powerful innovation capabilities (Boudreau, 2010), possibly solving the lack of innovation in healthcare (Furstenau et al., 2018). Furstenau et al. (2018) study how the technical design (architecture) of a digital platform and its governance structure can be developed to develop a digital platform in healthcare in the U.S. They come up with a framework for how a platform owner can set out to develop a digital platform in healthcare. Furstenau et al. (2018) propose several avenues for future research on digital platforms in healthcare:

1. The reconstruction of the process of platform design. In this research we do more extensive, comparative studies across different platforms and initiatives.
2. Longitudinal research over a timeperiod. An option may be to look at later phases of platform development and to examine for example how ecosystem extension continues.
3. Each of the areas of the framework of Furstenau et. Al (2018) warrants further research. In the research we want to develop more feedback loops to dive deeper in the framework and outcomes.
4. Industry and ecosystem studies are important to understand platform competition and market dynamic. We expect platform competition and platform battles as strategies for market domination and consolidation like in other industries.“
5. The impact of digital health platforms on national health systems is an interesting area of study.

6. Explore the effects of digital health platforms on the performance of health care delivery. We suggest interdisciplinary and longitudinal research designs to monitor and analyse these developments.”

In a work on how to reduce the silo-structure of IT in healthcare in a hospital-setting (different care departments have separate IT systems), Bygstad et al. (2015) study how a platform can integrate the IT systems in the different silos. They show that an integration platform can reduce complexity, because it reduces the number of interdependencies and information can be handled more easily between the different silos. However, in the long term such platforms may become increasingly difficult to govern due to the involvement of different parties, threatening stability of the system. They suggest future researchers to “investigate complementary and alternative solutions to the IT silo problem. Strategies for reducing complexity typically include modularizing and loose coupling (Parnas, 1972), or, in other terms, trying to make it simple by reducing the number of relationships. In practice this will mean to integrate less, and to integrate more loosely. The question, then, is: how do we sort out what can remain as IT silos, and what can be more loosely integrated? Can we rethink the silo problem by a looser coupling between clinical systems and work process support? The welcome benefits from this approach would be (i) that process support could be designed much closer to the clinicians and (ii) that the clinical silo systems could continue their life as silos.” In a follow-up research, Bygstad and Hanseth (2018) study platformization, how to transform a siloed IT-organization towards a platform-based system. They show how establishing of boundary resources and a data-layer are crucial steps in platformization. In addition, they state that organization of architecture and governance through boundary resources is crucial in giving the platform owner control over the ecosystem.

## **2.2 Openness and strategy**

A platform’s mode of openness can have significant consequences for the platform owners’ strategic goals. As a clear example, Van Alstyne et al. (2016) find that too little openness can limit network effects which may lead to the failure of a platform. Too much openness on the other hand may also have destructive effects due to loss of quality or misbehaviour of platform participants. This paragraph discusses some of the strategic issues relating to choosing openness of a platform.

Openness and complementor engagement – Benlian et al. (2015) find that the perceived openness of a platform affects how complementors choose to contribute to a platform. They say that openness of the platform will lead to greater willingness to contribute, thus greater innovation in complements.

Openness and launch strategy – At what side to open the platform, at the demand-side user or the supply-side user? If a platform fails to onboard a critical user, e.g., that of the caregivers, they will have a difficult time to onboard other users to the platform (Van Alstyne et al., 2016). De Reuver et al (2018) also study the role and effectiveness of platform launch strategies

Openness and critical mass – A critical mass of actors is crucial for the adoption of a platform. A platform should seek to reach the tipping point to get a sufficient group of users to board the platform. Ondrus et al. (2015) show that openness can lead to greater user adoption.

Openness of the platform (core) itself can lead to greater quality, as multiple developers contribute to making improvements in the codebase (Brunschwiker & Schechter, 2019). Openness of the core however may also come at the cost of loss of stability and predictability (Brunschwiker & Schechter, 2019) and may even result in applications rendering useless (Wareham et al., 2014).

### **2.3 How to define openness through the platform architecture**

Platform architectures can be configured in different ways (Blaschke et al., 2019; Kazan et al., 2018). Varying platform architectures result in varying platform behavior over both the short- and the long term. The complexity of a platform's architecture impacts the complementors perception of how attractive it is to innovate on a platform. A platform owner faces a trade-off on the complexity of its platform architecture.

