

**Four Essays on Digital Transformation
Strategies from the Perspectives of Capital
Markets, Incumbents and Start-ups**

DISSERTATION



zur Erlangung des Doktorgrades des Fachbereichs Wirtschaftswissenschaften
an der Wirtschaftswissenschaftlichen Fakultät der Universität Passau

vorgelegt von
M.Sc. Philipp Mosch

Erstgutachter: Prof. Dr. Robert Obermaier
Zweitgutachter: Prof. Dr. Jan H. Schumann
Vorsitzender Promotionsausschuss: Prof. Dr. Andreas König

Januar 2022
Tag der Disputation: 21.07.2022

Acknowledgements

“The journey is the reward.”

This quote, originally attributed to the famous philosopher Confucius, probably best describes my past 4 ½ years. Filled with many ups, but also many downs on an often rocky and exhausting path, the time I spent writing my doctoral thesis has been a process of intense learning for me. The countless words and hundreds of pages in this thesis are only the cognitive result of that process and cannot describe the valuable experiences, discussions, and conversations I was privileged to have at the many conferences, workshops, research meetings, and lunches with my chair colleagues. During my journey, I was fortunate to meet different people who not only supported me in what I do, but also changed my thinking about relevant problems in the world.

First and foremost, I want to thank my supervisor, Prof. Dr. Robert Obermaier, from whom I was able to learn so much and who, through the collaboration with ZF Friedrichshafen and the Bavarian Institute for Digital Transformation, gave me the opportunity to combine practice and research in a unique way. In numerous discussions, I appreciated his critical thinking and incredible knowledge in the field of business administration, always aiming to deepen my thoughts and providing structure and guidance when needed. Even the conversations away from research topics about business, music, politics or society have always been an enriching experience for me. I am especially grateful for the freedom he gave me over the past 1 ½ years to focus on writing and publishing our research studies and completing my dissertation.

Second, I would like to thank Prof. Dr. Jan H. Schumann who agreed to take on the role of second examiner for this dissertation. I also greatly appreciated his critical and valuable thoughts in the joint project with the Bavarian Research Institute for Digital Transformation, which resulted in the fourth paper of this dissertation.

Third, I would like say my thanks to my current and former colleagues. I am particularly grateful to Dr. Florian Kaiser, Stefan Schweikl, Michael Bleicher, Stefan Daschner, and Matthias Schinnen, not only for the valuable and insightful debates,

but also the great fun we had throughout the years. As dedicated employees at ZF Friedrichshafen, I would also like to highlight Michael Falkus and Philipp Ernst, who provided invaluable support as our counterparts in our joint ZF project. I would also like to thank Derk Lemke, who was an important and close friend during my time in Passau and who shared the pains, but also the beautiful parts of my journey. I already miss our running sessions together. Most of all, I would like to thank Corinna Winkler and Curd-Georg Eggert, who were not only co-authors in the fourth study, but also good and inspiring friends, particularly during the last 1 ½ years in our time together at the Bavarian Institute for Digital Transformation. A special thank goes to Ulrike Haberl, who was the administrative and humorous soul of the chair during my time in Passau, always providing support and encouraging words when I needed them. I would also like to thank the successor Marina Kirschner, who has been a friendly, reliable and helping hand right from the very beginning. Additionally, I would like to thank the many students and student assistants, who have been a valuable support in my research.

Fourth, I would like to express my sincere thanks to my family, i.e., my parents and my siblings Lena and Alexander, for their support in one way or another. Above all, my parents, Dagmar and Hans-Joachim are the main reason why I am able to submit this dissertation at all. They have given me everything I needed, from financial to moral support, to reach the goal of my journey. Thank you Mama and Papa, you have never put pressure on me and have always shown me your unwavering trust, faith, and love.

Lastly, but most importantly, I want to thank my girlfriend and now fiancée Daniela for her love and support during my entire journey. So many nights and weekends that she had to take a back seat and adjust to my working hours. I could not have completed the journey if it were not for her.

January 2022

Philipp Mosch

Content

Preface	I
---------------	---

Study I

It's not What you do, but How you do it – The First Half of Industry 4.0: A Real Options Perspective on Market Value Effects of Digital Innovation Announcements ..	1
---	---

Philipp Mosch

Study II

Trapped in the Supply Chain? Digital Servitization Strategies and Power Relations in the Case of an Industrial Technology Supplier	77
--	----

Philipp Mosch, Stefan Schweikl, Robert Obermaier

Study III

How New Kids on the Block Shape Competition on the Battleground – Classification and Reversing Value Creation Strategies of Industrial Internet-of-Things Platforms	123
---	-----

Philipp Mosch, Robert Obermaier

Study IV

Driving or Driven by Others? A Dynamic Perspective on How Data-Driven Start-Ups Strategize Across Different Network Roles in Digitalized Business Networks.....	167
---	-----

Philipp Mosch, Corinna Winkler, Curd-Georg Eggert, Jan H. Schumann, Robert Obermaier, Wolfgang Ulaga

Preface

Practical motivation

The digital transformation of society in the last decade is undoubtedly one of the most relevant topics and, at the same time, one of the greatest strategic challenges facing societal and economical actors today (Ritter and Pedersen 2020). Existing value creation systems are being changed and converged, while new ones are being created at an unprecedented pace (Volberda et al. 2021). This digital transformation process is fueled by digital technologies such as cloud computing and big data analytics that enable new products, services, and business models on the one hand, and newly structured organizational processes, e.g. in development or production, on the other (Obermaier 2019). However, it is not just products and processes that are subject to change, but entire organizations, including strategic topics such as supply chain positions, network roles, and collaboration models (Pagani and Pardo 2017; Huikkola et al. 2020). Therefore, economic actors need to develop new strategies to manage this major change by digital transformation, which can be created by taking a differentiated view from multiple perspectives.

In this thesis, three different perspectives are adopted to examine digital transformation processes in more detail and gain new insights, with each perspective encompassing different groups of actors facing various strategic hurdles to succeed (Hossnofsky and Junge 2019; Vendrell-Herrero et al. 2018): (1) capital market investors, (2) incumbent firms, and (3) start-ups.

First, the perspective of capital market investors serves as a suitable starting point for the study of digital transformation, as it can assign initial quantitative value assessment to respective digital transformation efforts. After all, digital transformation efforts require huge investments from companies, provided by capital market investors, to develop and build the necessary digital capabilities, resources, products and services (Hossnofsky and Junge 2019). However, these digital transformation efforts do not necessarily lead to value creation per se, as the concrete value creation potential of digital innovation projects remains unclear in many use cases. Especially, since digital transformation depends heavily on strategy formulation and implementation. Particularly, in the early years of digital

transformation, when many companies in almost all industries started to launch digital innovation projects and governments launched digital transformation initiatives in the early 2010s (e.g., Industry 4.0 in Germany), there existed great uncertainty about the expected digital innovation returns and what factors were driving them. As a result, the assessments of capital market investors may provide essential initial insights for companies into the observable circumstances under which the development of digital innovations is favorable (Kohli and Melville 2019), serving as solid foundation for the more in-depth investigation of the participating economic actors.

Second, the perspective of incumbent firms as one of these participating economic actors is particularly important and worth taking, since incumbents face the challenge of leveraging digital technologies to create new products and services while retaining and transferring existing physically-related products and services into the digital age (Volberda et al. 2021). In addition, digitally-native firms such as large technology or software companies have begun to approach industries they have not served before, for example, by providing digital platforms that may dissolve existing industry boundaries and create new competitors to incumbents while putting them under pressure (Vendrell-Herrero et al. 2018). Particularly, the manufacturing sector is affected by the changes brought about by the digital transformation, as value creation has hitherto typically taken place in the physical sphere (Yoo et al. 2010). Incumbent firms thus need to fundamentally rethink their products and services in terms of how they create and capture value in the future in order to maintain or enhance their competitive advantage (Priem et al. 2018). However, incumbents often lack the necessary capabilities and knowledge to acquire the critical resources to bring digital transformation to success (Benitez et al. 2020). The development of digital products and services thus often requires close collaborations and alliances between different actors such as suppliers, original equipment manufacturers (OEM), and customers, which calls for new strategies for incumbents to act in the best way according to the own digital product or service, individual relationships and supply chain positions (Pagani and Pardo 2017; Paiola and Gebauer 2020).

Third, taking a complementary perspective, start-ups penetrate established markets as new entrants, thereby integrating with or displacing incumbents and

occupying new market niches (Kumaraswamy et al. 2018). Specifically, data-driven start-ups take an essential role in the digital transformation process, as they are often the first to commercialize new digital product and service ideas through data-driven business models (Hartmann et al. 2016). Even though, data-driven start-ups often possess the required knowledge to develop complex digital products and services with innovative business models, their failure rate is still high and often related to lacking resources and inappropriate strategizing that fails to fit the start-up's role or position within their respective business network (Aaboen et al. 2016). Consequently, founders need appropriate strategies at hand on how to position themselves in different roles vis-à-vis incumbents to gain access to key resources for building a successful digital business.

Overall, the three perspectives and their respective bundle of different strategies do not stand side by side in isolation, but are necessarily mutually dependent. For example, incumbents increasingly cooperate with data-driven start-ups to gain access to novel digital technologies and business models, thus influencing the founders to align their strategies and vice versa. Another example is capital market investors, who significantly influence the strategy of listed incumbent firms through their investment decisions based on the valuation of digital innovations. Incumbents, on the other hand, may convince capital market investors of risky digital innovation decisions through successful digital transformation projects. Therefore, the combined and intertwined research incorporating all three perspectives can provide novel and fresh insights into successful digital transformation strategies.

Theoretical motivation

Previous research on digital transformation strategies and its different perspectives has produced numerous studies that are often grouped under different umbrella terms such as digital innovation (Nambisan et al. 2017; Fichman et al. 2014), Industry 4.0 (Liao et al. 2017), digital servitization (Gebauer et al. 2021), digital platforms (de Reuver et al. 2018), or digitalized business networks (Pagani and Pardo 2017). Although these research streams already provide first insights into the complexity and various nuances of digital transformation, researchers often call for a more detailed examination of the context-contingent strategic factors that exist not only between the

aforementioned three different perspectives, but specifically within them (Ritter and Pedersen 2020; Gebauer et al. 2021). This includes, for instance, what strategic factors influence the market value effects of digital innovations, what part the supply chain position of incumbents plays in this, or what roles are taken by data-driven start-ups in digitalized business networks. Therefore, there is a great need to address this hitherto incomplete picture regarding the digital transformation of value creation systems and complement it with new and relevant strategic insights. This thesis attempts to achieve this by conducting four studies that encompass the perspectives of capital markets, incumbents, and start-ups and approach the following research shortcomings detailed below.

Despite the enormous investments amounts that digital innovation projects require, less is known about how much market value they actually add for firms. Specifically, in the early years of digital transformation efforts in the manufacturing among other industries – often associated with the launch of the Industry 4.0-initiative in 2011 in Germany – the uncertainty regarding the expected returns of digital innovations was high, as the experience of the involved actors with digital technologies, use cases, and business models was low (Liao et al. 2017). Previous studies in Information Systems (IS) and innovation research are often limited to qualitative studies that surely provide rich and in-depth insights, but lack a focus on the early years of Industry 4.0 as part of the current digital transformation surge and a more general understanding of the quantitative consequences and interactions that digital innovations may bring (Sorescu and Schreier 2021). More specifically, examining different innovation types and institutional arrangements as important context-contingent strategic factors in early innovation phases may paint important nuanced colors in a rather dispersed and incomplete picture of Industry 4.0. Therefore, the thesis addresses the following first research shortcoming.

Research shortcoming 1: Previous research lacks a quantitative understanding of the market value potential that different digital innovation and institutional arrangement types may bring in the early phase of Industry 4.0.

In addition to the need of first quantitative insights, there is a lack of understanding referring to specific qualitative factors that drive the success of digital transformation strategies. One consequence of digital innovation efforts is the increasing bundling of

(physical) products and digital services, often described as digital servitization (Vendrell-Herrero and Wilson 2017; Kohtamäki et al. 2019). Previous studies in this research area have argued that OEMs are often at advantage in the downstream part of the supply chain because they possess close contacts with end-users and are able to collect field data needed to develop new digital services or digital product service systems (DPSS) (Vendrell-Herrero et al. 2017). On the contrary, firms positioned far upstream the supply chain such as industrial suppliers need to overcome significant hurdles to participate in digital servitization efforts, since they lack such direct end-user and data access. Attempts by industrial suppliers to participate in digital servitization despite these hurdles and the corresponding potential countermeasures of OEMs in dominant positions, e.g., in case the supplier starts competing downstream with the OEM, can thus lead to significant disruptions in the balance of power in the supply chain. However, the literature lacks in-depth insights into the disruptive potential of digital servitization for power structures in supply chains (Kohtamäki et al. 2019) and the context-contingent factors underpinning it (Ireland and Webb 2007). Therefore, the second research shortcoming is formulated as follows.

Research shortcoming 2: Previous literature lacks adequate understanding on how context-contingent factors affect the formation of power structures in digitally servitized supply chains and how upstream firms may strategically respond to this.

Digital servitization efforts often involve the development of digital platforms to offer digital services and DPSS on a large scale (Cenamor et al. 2017). While there is a rich literature on digital platforms in the consumer sector, only scarce knowledge exists with regard to digital platforms in the industrial field (Gebauer et al. 2021). Specifically in the manufacturing industry, so called Industrial Internet-Things Platforms (IIoTP) emerge, mainly driven by two main actor groups: (1) Internet technology firms and (2) incumbent manufacturing firms. IIoTPs are particularly important for the digital transformation of the industry, as they act as central intermediaries that form the basis for increasingly rapid transactions between different B2B players and enable innovation involving a large community of third-party complementors (Gawer 2021). IIoTPs are therefore often seen as critical offerings that are able to alter existing market structures and generate sustainable competitive advantage through large growth potential (Pauli et al. 2021). However, it

remains unclear which different IIoTP types exist at all and how they can be classified based on the value creation logics taking place on them (de Reuver et al. 2018; Hein et al. 2020). Additionally, there is only scarce knowledge regarding the strategic measures, which bring value creation logics to success in industrial markets, since they may considerably differ from consumer applications (Hein et al. 2019). Lastly, extant IIoTP research calls for a more detailed investigation of how the two main actor groups of Internet technology firms and incumbent manufacturing firms dynamically compete and cooperate on different layers of the digital platform ecosystem (Pauli et al. 2021). Based on this, the third research shortcoming is stated below.

Research shortcoming 3: Extant research on Industrial Internet-of-Things Platforms lacks the examination of what IIoTP types exist, how they can be classified, which specific strategic measures bring IIoTPs to success, and how Internet technology and incumbent manufacturing firms dynamically compete and cooperate.

Besides incumbent companies, data-driven start-ups as important actors in the digital transformation gain increasing attention in research. Especially in Industrial Marketing & Purchasing (IMP) literature, an increasing number of scholars have devoted themselves to the study of start-ups strategizing in business networks (Baraldi et al. 2019). Thereby, IMP researchers argue that start-ups act in more peripheral network positions and are typically driven by other actors, since they have limited access to resources and capabilities such as financial capital or legitimacy (Aldrich and Auster 1986). However, the start-ups investigated are from non-digital or blended contexts, ignoring the particularities that digital transformation may bring for strategizing. For instance, data-driven start-ups may be able to create central network positions and drive other actors in early stages by creating a large number of new bonds between previously unconnected actors through digital platforms (Pagani 2013). Therefore, it remains open in which different roles data-driven start-ups act in digitalized business networks and how they strategize accordingly between them. Based on this, the fourth research shortcoming is posed in the following.

Research shortcoming 4: Previous studies lack insights regarding which roles data-driven start-ups take in digitalized business networks and how they strategize within and across them.

Research questions

This dissertation encompasses four studies that ask specific research questions, aiming to specifically address the four research shortcomings described before (see Table 1 for details). Thereby, all four papers draw on quantitative and qualitative methods to capture the phenomenon of digital transformation strategies in the empirical world.

Table 1. Overview of thesis studies.

Perspective	Method	Study	Research question
Capital market	Quantitative empirical Event study	Study I: It's not What you do, but How you do it – The First Half of Industry 4.0: A Real Options Perspective on Value Effects of Digital Innovation Announcements	(1) What effect do digital innovation announcements in the initial Industry 4.0 phase have on the market value of firms? (2) To what extent do innovation and institutional arrangement types influence the market value effect of digital innovation announcements in the initial Industry 4.0 phase and how do they interact?
	Qualitative empirical Single-case study	Study II: Trapped in the supply chain? Digital servitization strategies and power relations in the case of an industrial technology supplier	(1) How does digital servitization affect the power structure between an industrial supplier and its OEM customers? (2) Which response strategies does an industrial supplier undertake to counteract the power structure effects of digital servitization?
Incumbent	Qualitative empirical Multiple-case study	Study III: How New Kids on the Block Shape Competition on the Battleground – Classification and Reversing Value Creation Strategies of Industrial Internet-of-Things Platforms	(1) Which different types, actors and elements of IloTPs can be described? (2) Which value creation logics derived from digital consumer platforms are applied to different IloTP types and how can the different IloTP types be classified? (3) Which strategic measures are crucial for the successful evolvement of value creation logics on IloTPs by incumbent industrial firms and Internet technology firms? (4) Which dynamic strategic trajectories of IloTPs by incumbent industrial firms and Internet technology companies can be identified and how do they affect the cooperative situation between these two actor groups?
Start-up	Qualitative empirical Theories-in-use and multiple case study	Study IV: Driving or Driven by Others? A Dynamic Perspective on How Data-Driven Start-Ups Strategize Across Different Network Roles in Digitalized Business Networks	(1) What roles do data-driven start-ups take in digitalized business networks? (2) How do data-driven start-ups dynamically strategize within and across different network roles on various strategic trajectories in digitalized business networks?

Study I aims to approach the first research shortcoming with regard to the lacking quantitative understanding of digital innovations in the early phase of Industry 4.0 and formulates two research questions (see Table 1). The study¹ is titled “*It’s not What you do, but How you do it – The First Half of Industry 4.0: A Real Options Perspective on Value Effects of Digital Innovation Announcements*” and investigates 578 announcements of digital innovations from German and U.S. firms between 2011 and 2016, covering the starting point of Industry 4.0 efforts. The study builds on five

¹ The first paper has been presented in very early versions at the 13th EIASM Interdisciplinary Conference on Intangibles and Intellectual Capital in 2018 and the POMS International Conference in 2019. The author plans to submit this paper to Schmalenbach Journal of Business Research (VHB ranking: B).

hypotheses derived from real options (Fichman 2004) and extended resource-based view (RBV) (Lavie 2006) theory that link digital innovation and institutional arrangement types as well as their interactional relationship to market value. In relation to the first research question, the paper shows that digital innovations lead to significantly negative market value effects. Concerning the second research question, this counterintuitive result is further differentiated by finding that, in contrast to the type of digital innovation (process vs. product), only the type of institutional arrangement (alliance vs. in-house) has a significant effect on market value. More specifically, in-house developments of digital innovations drive the overall negative market value effect. The type of digital innovation comes into play again when the study examines the interaction effects between the two variables. It turns out that digital process innovations are better developed in alliances, while digital product innovations are better developed in-house.