- Cennamo et al. (2018) find that the simpler architecture leads to (+) greater innovation in the complements, but also to (-) higher fungibility of the platform. Moreover, a more demanding architecture makes a platform (+) more unique, but also (-) requires greater effort from the complementor.

- Aulkemeier et al. (2019) study how collaboration between different information systems in one context can better cooperate. They find that a platform can successfully coordinate collaboration between different existing users. It allows both easy coupling and decoupling of functionality, without harming other functions affiliated with the platform. Furthermore, it can enhance data exchange between different systems.
- Saadatmand defines platform taxonomies based on the openness of their architectures on four dimensions. On these dimensions, they see different modes of organization and openness. On the bases of these configurations, they find three taxonomies of different platforms. Service: oriented at, Ecosystem, Core or Infrastructure.

Companies in a platform ecosystem are mutually dependent for the survival of the platform (Alves et al., 2018). Governance should seek to balance the interest of the involved parties for long term sustainability.

- From Benlian et al. (2015) perceived platform openness (PPO) to the complementors determines how attractive a platform is to complementors and, as a consequence, determines the innovation that takes place on a platform.

Boundary resources serve as a means to integrate developments by third parties with a digital platform's core. Moreover, boundary resources govern the relationship between the platform and external developers (Hein et al., 2019)

Boundary resources are related both to architecture and to governance (Schrieck et al., 2016). Boundary resources are the “the software tools and regulations that serve as the interface for the arm's-length relationship between the platform owner and the application developer” (Ghazawneh & Henfridsson, 2013). Moreover, boundary resources mediate access to the platform's core (De Reuver & Van der Wielen, 2017).

Important mechanisms to achieve openness, without fully giving up control over the technology, are boundary resources.

## 2.4 Scientific research gap

This research extends scientific work on the relationship between platform architecture, platform openness and the rate of innovation. Blaschke et al. (2019) and Kazan et al. (2018) requested future researchers to explore the understanding link between platform architecture configurations and achieving strategic goals. This research has the aim to show how potential platforms can clarify innovation attractiveness by considering different mechanisms of openness for a platform architecture.

Design science research literature states that rigorous design needs to account for a class of problems in order to be valid outside the boundaries of its original environment (Hevner et al., 2004).

An approach to achieve this is the meta-design approach, consisting of three subsequent stages. First, a core theory is identified to underpin the design process. Second, of the constructs provided by this theory, meta-requirements are identified and systematized. Third, a meta-design is created to take into account the identified meta-requirements.

The conceptual model, in figure 1, shows the relations between the research objective and the research questions, meta design and meta-requirements.

It shows the relation between openness how it contributes to innovations and how to design openness.

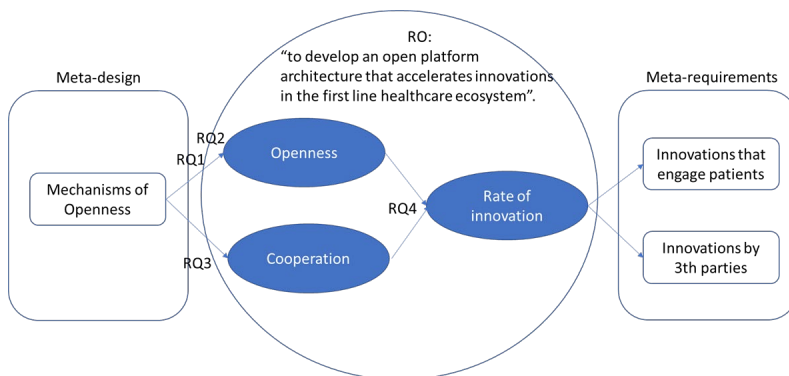


Figure 1: Conceptual Model



### **3 Research**

#### **3.1 Research objective**

Considering the preceding discussion, the research objective is “to develop an open platform architecture that accelerates innovations in the first line healthcare ecosystem”.

#### **3.2 Research questions**

RQ1: ‘What are possible forms of platform openness in first line healthcare, and how do these affect innovativeness’

RQ2: What influences the openness of the architecture in the 1st line healthcare?

RQ3: How to compile, with forms of openness, an open architecture that improves cooperation in the 1st line healthcare of patients?

RQ4: Does the use of this open architecture accelerate the number of innovations in the 1st line healthcare?

The relations between these research questions are visualised in figure 1, the conceptual model.