The described lack of understanding on context-contingent factors that affect power structures in digitally servitized supply chains and adequate response strategies in the second research shortcoming leads to two research questions in study II (see Table 1). Addressing them, the second paper², entitled “*Trapped in the Supply Chain? Digital Servitization Strategies and Power Relations in the Case of Industrial Technology Supplier*” (co-authored by Stefan Schweikl and Prof. Dr. Robert Obermaier), investigates a large European industrial supplier of powertrain technology applying single case study research. Thereby, the study relies on resource dependence theory as theoretical foundation (Pfeffer and Salancik 1978) and builds on insights from 18 in-depth expert interviews and extensive access to internal and external archival data. Referring to the first research question, the study identifies three critical resources, namely frequent end-user interactions, continuous data access, and inter-organizational trust with OEM customers, that need to be controlled to sustain or gain power in digitally servitized supply chains. Answering the second research question, the paper identifies and describes five different strategies that

² The second paper has been published in the *International Journal of Production Economics*, 236, (in press) in 2021 (VHB ranking: B) and in the *Research-in-Progress Proceedings of the 28th European Conference on Information Systems* in 2020 (VHB ranking: B). Moreover, the paper was presented in different development stages on the *POMS International Conference* in 2019, the *11th Academy of Innovation, Entrepreneurship, and Knowledge Conference* in 2020, and the *28th European Conference on Information Systems* in 2020.

industrial suppliers can apply when they are in a disadvantageous position towards their OEM customers and aim to increase their power in digital servitization efforts: (1) leverage DPSS-critical component knowledge, (2) facilitate data-exchange specific investments, (3) signal relationship commitment in traditional service offerings, (4) exploit empowered end-users to pull demand through the supply chain, and (5) move downstream in OEM-unserved markets.

The third paper³ (co-authored by Prof. Dr. Robert Obermaier) results from research shortcoming 3, which builds on the scarce research on Industrial Internet-of-Things Platforms (IIoTP). The study is titled “*How New Kids on the Block Shape Competition on the Battleground – Classification and Reversing Value Creation Strategies of Industrial Internet-of-Things Platforms*” and formulates four different research questions that address several research needs (see Table 1). The study reviews existing studies on value creation logics of digital platforms and IIoTP types to build a classification framework that serves as starting point for multiple case study research of two specific IIoTP types. In doing so, the paper answers the first research question by revealing and describing four different IIoTP types, namely Digital Marketplace, Connectivity Platform, Hyperscaler, and Integrated IIoTP. Addressing the second research question, the study shows that value creation logics of digital platforms in B2C settings are partially different from their application in B2B IIoTP markets. Using multiple case study research and approaching the third research question, the paper identifies five strategic measures that Hyperscalers and Integrated IIoTPs need to bring their value creation logics to success: (1) ensuring data ownership and security, (2) building an open and modular platform structure, (3) managing a multi-community landscape, (4) acquiring and maintaining domain knowledge, and (5) establishing a demarcated relationship between Hyperscalers and Integrated IIoTPs. With regard to the fourth research question, the study further draws dynamic strategic trajectories between Hyperscalers and Integrated IIoTPs.

³ The first part of the third paper including the first two research questions has been published in the *Handbook on Digital Business Ecosystems: Strategies, Platforms, Technologies, Governance and Societal Challenges* edited by Prof. Dr. Sabine Baumann in 2022. An earlier version has been published in the *Handbuch Industrie 4.0 und Digital Transformation – Betriebswirtschaftliche, technische und rechtliche Herausforderungen* edited by Prof. Dr. Robert Obermaier in 2019. The second part encompassing the subsequent two research questions has been submitted to the *International Journal of Production Economics* (VHB ranking: B) in a separate version and is currently in the second round under review.

The fourth paper⁴ (co-authored by Corinna Winkler, Curd-Georg Eggert, Prof. Dr. Jan H. Schumann, Prof. Dr. Robert Obermaier and Prof. Dr. Wolfgang Ulaga) arises from research shortcoming 4 referring to the lack of insights on the roles and strategizing trajectories that data-driven start-ups take in digitalized business networks. The study is titled “*Driving or Driven by Others? A Dynamic Perspective on How Data-Driven Start-ups Strategize Across Different Network Roles in Digitalized Business Networks*” and asks two research questions (see Table 1). The paper first reviews IMP literature on start-ups to conceptually derive four tenets related to strategizing that are then contrasted with strategizing tenets of data-driven start-ups. The resulting framework serves as foundation to conduct theories-in-use and multiple case study research to better understand the various nuances of how data-driven start-ups strategize in different network roles. In doing so, the study builds on the analysis of 23 data-driven start-ups and insights from expert interviews with their founders. In answering the first research question using the Activity-Resource-Actor (ARA) model as analysis tool (Håkansson and Snehota 1995), four network roles of data-driven start-ups are identified: (1) extender, (2) enabler, (3) transformer, and (4) orchestrator. The network roles are then classified based on the strength of network ties to access data and the network position. In order to approach the second research question, the study draws three main strategizing trajectories that data-driven start-ups follow, thereby explaining how they dynamically strategize in digitalized business networks.

Contributions

Overall, the thesis sheds light on how firms strategize successfully when developing and offering digital products or services and thereby significantly contributes to a better understanding regarding the digital transformation of value creation systems (Volberda et al. 2021). From the perspectives of capital markets, incumbents, and start-ups, the present thesis highlights the need to consider one's position and role in the respective supply chain or business network as a critical factor for a successful

⁴ The fourth paper has been published in the *Industrial Management Marketing*. 102, pp. 381-402 in 2022 (VHB ranking: B). Additionally, it was presented in an early stage at the 14th *EIASM Interdisciplinary Conference on Intangibles and Intellectual Capital* in 2019.

digital transformation strategy. More specifically, the four studies provide the following contributions to academia and practice.

Study I provides initial findings on the market value effects of digital innovations in the early phase of Industrie 4.0, focusing on the digital pioneer countries Germany and the USA. By combining real options and extended RBV theories, the study particularly extends IS literature that emphasizes that the relationship between digital innovations and competitive advantage should be considered in such nuanced way (Fichman 2004). By finding that digital innovations lead to significantly negative market value effects, the paper refines the common notion of many qualitative studies in IS and innovation research that view digital innovations per se as value creating for the firm (Parker et al. 2016; Fichman et al. 2014). Instead, the study contributes to (modern) Solow Paradox research in the digital age (Agrawal et al. 2019; Brynjolfsson et al. 2019) by pointing to differences in firm size, IT-intensity, and industry type when it comes to explain investors' negative perception of digital innovations. In addition, by showing that digital process innovations are better developed in alliance and digital product innovations in in-house settings, the paper extends previous event studies in IS (Konchitchki and O'Leary 2011) and innovation (Sorescu et al. 2017) literatures, which typically examine innovation types and institutional arrangements in isolation from each other.

Second, Study II highlights that not only the development of digital capabilities is crucial for the successful digital servitization efforts, but the control of three critical resources, namely frequent end-user interaction, continuous access to product usage data, and inter-organizational trust with OEM customers. Thereby, the paper enriches existing digital servitization literature with power regime research, pointing to the increasing relevance of network-level power sources, e.g., the control over strategic relationships (Kohtamäki et al. 2019). Moreover, the study shows that not in every case downstream firms are in a favorable position to develop digital product-service systems compared to more upstream companies, since it depends on the power structure between both actors prior to the advent of digital servitization. This finding refines the common notion in digital servitization research of favoring downstream actors to develop successful DPSS (Vendrell-Herrero et al. 2017). Additionally, the identification of five strategic responses that upstream firms can undertake to tackle

their weak power position towards OEM customers provides essential guidance for managers in upstream firms that aim to participate in digital servitization efforts.

Third, study III extends previous studies in IS (Pauli et al. 2021; de Reuver et al. 2018) and market-based platform literature (Eisenmann et al. 2006; Parker et al. 2016; Gawer 2021) by identifying, describing, and classifying four different IIoTP types, which provides a comprehensive drawing of the IIoTPs' boundaries and the entire IIoTP market. Moreover, by showing that value creation logics of digital platforms in B2C settings are partially different from their application in IIoTP markets, the study provides knowledge that IIoTPs need to be examined not only with a clear distinction from digital B2C platforms, but also between different IIoTP types. By identifying five distinct strategic measures of Hyperscalers and Integrated IIoTPs, the paper provides important contextualization on different vertical platform layers within the same IIoTP ecosystem. Dynamic strategic trajectories of Hyperscalers and Integrated IIoTPs show that upstream positioned Hyperscalers are in the best position to profit from exploiting value creation logics in IIoTP markets, reversing the common logic that value creation in digital markets is best achieved at the downstream interface with the end-user.

Fourth, through the identification of four network roles of data-driven start-ups, Study IV adds the digital transformation dimension to IMP literature on start-ups (Baraldi et al. 2019). Thereby, the paper not only includes the resource level, but integrates the activity and actor angle to build a unique classification framework of network roles in digitalized business networks. This insight complements IMP studies on start-ups that focus on non-digital contexts (Oukes et al. 2019) and derive the network roles solely from the rather static resource level (Aaboen et al. 2016). Moreover, when it comes to strategizing, the study shows that strategizing of data-driven start-ups considerably differs from that of non-data-driven start-ups in certain network roles. Specifically, the network role of the orchestrator contradicts the majority of strategizing tenets in non-digital contexts, indicating a certain disruption potential in business networks and the ability to drive other actors. This enriches market shaping literature by finding that only data-driven start-ups that operate in certain network roles are able to drive markets and hence other actors (Jaworski et al. 2000). Additionally, while strategizing and aiming to move from one network role to

another, founders of data-driven start-ups should specifically draw their attention to the strength of network ties to access data and the network position. Thereby, it is particularly important that they avoid to exceed a certain magnitude of change and instead take a step-wise approach to increase the success of achieving the desired network role and sustain in digitalized business networks.