#### **3.3 Research approach**

The intended outcome is a working proof of concept that shows the design choices that platform owners have for choosing platform architectures with different degrees of openness realizing more innovations. Based on this PoC, experts should be able to express their perception of this platform architecture will be suitable to drive innovations in first-line healthcare.

Intended method at this stage:

A combination of methods will be used to design the Proof of Concept as a working prototype to demonstrate the proof.

Firstly, following DSR-suggestions by Johannesson and Perjons (2014) and Peffers et al. (2007), the purpose and intended

outcome of the PoC is made explicit. This done with defining the requirements the PoC must meet.

Secondly, brainstorming must take place to develop ideas with other architects and healthcare professionals for the PoC (inspired by an approach from Johannesson and Perjons (2014)).

#### **4 Final document**

The final product of this research will be a collection of 3-4 papers, with an overarching introduction and conclusion section. This report, which consists of six chapters. We will begin in Chapter 1 by introducing practical and scientific problems at hand as well as objectives and an overview of our research design. There will be an overview of core concepts used in this research, Openness, digital platforms, architecture and boundary resources. The purpose in this chapter is to outline knowledge gaps in literature streams as well as the relations between these concepts. Chapter 2, will be the first scientific paper, answering RQ1. *More than one way to open platforms and solve the innovation challenge in primary healthcare*. Chapter 3, will be the second scientific paper answering RQ2. What influences the openness of the architecture in the 1st line healthcare? Chapter 4, will be a design of the architecture, answering RQ3. an open architecture that improves cooperation in the 1st line healthcare of patients. In Chapter 5, we will develop an open architecture that improves cooperation, implement it in a pilot situation and evaluate if this accelerates the number of innovations. Finally, in Chapter 6, we will answer our research questions by elaborating on our main findings as well as discussing theoretical and practical implications for the 1<sup>st</sup> line healthcare. In the end, we will outline several limitations of our study and suggestions for future research.

#### **References**

- Aanestad, M., Grisot, M., Hanseth, O., & Vassilakopoulou, P. (2017). Information infrastructures within European health care: Working with the installed base. Springer Nature.
- Anderson, E., Belcher, N., and Parker, G. (2020). Will the coronavirus spark an overdue platform revolution in health care? MIT Management: Sloan School. Accessed: 5-5-2020 through:

- <https://mitsloan.mit.edu/ideas-made-to-matter/will-coronavirus-spark-overdue-platform-revolution-health-care>.
- Aulkemeier, F., Iacob, M. E., & van Hillegersberg, J. (2019). Platform-based collaboration in digital ecosystems. *Electronic markets*, 29(4), 597-608.
- Baldwin, C. Y., & Woodward, J. C. (2009). The Architecture of Platforms: A Unified View. In *Journal of Polymer Science, Part B: Polymer Physics* (Vol. 39).  
<https://doi.org/10.1002/polb.10065>
- Bannister, F. (2001). Dismantling the siloes: extracting new value from IT investments in public administration. *Information Systems Journal*, 11(1), 65-84.
- Becker, Jörg; Beverungen, Daniel; Breuker, Dominic; Dietrich, Hanns-Alexander; Knackstedt, Ralf; and Rauer, Hans Peter, "How to model service productivity for data envelopment analysis? A meta design approach" (2011). ECIS 2011 Proceedings. 111.
- Benlian, A., Hilkert, D., and Hess, T. (2015). How open is this platform? The meaning and measurement of platform openness from the complementors' perspective. *Journal of Information Technology*, 30(3):209–228.
- Blaschke, M., Haki, K., Aier, S., & Winter, R. (2019). Taxonomy of digital platforms: a platform architecture perspective.
- Boudreau, K. J. (2010). Open platform strategies and innovation: Granting access vs. devolving control. *Management Science*, 56(10):1849–1872.
- Boudreau, K. J. and Hagiu, A. (2009). Platform rules: Multi-sided platforms as regulators. *Platforms, markets and innovation*, 1:163–191.
- Brunswick, S., & Schecter, A. (2019). Coherence or flexibility? The paradox of change for developers' digital innovation trajectory on open platforms. *Research Policy*, 48(8), 103771.  
<https://doi.org/10.1016/j.respol.2019.03.016>
- Burcharth, A., Knudsen, M. and Søndergaard, H. (2014). Neither invented nor shared here: The impact and management of attitudes for the adoption of open innovation practices. *Technovation*, 34: 149-161.
- Bygstad, B., Hanseth, O., and Le, D. T. (2015). From IT Silos to Integrated Solutions. A Study in E-Health Complexity. In ECIS 2015, pages 0–15.
- Bystad, B., Hanseth, O. (2018). Transforming digital infrastructures through platformization. In 26th European Conference on Information Systems: Beyond Digitization - Facets of Socio-Technical Change, ECIS 2018.
- Cennamo, C., Ozalp, H., & Kretschmer, T. (2018). Platform architecture and quality trade-offs of multihoming complements. *Information Systems Research*, 29(2), 461–478.  
<https://doi.org/10.1287/isre.2018.0779>
- Constantiou, I., Eaton, B., & Tuunainen, V. K. (2016, January). The evolution of a sharing platform into a sustainable business. In 2016 49th Hawaii International Conference on System Sciences (HICSS) (pp. 1297-1306). IEEE.
- Darmon, D., Sauvart, R., Staccini, P., & Letrilliart, L. (2014). Which functionalities are available in the electronic health record systems used by French general practitioners? An assessment study of 15 systems. *International journal of medical informatics*, 83(1), 37-46.
- Deloitte (2020). Open Banking around the world: Towards a cross-industry data sharing ecosystem. <https://www2.deloitte.com/global/en/pages/financial-services/articles/open-banking-around-the-world.html>. Accessed: 20-08-2020
- de Reuver, M., Nederstigt, B., & Janssen, M. (2018). Launch strategies for multi-sided data analytics platforms.
- De Reuver, M., Sørensen, C., & Basole, R. C. (2018). The digital platform: a research agenda. *Journal of Information Technology*, 33(2), 124-135.
- Dixon, B. E., Rahrkar, S., & Apathy, N. C. (2020). Interoperability and health information exchange for public health. In *Public health Informatics and information systems* (pp. 307-324). Springer, Cham.