References

- Aaboen, Lise; Laage-Hellman, Jens; Lind, Frida; Öberg, Christina; Shih, Tommy (2016): Exploring the roles of university spin-offs in business networks. In *Industrial Marketing Management* 59, pp. 157–166.
- Agrawal, Ajay; McHale, John; Oettl, Alexander (2019): Finding Needles in Haystacks: Artificial Intelligence and Recombinant Growth. In: Ajay Agrawal, Joshua Gans and Avi Goldfarb (Eds.): *The Economics of Artificial Intelligence: An Agenda*. Chicago: University of Chicago Press, pp. 149–174.
- Aldrich, Howard; Auster, Ellen R. (1986): Even dwarfs started small: Liabilities of age and size and their strategic implications. In *Research in Organizational Behavior* 8, pp. 165–198.
- Baraldi, Enrico; Havenvid, Malena Ingemansson; Linné, Åse; Öberg, Christina (2019): Start-ups and networks: Interactive perspectives and a research agenda. In *Industrial Marketing Management* 80, pp. 58–67.
- Benitez, Guilherme Brittes; Ayala, Néstor Fabián; Frank, Alejandro G. (2020): Industry 4.0 innovation ecosystems: An evolutionary perspective on value cocreation. In *International Journal of Production Economics* 228, in press.
- Brynjolfsson, Erik; Rock, Daniel; Syverson, Chad (2019): Artificial Intelligence and the Modern Productivity Paradox: A Clash of Expectations and Statistics. In: Ajay Agrawal, Joshua Gans and Avi Goldfarb (Eds.): *The Economics of Artificial Intelligence: An Agenda*. Chicago: University of Chicago Press, pp. 23–57.
- Cenamor, Javier; Sjödin, D. Rönnberg; Parida, Vinit (2017): Adopting a platform approach in servitization: Leveraging the value of digitalization. In *International Journal of Production Economics* 192, pp. 54–65.
- de Reuver, Mark; Sørensen, Carsten; Basole, Rahul C. (2018): The digital platform: a research agenda. In *Journal of Information Technology* 33 (2), pp. 124–135.
- Eisenmann, Thomas; Parker, Geoffrey; van Alstyne, Marshall W. (2006): Strategies for two-sided markets. In *Harvard Business Review* 84 (10), pp. 92–101.
- Fichman, Robert G. (2004): Real options and IT platform adoption: Implications for theory and practice. In *Information Systems Research* 15 (2), pp. 132–154.
- Fichman, Robert G.; Dos Santos, Brian L.; Zheng, Zhiqiang (2014): Digital innovation as a fundamental and powerful concept in the information systems curriculum. In *MIS Quarterly* 38 (2), pp. 329–354.
- Gawer, Annabelle (2021): Digital platforms' boundaries: The interplay of firm scope, platform sides, and digital interfaces. In *Long Range Planning* 54 (5), in press.
- Gebauer, Heiko; Paiola, Marco; Saccani, Nicola; Rapaccini, Mario (2021): Digital servitization: Crossing the perspectives of digitization and servitization. In *Industrial Marketing Management* 93, pp. 382–388.
- Håkansson, Håkan; Snehota, Ivan (1995): *Developing relationships in business networks*. London: Routledge.

- Hartmann, Philipp Max; Zaki, Mohamed; Feldmann, Niels; Neely, Andy (2016): Capturing value from big data—a taxonomy of data-driven business models used by start-up firms. In *International Journal of Operations & Production Management* 36 (10), pp. 1382–1406.
- Hein, Andreas; Schrieck, Maximilian; Riasanow, Tobias; Setzke, David Soto; Wiesche, Manuel; Böhm, Markus; Krcmar, Helmut (2020): Digital platform ecosystems. In *Electronic Markets*, pp. 1–12.
- Hein, Andreas; Weking, Jörg; Schrieck, Maximilian; Wiesche, Manuel; Böhm, Markus; Krcmar, Helmut (2019): Value co-creation practices in business-to-business platform ecosystems. In *Electronic Markets* 29, pp. 503–518.
- Hossnofsky, Verena; Junge, Sebastian (2019): Does the market reward digitalization efforts? Evidence from securities analysts' investment recommendations. In *Journal of Business Economics* 89 (8), pp. 965–994.
- Huikkola, Tuomas; Rabetino, Rodrigo; Kohtamäki, Marko; Gebauer, Heiko (2020): Firm boundaries in servitization: Interplay and repositioning practices. In *Industrial Marketing Management* 90, pp. 90–105.
- Ireland, R. Duane; Webb, Justin W. (2007): A multi-theoretic perspective on trust and power in strategic supply chains. In *Journal of Operations Management* 25 (2), pp. 482–497.
- Jaworski, Bernard; Kohli, Ajay K.; Sahay, Arvind (2000): Market-driven versus driving markets. In *Journal of the Academy of Marketing Science* 28 (1), pp. 45–54.
- Kohli, Rajiv; Melville, Nigel P. (2019): Digital innovation: A review and synthesis. In *Information Systems Journal* 29 (1), pp. 200–223.
- Kohtamäki, Marko; Parida, Vinit; Oghazi, Pejvak; Gebauer, Heiko; Baines, Tim (2019): Digital servitization business models in ecosystems: A theory of the firm. In *Journal of Business Research* 104, pp. 380–392.
- Konchitchki, Yaniv; O'Leary, Daniel E. (2011): Event study methodologies in information systems research. In *International Journal of Accounting Information Systems* 12 (2), pp. 99–115.
- Kumaraswamy, Arun; Garud, Raghu; Ansari, Shahzad (2018): Perspectives on disruptive innovations. In *Journal of Management Studies* 55 (7), pp. 1025–1042.
- Lavie, Dovev (2006): The competitive advantage of interconnected firms: An extension of the resource-based view. In *Academy of Management Review* 31 (3), pp. 638–658.
- Liao, Yongxin; Deschamps, Fernando; Loures, Eduardo de Freitas Rocha; Ramos, Luiz Felipe Pierin (2017): Past, present and future of Industry 4.0—a systematic literature review and research agenda proposal. In *International Journal of Production Research* 55 (12), pp. 3609–3629.

- Nambisan, Satish; Lyytinen, Kalle; Majchrzak, Ann; Song, Michael (2017): Digital Innovation Management: Reinventing innovation management research in a digital world. In *MIS Quarterly* 41 (1), pp. 223–238.
- Obermaier, Robert (2019): Industrie 4.0 and Digitale Transformation als unternehmerische Gestaltungsaufgabe. In Robert Obermaier (Ed.): *Handbuch Industrie 4.0 and Digitale Transformation. Betriebswirtschaftliche, technische and rechtliche Herausforderungen*. Wiesbaden: Springer Gabler, pp. 3–46.
- Oukes, Tamara; Raesfeld, Ariane von; Groen, Aard (2019): Power in a startup's relationships with its established partners: Interactions between structural and behavioural power. In *Industrial Marketing Management* 80, pp. 68–83.
- Pagani, Margherita (2013): Digital business strategy and value creation: Framing the dynamic cycle of control points. In *MIS Quarterly*, pp. 617–632.
- Pagani, Margherita; Pardo, Catherine (2017): The impact of digital technology on relationships in a business network. In *Industrial Marketing Management* 67, pp. 185–192.
- Paiola, Marco; Gebauer, Heiko (2020): Internet of things technologies, digital servitization and business model innovation in BtoB manufacturing firms. In *Industrial Marketing Management* 89, pp. 245–264.
- Parker, Geoffrey; van Alstyne, Marshall; Choudary, Sangeet Paul (2016): *Platform revolution. How networked markets are transforming the economy - and how to make them work for you*. New York: W.W. Norton & Company.
- Pauli, Tobias; Fiel, Erwin; Matzner, Martin (2021): Digital Industrial Platforms. In *Business & Information Systems Engineering* 63 (2), pp. 181–190.
- Pfeffer, Jeffrey; Salancik, Gerald R. (1978): *The external control of organizations: A resource dependence perspective*. Stanford: Stanford University Press.
- Priem, Richard L.; Wenzel, Matthias; Koch, Jochen (2018): Demand-side strategy and business models: Putting value creation for consumers center stage. In *Long Range Planning* 51 (1), pp. 22–31.
- Ritter, Thomas; Pedersen, Carsten Lund (2020): Digitization capability and the digitalization of business models in business-to-business firms: Past, present, and future. In *Industrial Marketing Management* 86, pp. 180–190.
- Sorescu, Alina; Schreier, Martin (2021): Innovation in the digital economy: a broader view of its scope, antecedents, and consequences. In *Journal of the Academy of Marketing Science* 49, pp. 627–631.
- Sorescu, Alina; Warren, Nooshin L.; Ertekin, Larisa (2017): Event study methodology in the marketing literature: an overview. In *Journal of the Academy of Marketing Science* 45 (2), pp. 186–207.
- Vendrell-Herrero, Ferran; Bustinza, Oscar F.; Parry, Glenn; Georgantzis, Nikos (2017): Servitization, digitization and supply chain interdependency. In *Industrial Marketing Management* 60, pp. 69–81.

- Vendrell-Herrero, Ferran; Wilson, James R. (2017): Servitization for territorial competitiveness: Taxonomy and research agenda. In *Competitiveness Review: An International Business Journal* 27 (1), pp. 2–11.
- Vendrell-Herrero, Ferran; Parry, Glenn; Bustinza, Oscar F.; Gomes, Emanuel (2018): Digital business models: Taxonomy and future research avenues. In *Strategic Change* 27 (2), pp. 87–90.
- Volberda, Henk W.; Khanagha, Saeed; Baden-Fuller, Charles; Mihalache, Oli R.; Birkinshaw, Julian (2021): Strategizing in a digital world: Overcoming cognitive barriers, reconfiguring routines and introducing new organizational forms, In *Long Range Planning*, in press.
- Yoo, Youngjin; Henfridsson, Ola; Lyytinen, Kalle (2010): Research Commentary — The New Organizing Logic of Digital Innovation: An Agenda for Information Systems Research. In *Information Systems Research* 21 (4), pp. 724–735.

It's not What you do, but How you do it –
The First Half of Industry 4.0: A Real Options Perspective on
Market Value Effects of Digital Innovation Announcements

Philipp Mosch (philipp.mosch@uni-passau.de)
Chair for Business Economics, Accounting and Control
DE-94032 Passau, Germany

Abstract

In the course of Industry 4.0, companies are driven to invest massively in the development of digital innovations. Especially in the initial phase of Industry 4.0 initiatives starting in 2011, investments are associated with great uncertainty and irreversibility. However, the existing literature lacks quantitative research on whether and under which strategies digital innovations create value during this period. In particular, studying the interrelationship between digital innovation type (process vs. product) and institutional arrangement (alliance vs. internal) requires more attention, as managers at this early stage need to know what and how to develop digital innovations that actually create value. Based on real options theory and extended resource-based view, this study applies event study methodology to 578 digital innovation announcements by German and U.S. companies between 2011 and 2016, providing three important contributions to innovation and IS literature. First, this research is unique in its thematic, temporal, and theoretical investigation in quantifying market value effects associated with digital innovations. Second, the author reveals that digital innovations in the initial phase exhibit negative abnormal returns of -0.23%. This surprising finding refines the common notion that digital innovations must be value-adding per se, thus specifically complementing studies on the (modern) Solow Paradox by pointing out nuances related to IT intensity, firm size, and industry type. Third, the study provides deeper understanding of digital innovation by finding a significant interaction effect between digital innovation type and institutional arrangement. This provides valuable guidance to managers that digital process innovations are better developed in alliances and digital product innovations in-house.

Keywords: Industry 4.0; Digital Innovation; Market Value; Real Options; Extended Resource-based View; Event Study

1. Introduction

In the last decade, the development of digital innovations such as cloud computing or big data analytics (Chen et al. 2014) has increasingly found its way to various industries, particularly the manufacturing sector (Gebauer et al. 2020). The start of this movement is often associated with the establishment of the “Industrie 4.0”-initiative in 2011 (Kagermann et al. 2011). The focus of Industry 4.0 is on the traditional strength of the German economy in the manufacturing industry, with the aim of digitally innovating production processes and thus increasing efficiency potential, but also enriching physical products with digital services to enhance revenues (Kagermann et al. 2016). The proliferation of digital innovations in the manufacturing sector is therefore often referred to as the fourth industrial revolution, or in short as Industry 4.0 (Liao et al. 2017; Liao et al. 2018). This has led to a major surge in digital innovation and initiatives in numerous other industries and countries, e.g., the Industrial Internet Consortium in the U.S., making the term Industry 4.0 synonymous with the development of digital innovations and their implications.

Digital innovations, which can affect processes and/or products (Fichman et al. 2014), play a decisive role in shaping the digital transformation of entire value creation systems, thus having far-reaching effects on all economic actors and concretely influencing what and how value is created (Obermaier 2019). Three aspects illustrate the changes and consequences brought about by digital technologies and innovations for companies and their managers.

First, digital technologies are reprogrammable due to the fact that they are based on a digital code base, which enables their continuous manipulation and makes modularity much broader and more significant than for physical technologies. The self-referential nature of digital technologies further reinforces the cycle of data network externalities, lower barriers to entry, and faster diffusion rates the more digital technologies are adopted, eventually making digital innovations more affordable and accessible to a wide range of economic actors (Yoo et al. 2010; Yoo et al. 2012). This means that the management of digital innovations is very complex and fast-moving, as digital technologies are constantly changing in short development periods and offering market opportunities to new entrants (Bharadwaj et al. 2013).

Second, digital technologies are associated with marginal costs close to zero, as digital processes and products can be perfectly replicated with almost no costs almost anywhere in the world, making business growth very cost-effective and fast (Rifkin 2014). As a result, it is easier for new entrants to penetrate areas far removed from the core business, establish themselves quickly, and thus challenge incumbent companies (Bharadwaj et al. 2013). Third, digital technologies enable closer and more frequent interaction between organizations, leading to more complex and closer interorganizational alliances or even entire ecosystems (Wang 2021). In this context, the ability to decide which digital innovation is best to develop in which strategy becomes both more difficult and more important, making strategic management and partnership skills an important complementary factor in digital innovation development (Pagani and Pardo 2017).

Based on these aspects, we state that while digital innovations are capable of creating enormous added value, their success depends heavily on the application of appropriate strategies. Specifically, in the initial years of Industry 4.0 from 2011 onwards, a well-aligned strategy is key for success to tackle the high uncertainties and lack of experience associated with digital innovations. However, a recent survey among managers, CEOs and senior executives shows that there is still a great lack of knowledge about what the right strategy for developing digital innovations means. It is estimated that of the \$1.3 trillion spent worldwide on digital innovation projects in 2018, 70% were not invested properly and purposefully to create successful and value-creating digital innovations (Sun 2018; ZoBell 2018). Adding to that, productivity gains at the industry level from digital innovation are not yet measurable, suggesting the return of the modern Solow Paradox (Brynjolfsson et al. 2019) and prompting a more skeptical view on digital innovations. One key reason for the lack of value creation from digital innovations is mismanagement (Schweickl and Obermaier 2020). Indeed, the lack of a coherent strategy may be responsible for the massive destruction of potential value creation (Tabrizi et al. 2019), entailing the crucial decision of what digital innovations to focus on and in which institutional arrangements to develop them in the first half of Industry 4.0 (Kohli and Melville 2019; Mosch et al. 2021).

However, in contrast to the increasing attention paid by IS and innovation literature to the impact of specific innovations and IT investments on market value (Wang and Ngai 2020), both literature streams remain surprisingly largely silent on digital innovations and their context-specific factors in these crucial initial years. Instead, researchers focus either on process (Dewan and Ren 2007; Subramani and Walden 2001) or product innovations (Sorescu et al. 2007; Sorescu and Spanjol 2008), without including the phenomenon of digital innovation. Others concentrate on institutional arrangements such as alliances (Oxley et al. 2009; Park et al. 2004) or in-house developments (Eberhart et al. 2004; Chan et al. 2001), but without considering different types of innovation. Contrary to the lack of quantitative research on digital innovation, qualitative research methods are examined frequently to shed light into the issues related to digital innovation or Industry 4.0 (Rabetino et al. 2018). Qualitative studies, however, inherently fail to quantify value contributions of digital innovations, to include the perspective of capital market investors and, in particular, to bring different variables into a quantitative-causal relationships. Specifically, quantitative research on digital innovation may help to uncover potential interaction effects in the dynamic first half of Industry 4.0 – as in our case by investigating innovation and institutional arrangement types simultaneously –, which is increasingly demanded by literature to better understand the nuances of innovation in the digital age and thus create new insights (Sorescu and Schreier 2021). Therefore, we aim to address the following two research questions:

(1) What effect do digital innovation announcements in the initial Industry 4.0 phase have on the market value of firms?

(2) To what extent do innovation and institutional arrangement types influence the market value effect of digital innovation announcements in the initial Industry 4.0 phase and how do they interact?

Addressing our research questions, we develop five hypotheses based on real options theory (Fichman 2004b) and the extended resource-based view (RBV) (Lavie 2006), thereby constructing a theoretical framework that links digital innovation to market value. Building on event study methodology (Brown and Warner 1985; MacKinlay 1997), we subsequently investigate 578 digital innovation announcements to measure

their abnormal returns. The time period of our investigation lasts from 2011 to 2016, thereby explicitly examining and shedding light on the initial years of the Industry 4.0 movement (Liao et al. 2017) by German and U.S. firms, representing two of the most innovative countries worldwide in the context of digital innovation (WEF 2019). Our research setting using real options theory, extended RBV, and event study methodology is particularly appropriate for this study, since it determines the market value based on future cash-flows, and thus the risks and returns of highly uncertain and irreversible digital innovation investments in the early phase of Industry 4.0 that have the potential to create competitive advantage (Yang et al. 2012; Dewan and Ren 2007).

Building on this research setting, we provide guidance for academia and practice by making the following three contributions. First, our study is – to the best of our knowledge – unique in its thematic and temporal exploration of quantifying the market value effects associated with digital innovations. We shed light into the highly uncertain and dynamic initial stage of Industry 4.0 between 2011 and 2016 in Germany and USA, by using a combination of real option theory and extended RBV as the distinctive basis of an event study setting. Thereby, we explicitly draw on Fichman (2004b), who emphasizes that the relationship between digital innovations and competitive advantage should be considered in a more nuanced way through such a theoretical foundation. Second, we show that digital innovations lead to significantly negative market value effects. In doing so, we refine the common notion of many qualitative studies in IS and innovation research that view digital innovations per se as value creating for the firm (Parker et al. 2016; Fichman et al. 2014). Instead, we draw on recent studies that emphasize the return of the Solow Paradox in the digital age (Agrawal et al. 2019; Brynjolfsson et al. 2019) to explain investors' negative perception of digital innovations, pointing to differences in firm size, IT-intensity, and industry type. Third, we provide evidence that digital process innovations are better developed in alliance settings, whereas digital product innovations are better developed in-house. In this way, we considerably extend previous event studies in IS (Konchitchki and O'Leary 2011) and innovation (Sorescu et al. 2017) literatures, which typically examine innovation types and institutional

arrangements in isolation from each other, by bringing them together and generating new insights into their interactional relationship.