- EHRIntelligence (2020a). Health Information Exchange Sees Participation Surge Amid COVID-19. <https://ehrintelligence.com/news/health-information-exchange-sees-participation-surge-amid-covid-19>. Accessed: 19-08-2020.
- EHRIntelligence (2020b). COVID-19 Accelerating Interoperability, Data Exchange, Analytics. <https://ehrintelligence.com/features/covid-19-accelerating-interoperability-data-exchange-analytics>. Accessed: 19-08-2020.
- Eisenmann, T. R., Parker, G., and Van Alstyne, M. (2009). Opening platforms: How, when and why? *Platforms, Markets and Innovation*, pages 131–162.
- Frontoni, E., Mancini, A., Baldi, M., Paolanti, M., Moccia, S., Zingaretti, P., Landro, V. & Misericordia, P. (2019). Sharing health data among general practitioners: The Nu. Sa. project. *International journal of medical informatics*, 129, 267-274.
- Fürstenau, D., Auschra, C., Klein, S., & Gersch, M. (2019). A process perspective on platform design and management: evidence from a digital platform in health care. *Electronic Markets*, 29(4), 581-596.
- Ghazawneh, A., & Henfridsson, O. (2013). Balancing platform control and external contribution in third-party development: the boundary resources model. *Information systems journal*, 23(2), 173-192.
- Grisot, M., Vassilakopoulou, P., and Aanestad, M. (2018). Dealing with tensions in technology enabled healthcare innovation: two cases from the Norwegian healthcare sector. In *Controversies in Healthcare Innovation*, pages 109–132. Springer.)
- Hein, A., Weking, J., Schreieck, M., Wiesche, M., Böhm, M., & Krcmar, H. (2019). Value co-creation practices in business-to-business platform ecosystems. *Electronic Markets*, 29(3), 503-518.
- Hermes, S., Riasanow, T., Clemons, E. K., Böhm, M., & Krcmar, H. (2020). The digital transformation of the healthcare industry: exploring the rise of emerging platform ecosystems and their influence on the role of patients. *Business Research*, 1-37.
- Johannesson, P. and Perjons, E. (2014). *An introduction to design science*. Springer.
- Kallinikos, J., Aaltonen, A., & Marton, A. (2013). The Ambivalent Ontology of Digital Artifacts. *Mis Quarterly*, 37(2), 457–370.
- Karhu, K., Gustafsson, R., and Lyytinen, K. (2018). Exploiting and defending open digital platforms with boundary resources: Android’s five platform forks. *Information Systems Research*, 29(2):479–497. *Electronic Markets*, 29:503– 518.
- Kazan, E., Tan, C. W., Lim, E. T., Sørensen, C., & Damsgaard, J. (2018). Disentangling digital platform competition: The case of UK mobile payment platforms. *Journal of Management Information Systems*, 35(1), 180-219.
- Lenert, L., McSwain, B.Y. (2020). Balancing health privacy, health information exchange, and research in the context of the COVID-19 pandemic. *Journal of the American Medical Informatics Association*, 27(6): 963–966.
- Niehaves, B., & Ortbach, K. (2016). The inner and the outer model in explanatory design theory: the case of designing electronic feedback systems. *European Journal of Information Systems*, 25(4), 303-316.
- OECD (2011). *OECD-NSF Workshop: Building a Smarter Health and Wellness Future*. Accessed: 14-10-2020, through: <https://www.oecd.org/sti/ieconomy/48915787.pdf>
- Ondrus, J., Gannamaneni, A., and Lyytinen, K. (2015). The impact of openness on the market potential of multi-sided platforms: A case study of mobile payment platforms. *Journal of Information Technology*, 30(3):260–275.
- Peffer, K., Tuunanen, T., Rothenberger, M. A., and Chatterjee, S. (2007). A Design Science Research Methodology for Information Systems Research A Design Science Research Methodology for Information Systems Research. *Journal of Management Information Systems*, 24(3):45–77.
- Rijksoverheid.nl (2020). Belangrijkste huisartsinformatie tijdelijk te raadplegen. Accessed: 24-4-2020 through: <https://www.rijksoverheid.nl/ministeries/ministerie-van-volksgezondheid-welzijn-en-sport/nieuws/2020/04/08/belangrijkste-huisartsinformatie-tijdelijk-te-raadplegen>.

- Saadatmand, F., Lindgren, R., & Schultze, U. (2019). Configurations of platform organizations: implications for complementor engagement. *Research Policy*, 48(8), 103770.
- Schrieck, M., Wiesche, M., Kude, T., & Krcmar, H. (2019). Shifting to the cloud—how SAP's partners cope with the change. In *Proceedings of the 52nd Hawaii International Conference on System Sciences*.
- Schreiweis, B., Pobiruchin, M., Strotbaum, V., Suleder, J., Wiesner, M., & Bergh, B. (2019). Barriers and facilitators to the implementation of eHealth services: Systematic literature analysis. *Journal of medical Internet research*, 21(11), e14197.
- Scott Kruse, C., Karem, P., Shifflett, K., Vegi, L., Ravi, K., & Brooks, M. (2018). Evaluating barriers to adopting telemedicine worldwide: A systematic review. *Journal of telemedicine and telecare*, 24(1), 4-12.
- Spena, T. R., & Cristina, M. (2019). Practising innovation in the healthcare ecosystem: the agency of third-party actors. *Journal of Business & Industrial Marketing*.
- Tilson, D., Lyytinen, K., and Sørensen, C. (2010). Digital infrastructures: The missing IS research agenda. *Information Systems Research*, 21(4):748–759.
- Tilson, D., Sorensen, C., and Lyytinen, K. (2012). Change and control paradoxes in mobile infrastructure innovation: the Android and iOS mobile operating systems cases. In *2012 45th Hawaii International Conference on System Sciences* (pp. 1324-1333). IEEE.
- Tiwana, A. (2014). *Platform Ecosystems: Aligning Architecture, Governance, and Strategy*. Elsevier, Waltham.
- Tiwana, A., Konsynski, B., and Bush, A. A. (2010). Research commentary—platform evolution: Coevolution of platform architecture, governance, and environmental dynamics. *Information systems research*, 21(4):675–687.
- West, J. (2003). How open is open enough? Melding proprietary and open source platform strategies. *Research Policy*, 32(7):1259–1285.
- World Health Organization (2020). *The New European Policy for Health – Health 2020 – A European policy framework and strategy for the 21st century*. World Health Organization, Regional Office for Europe.
- Zachariadis, M., & Ozcan, P. (2017). *The API economy and digital transformation in financial services: the case of open banking*.
- Zittrain, J. (2008). *The future of the internet—and how to stop it*. Yale University Press.