The remainder of this study is organized as follows. In the following section, we provide an overview of existing event studies on (digital) innovation types and institutional arrangements. In section 3, we describe the theoretical foundation and derive the hypotheses tested in this paper. We then explain the methodology used in section 4. In section 5, we illustrate the results, and in the final section, we discuss them and deduce the contributions of this study.

2. Literature review

2.1 Definition of key terms

The conceptual understanding of our study is based on two research streams: (1) IS literature that includes studies examining IT investments and their impact on firm value, and (2) innovation literature from the marketing field that links different types of innovation and/or institutional arrangements to firm value. Before delving deeper into both research streams, we first define five terms associated with Industry 4.0 central to our study: digital innovation, digital process innovation, digital product innovation, alliances, and in-house developments.

Digital innovations based on digital technologies exhibit the distinct characteristics of (1) convergence and (2) generativity (Yoo et al. 2012; Ciriello et al. 2018). Convergence means that digital innovation brings previously unconnected components, actors, and industries together. For example, smartphones as newly developed smart physical products merge different, previously separate tools and technologies onto a single device, or digital platforms connect users and industries that were previously apart and isolated. As the main pillar of convergence, digital infrastructures further establish new digital processes of organizational interactions, enabling companies to create digital innovation (Tilson et al. 2010). Generativity refers to the inherent dynamism and unexpectedness of digital innovations. More specifically, digital innovations generate additional data through customer use that in turn can lead to new innovations that were not previously anticipated in this form, potentially leading to unintended changes in the roles and scopes of existing players.

In our study, we therefore define digital innovation as the generative and convergent innovation of processes, products or business models through the use of digital technologies (Nambisan et al. 2017; Yoo et al. 2010; Yoo et al. 2012).

Following IS (Swanson 1994; Yoo et al. 2010; Fichman et al. 2014) and innovation research (Zmud 1982; Utterback and Abernathy 1975), we distinguish digital innovations into the innovation types of *digital process innovations* and *digital product innovation*, illustrating the question of “what” digital innovation type to develop. For instance, companies may implement an digital infrastructure like internal data platforms as digital process innovation that helps connect and analyze the data available in the company and enables additional digital innovations (Fichman 2004b; Tilson et al. 2010). This may further incorporate cyber-physical systems (CPS) and manufacturing execution systems (MES) that form networked and smart processes culminating in smart factories (Obermaier 2019; Swanson 1994). Overall, in defining digital process innovations, we take the perspective of adopting firms, i.e., users, that aim to improve overall process connectivity and efficiency, reduce costs, and thus increase or maintain competitive advantage by implementing and adopting digital process innovations. With regard to the second innovation type, a digital product innovation may be a physical product that is enriched with a digital service, e.g., regarding virtual maintenance services or connected wind turbines (Porter and Heppelmann 2014). Thereby, digital product innovations can be conceptualized as combinations of digital and physical products and services or stand-alone digital services such as digital intermediary platform services (Nambisan et al. 2017; Sorescu and Schreier 2021). Overall, in describing digital product innovation, we take the perspective of innovators that produce digital products and services to increase revenue and market share, thereby further increasing and maintaining competitive advantage through differentiation (Fichman et al. 2014).

However, digital innovations differ not only in their components, technologies, and complementary character, but also exhibit alterations in their strategy settings, i.e., institutional arrangements, representing the “how” of digital innovation development (Borah and Tellis 2014). For instance, due to the complex nature of digital markets, digital innovations increasingly incorporate different forms of cooperations (Pagani and Pardo 2017). These include open innovation settings, joint

ventures with other companies, strategic alliances, development cooperations, or technology partnerships (Borah and Tellis 2014). Such strategies are specifically necessary, since the convergence of digital technologies leads to a significantly higher heterogeneity of knowledge resources across different actors or industries (Yoo et al. 2012). Therefore, sharing data, knowledge, and capabilities in alliances with other actors constitutes an increasingly critical task to successfully develop and implement digital innovations (Fichman et al. 2014). When possible, however, companies strive to develop digital innovations based on their own capabilities and resources, without the involvement of an external player to ensure their own proprietary access and full value absorption. In the literature, this approach is often associated with an organic growth strategy, in which the company is required to concentrate on its key resources and capabilities and leverage them while taking the customer needs into account (Kling et al. 2009). Therefore, we distinguish two types of institutional arrangements for the development of digital innovations: *alliance* and *in-house development*.⁵

2.2 Empirical research on digital innovation and institutional arrangement

In our literature review, we focus on event studies from the two research streams of (1) IS and (2) innovation literature that establish a link between (digital) innovation and/or institutional arrangement and firm value. Thereby, we structure the literature review in terms of the focus that event studies take in examining the types of institutional arrangements and (digital) innovations. This can be either the study of only one or no particular type or of several types of institutional arrangements and (digital) innovation. Overall, our literature review clearly shows that – to the best of

⁵ We are well aware that there is a third option for institutional arrangements to develop digital innovations: mergers and acquisitions (M&A). See here specifically Borah and Tellis (2014) that describe all three different options that companies follow: make, buy, and ally. In this study, however, we deliberately refrain from including M&A activities for three reasons. First, we observed that M&A announcements typically include detailed information about the purchase price, price premiums, or synergies rather than the digital innovation itself. This makes it difficult to isolate the value effect of the digital innovation, not always, but often leading to confounding events. Second, M&A activities are often preceded by announcements of strategic alliances between the companies involved, so that the digital innovation may already have been evaluated by the capital market before the actual M&A takes place. Third, digital innovation M&A announcements accounted for only 10% of our total dataset, leading to a generally low impact of this category anyway. The focus on alliances and in-house development therefore represents the vast majority of the different institutional arrangements in which digital innovations are developed, making the results of our study transferable and meaningful.

our knowledge – there are no event studies so far that examine distinctive types of (digital) innovations simultaneously and combine that with different types of institutional arrangements. However, such distinction is crucial to better understand the nuances of (digital) innovation efforts (Tidd 2001). In this respect, it is surprising that insights from the rich literature on the (modern) Solow Paradox, which could provide the framework for studying such context-specific nuances on digital innovation (see Schweikl and Obermaier (2020) for an excellent review on this), are often limited to the IS research field, thereby receiving only little attention in the innovation literature. Since we are interested in which type of innovation is better developed in which strategy, i.e. institutional arrangement, we therefore want to study several types of innovation and institutional arrangements simultaneously, thereby focusing on their interactions to gain insights into context-specific factors related to value creation of digital innovations.

Event studies on (digital) innovation types

We observe a clear difference in the focal points of the two research directions: IS literature tends to concentrate on process innovations in terms of their relationship to market value (Roztocki and Weistroffer 2009), while innovation literature studies this relationship mainly with respect to product innovations (Sorescu et al. 2017). Based on this, we review event studies on (digital) process innovations mainly from IS literature and event studies on (digital) product innovations from innovation literature.

Surprisingly, studies that specifically link digital process innovation to firm value are scarce. Instead, rich IS literature from the 1990s and 2000s examines how process-oriented IT investments shape the market value of firms (Ranganathan and Brown 2006; Hayes et al. 2001) focusing on the adoption, implementation, purchase, or use of IS technology (Konchitchki and O'Leary 2011) and examining what we consider process innovation. However, the findings from these studies are inconsistent: while some studies find a positive relationship (Chatterjee et al. 2002; Hayes et al. 2001; Subramani and Walden 2001), others doubt the overall positive effects of IT investments on stock prices (Dos Santos et al. 1993; Im et al. 2001). Specifically, the latter studies stand in the light of the Solow Paradox that was

originally posited by Nobel Prize winner Robert Solow and basically says that productivity gains from the introduction of computers are not measurable on the industry- or economy-wide level (Solow 1987). At the company layer, an extension of the Solow Paradox states more specifically that there is no correlation between IT investments and profitability (Strassmann 1997). Therefore, researchers put on more nuanced glasses by finding that only innovative IT investments lead to positive stock market reactions (Dos Santos et al. 1993). Im et al. (2001) further conclude in their analysis that the magnitude of the stock market reaction is negatively related to the size of the firm, so that the reaction to announcements of larger firms is weaker than that of smaller firms. Even though, these studies already provide some explanations for the inconsistent finding and the Solow Paradox, they largely ignore the recent emergence of digital technologies such as cloud computing and big data analytics techniques. Instead, they usually examine IT investments in general (Dos Santos et al. 1993), specific technologies such as ERP systems (Hayes et al. 2001), or phenomena such as electronic commerce (Subramani and Walden 2001; Dewan and Ren 2007) and virtual worlds (Yang et al. 2012).

Consistent with broader innovation research (Hauser et al. 2006), researchers of innovation event studies have predominantly examined product innovations (Sorescu et al. 2007; Chaney et al. 1991). However, similarly to digital process innovations, there is little research on the relationship between digital product innovations and market value. Moreover, if we consider the existing studies on (non-digital) product innovations and their impact on firm value, the results are inconclusive (Lee and Chen 2009), similar to event studies examining process innovations. Whereas some find a positive relationship (Chaney et al. 1991; Sood and Tellis 2009), others measure non-significant (Sorescu et al. 2007; Eddy and Saunders 1980), or even negative effects on stock prices (Su and Rao 2010). Therefore, most event studies address different characteristics of product innovations to bring more differentiation to the ambiguous findings. For instance, product innovations are differentiated by their different innovation stages, e.g., initiation vs development vs commercialization (Sood and Tellis 2009), their radicalness potential, e.g., breakthrough vs incremental (Sorescu and Spanjol 2008), or their differences in the technological degree of industries, e.g., high vs. low technology (Chaney et al. 1991). Surprisingly, there are

no studies in the innovation literature that attempt to explain the differences among value effects in light of the Solow Paradox.

However, the two types of digital innovation do not necessarily develop in isolation from each other, but have a reciprocal relationship that requires a combined view incorporating the lessons learned from the Solow Paradox. For example, digital innovations can be simultaneously viewed as a digital product innovation from the perspective of an innovator (e.g., offering a predictive maintenance service) and a digital process innovation from the perspective of the adopter (e.g., using predictive maintenance services in the own production processes) (Fichman et al. 2014). Moreover, digital product innovations can arise from digital process innovations that were successfully introduced within the company, which in turn can be sold to third parties (Obermaier and Wagenseil 2019). Similarly, development projects of digital product innovations usually inevitably lead to the introduction of digital process innovations in order to create a technical basis in the first place. Therefore, the interdependent nature of digital process and product innovations makes it clear that they are by no means to be regarded as substitutes, but rather as mutually dependent complementarities (Obermaier et al. 2021), calling for a combined and interrelated investigation of this topic.

Event studies on institutional arrangement types

The study of different institutional arrangements tends to be conducted by innovation researchers. Not surprisingly, the vast majority of event studies investigating the relationship between alliances to develop (digital) innovations and firm value measure positive abnormal returns. For example, Das et al.'s (1998) study of 119 strategic alliances measures higher abnormal returns for technology alliances that support the development of innovations compared to marketing alliances. Similarly, Oxley et al. (2009) and Park et al. (2004) find that technology alliances result in positive abnormal returns. Most of these event studies focus on innovation in general, without necessarily distinguishing between digital and non-digital categories (Sood and Tellis 2009; Borah and Tellis 2014). One of the few exceptions is the study by Lee and Lim (2006), which links alliances more specifically to IT. Here, they examine differences in the effects of strategic alliances on IT firms and non-IT firms

and surprisingly find that abnormal returns are highest for alliances of non-IT firms and the smaller partner firm.

Event studies investigating in-house developments of (digital) innovations usually focus on the (long-term) R&D spending of the individual firm to make this type of institutional arrangement tangible. For instance, Doukas and Switzer (1992) find that abnormal returns to R&D announcements depend on market concentration. The higher the market concentration, the higher the abnormal return. Eberhart et al. (2004) are able to measure positive abnormal returns after five years, after the company has increased its R&D spending. Thus, it seems that the investors respond significantly positively only after a longer evaluation period (Rothaermel and Hess 2010). This is further supported by the study of Chan et al. (2001) that compared firms with and without R&D investments, thereby finding that firms with R&D spending do not exhibit significantly different abnormal returns after a shorter period of three years. Overall, the results of previous literature on in-house development of (digital) innovations tend to view the increase in R&D investment and thus the application of in-house development as beneficial solely in the long run.

After reviewing previous event-study research on (digital) innovation and institutional arrangement types, we conclude the following two aspects. First, there is a great lack of research on the market value effects of digital innovations. However, digital technologies are inherently non-stationary over time, leading to ever-changing investor perceptions and thus different stock returns (Konchitchki and O'Leary 2011). Therefore, a constantly updated view on digital innovations and market value is essential but still missing to extend the findings of the previous IS and innovation literature. Particularly, the initial phase of Industry 4.0 may bring up uncertainties that result in altered perceptions of capital market investors. Moreover, the emergence of the modern Solow Paradox that emphasizes a lack of productivity gains through digital technologies (Schweikl and Obermaier 2020; Brynjolfsson et al. 2019) demands a refreshed investigation of the market value effects of digital innovations (Dehning and Richardson 2002). Second, to the best of our knowledge, there is a lack of event studies that simultaneously distinguish between (digital) process and product innovations on the one hand, and studies that differ according to distinct institutional arrangement types such as alliance and in-house developments on the other.

However, a study that combines both research areas is important to bring interrelated nuances to digital innovation research, providing important and new explanations to the modern Solow Paradox. Therefore, this study aims to explore the relationship between digital innovation types and institutional arrangements in the first half of Industry 4.0 to address the topic of (1) whether digital innovations create positive abnormal returns and (2) which innovation type is better developed in which institutional arrangement.

3. Theory and Hypotheses

3.1 Real options theory

The theoretical foundation of our study stands on two pillars: (1) real option theory (Fichman 2004b) and (2) extended resource-based view (RBV) (Lavie 2006).

The *Real Options Theory* is widely accepted and applied in a number of studies, specifically in the IS literature (Fichman 2004b). Examples include studies on decision support systems (Kumar 1999) or ERP systems (Taudes et al. 2000). More recent IS studies link the real options theory to the event study methodology (Yang et al. 2012), thereby paving the way for a new and fresh perspective on investment decisions. Real options can be defined as a company's future options for scope of action and investment opportunities in connection with the ability of management to adapt operational decisions to changing environmental developments (Hommel and Pritsch 1999). Generally, taking the real options perspective is especially suitable in cases when managers are confronted by two specific challenges while investing: (1) high uncertainty regarding the extent of their potential payoffs, and (2) the irreversibility referring to the costs that are related to the investment (Amram and Kulatilaka 1999; Trigeorgis 1993). The real options perspective provides managers with flexibility in their actions, thereby being considered an effective evaluation mechanism for digital innovations in the early years of Industry 4.0 that exhibits all characteristics described above. More specifically, we view digital innovation events as real growth options, conferring the right to make future investment decisions

without a current obligation to fully invest (Fichman 2004a; Sambamurthy et al. 2003)⁶.

All real growth options are basically referred to as so-called waiting options, as they include the right to decide on the overall investment after a certain waiting period, thus reducing uncertainty. Therefore, the holder of a real growth options typically makes several small initial investments (e.g., initial pilot projects or prototypes as introduced in the initial phase of Industry 4.0), thereby providing managerial flexibility to seize promising investment opportunities and build organizational capabilities that enable sustained performance and competitive advantage (Sambamurthy et al. 2003). In case of positive changes in the respective investment environment (e.g., successful establishment and adoption of the investment in the first digital innovation), real growth options can lead to substantial additional profit opportunities. Overall, real option value increases, if (1) the expected value of the potential payoffs increases, (2) the variance of potential returns increases, and/or (3) managerial flexibility in exercising the real growth option increases (Fichman 2004b). The option value is positive, i.e., the option is in the money, when the strike price (present value of future cash-flows when exercising) exceeds the premium (investment) (Dreyer 2004; Tsai 2001).

3.2 Extended resource-based view

The second theoretical base is the so-called extended resource-based view (RBV) (Lavie 2006) that integrates the relational view (Dyer and Singh 1998) and the traditional RBV (Barney 1991; Wernerfelt 1984). The traditional RBV states that resources need to be valuable, rare, imperfect imitable, and imperfect substitutable to generate sustainable competitive advantage (Barney 1991). However, RBV fails to explain how alliances contribute to the generation of competitive advantage, since RBV argues that resources are tied semi-permanently to and typically controlled by

⁶ In this context, the strike price of each real growth option, i.e., when the real option is exercised, is determined by the present value of the respective digital innovation event (e.g., launch of the digital product innovation). It should be noted that unlike financial growth options, where the underlying asset is usually available and traded, the underlying asset (investment good) in real growth options is often created only by exercising the real growth option, generating market imperfections due to lacking data history (Dreyer 2004). The initial digital innovation investment itself can be interpreted as the premium of the option (Tsai 2001).

the focal firm (Wernerfelt 1984; Barney 1991). This proprietary and intra-firm assumption relates to the central idea that firms secure rents by erecting barriers to protect their proprietary resources from potential competition (Lavie 2006), emphasizing the in-house development of innovations. However, in this study we also aim to explain the key role alliances play in creating competitive advantage and value through digital innovation. Finally, resources are distributed among at least two actors in alliances, making classical RBV not applicable. Therefore, we specifically follow Lavie (2006), who argues that network resources embedded in alliances provide strategic opportunities and influence firm behavior and value, thereby providing an inter-firm perspective on competitive advantage. This assumption brings in the relational view developed by Dyer and Singh (1998), which basically states that critical resources may cross corporate boundaries, and in doing so, companies may achieve relational rents that are created in alliances with other partners and enable sharing of knowledge and information (Lavie 2006). Overall, bringing both, RBV and relational view, together allows us to explain how networked companies combine their internal resources and network resources to achieve competitive advantage in the digital age (Lavie 2006).

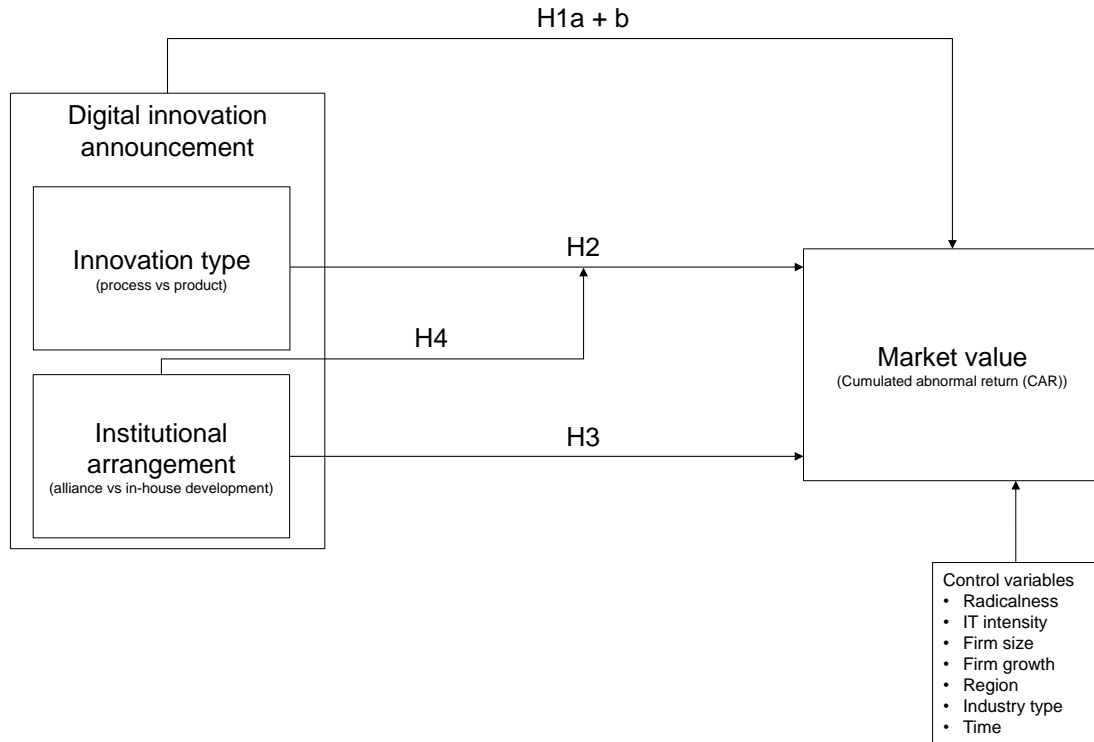
3.3 Hypotheses

Based on both theories and extant research, we build five different hypotheses referring to digital innovations, innovation types, and institutional arrangements and their relations to real option value and market value. Figure 1 describes our research framework.

Digital innovations are currently giving rise to many new types of production processes, products, business models and markets that were previously thought impossible, thereby replacing existing ones and being one of the main drivers of value in the world of business (Fichman et al. 2014). Digital technologies enable companies to involve customers and users much more intensively in business model and product development. As a result, new digital products and services with greater user-centeredness, modularization and individualization based on user feedback are

established to acquire new revenue opportunities and achieve higher customer loyalty (Burmeister et al. 2016).

Figure 1. Research framework.



Often, network effects play a major role in the success of digital innovations (Shapiro and Varian 1999). For instance, digital platform companies such as Amazon or Facebook bring together various players at a central hub, acting as intermediary, orchestrator, and interface to the end customer, while exhibiting potential tremendous growth rates, market value and market dominance (Parker et al. 2016). Typically, such development is tied to first-mover advantages, making it difficult to get imitated or substituted by competitors. Therefore, digital innovations are able to create significant competitive advantage, leading to high expected returns and thus to a positive real option value and investor reaction.

Furthermore, payoffs of digital innovation are associated with high uncertainty, since digital technologies underlying digital innovations change rapidly over short periods of time, making the management and application of digital innovation extremely complex (Peppard and Rylander 2006), but difficult to imitate by

competitors. The permanent progress in digital technologies leads to the ever-advancing elimination of technical boundaries for digital innovations, giving them an unprecedented level of unpredictability, indefiniteness and dynamism (Nambisan et al. 2017). However, this also creates an endless flow of opportunities to develop new digital innovations. Therefore, the variance of expected returns to digital innovations may increase considerably, thereby having a positive impact on the real options value and hence on the market value effect.

In sum, investments in digital innovations may create significant growth opportunities at the expense of high uncertainty regarding the future payoffs, leading to our first hypothesis:

Hypothesis 1a: Digital innovations are associated with positive market value effects.

However, there is also a rich literature of qualitative and quantitative studies that emphasizes a more critical assessment of the value creation potential of (digital) innovations based on the so-called Solow Paradox. Indeed, more recent studies observe a comeback of the Solow Paradox in the digital age (Brynjolfsson et al. 2019; Agrawal et al. 2019). The absence of productivity and profitability increases may therefore also apply to potential cash-flow increases following digital innovation investments, which accordingly also fail to materialize. One important reasons for this development is mismanagement (Schweikl and Obermaier 2020).

During the investigated time period between 2011 and 2016, most companies are in the initiating or learning phase to develop digital innovations. Investments in digital innovations and their associated digital technologies are complex and need time to get developed or launched to market. In this regard, intensive training for employees regarding digital technologies is needed to equip the own workforce with the skills needed to succeed in the digital age (Brynjolfsson et al. 2021). In addition, managers may not be able to realize the full potential of digital innovation and make poor decisions due to a lack of knowledge, use cases and best practices. However, the lack of necessary resources and skills, such as big data analytics, is not limited to the company's own operations, as digital innovations are often not fully established or

understood on the customer side either (Benitez et al. 2020). As a result, consulting firms are often engaged to provide support in the early phase of the Industry 4.0 and to define possible organizational and strategic changes, entailing further investments that cannot be recovered (Schweikl and Obermaier 2020). In addition, digital innovations may not deliver what they seem to promise, and managers are thus prone to exaggerated expectations (Nordhaus 2021). For example, digital innovations in the consumer market (e.g., smart running shoes, smart washing machines, smart televisions) do not have the far-reaching impact on customers' normal lives as the development of the steam engine or electricity in past times (Schweikl and Obermaier 2020). This, in turn, may make customers unwilling to pay higher prices for such digitally-enabled products. Moreover, the growth potential of digital innovations may be overestimated by managers, further diminishing potential returns of digital innovations. Potential gains from investments in digital innovations may thus not yet materialize, but lead to massive expenditures in the present. Investments involved in the development and introduction of digital processes and products are therefore irreversible and considered a sunk cost that the company cannot easily divest (Yang et al. 2012). This may lead to less managerial flexibility, as investments in digital innovation cannot be easily broken down into small parts without requiring high initial investments that increase the premium of the growth value option.

In sum, digital innovations may be subject to mismanagement, leading to lower expected returns in general, reduced variance of returns, and less managerial flexibility. Thus, we state the alternative second hypothesis as follows:

Hypothesis 1b: Digital innovations are associated with negative market value effects.

Differentiating into the two different digital innovations types, we further aim to explore potential differences between digital process and product innovation. As outlined above for hypothesis 1a, both digital innovation types may be able to create competitive advantage for companies. However, (digital) process innovations are much more sticky, tacit or embedded, i.e., costly to acquire, transfer and use in a different setting (Fichman 2004b). Additionally, (digital) process innovations may not

be well observable for actors outside the firm, since they are usually deeply embedded in internal processes and operations. These characteristics may make it therefore more difficult for competitors to substitute or imitate digital process innovations. In contrast, due to their nature of being offered to the market, digital product innovations are typically easier to understand for customers, suppliers, and competitors and hence associated with less imitation costs (Cohen and Klepper 1996). Therefore, the potential to generate competitive advantage in the early years of Industry 4.0 by digital process innovations may be higher than for digital product innovations.

Furthermore, the growth potential for digital process innovations may be higher than for digital product innovations, since they usually lay the foundation for a wide range of further digital innovations. For example, establishing internal data platforms as digital process innovations that support the collection, processing, and analysis of data is what enables the creation of further digital process and product innovations in the first place (Obermaier et al. 2021). Without digital process innovations, which are usually established at first and organize the data, resources, and digital capabilities within the firm, digital product innovations are impossible to get developed successfully.

Therefore, we argue that digital process innovations, specifically in the initial phase we studied from 2011 to 2016, generate more sustainable expected returns and equip managers with higher flexibility regarding the development of additional digital innovations. This in turn may lead to higher growth option value and hence to higher abnormal returns compared to digital product innovations. We state Hypothesis 2 accordingly:

Hypothesis 2: Digital process innovations are associated with higher market value effects compared to digital product innovations.

Referring to the institutional arrangements, we also investigate how alliances and in-house developments may differ in their market value effects. In the context of digital innovation, it is common sense that alliances are considered a more crucial role in creating value than in-house developments (Pagani and Pardo 2017). First, many

companies struggle to offer digital innovations due to a lack of competencies (Benitez et al. 2020) and the high complexity of digital markets (Pagani and Pardo 2017), demanding alliances that help to overcome these hurdles. Second, the leverage of digital innovations to create digital platforms and ecosystems demands the careful curation of third-party development cooperations and other partnerships (Parker et al. 2016). Third, the increasing application of open source software tools and open innovation settings in developing digital innovations requires a different, much more coordinated way of managing proprietary knowledge with partners, suppliers and customers (Osterloh and Rota 2007).

Conversely, in-house developments lower the transaction costs, especially for company-specific technologies compared to an external technology generation (Mowery and Rosenberg 1989). The developed knowledge can also be better protected against theft by own patents and does not have to be shared with other companies. This may be particularly important with regard to digital innovations that may be subject to rapid imitation when accessible to a wide range of partners (Wang et al. 2018). Therefore, a high proportion of the research and development (R&D) budget is used in all sectors to develop and bring their own digital innovations to market.

However, in-house developments are also associated with longer development times and a higher risk of investment failure (Rothaermel and Hess 2010). Additionally, due to rising development costs in the context of digital innovation, external research collaborations are becoming increasingly interesting in order to be able to split these costs over several pillars. The benefits of lower transaction costs for internal development projects are increasingly being offset by the benefits of sharing risk, capital and knowledge with other partners (Porter and Fuller 1986), thereby generating higher competitive advantage by establishing alliances (Lavie 2006). Specifically, network effects and the speed to market in alliances can be better exploited than in in-house development settings (Park et al. 2004). Moreover, alliances ensure a high level of managerial flexibility. If the cooperation proceeds successfully, it can be intensified; in the case of cooperation that proves inferior, it can also be terminated at short notice (Borah and Tellis 2014).

Overall, alliances are advantageous when uncertainty is high (Dyer et al. 2004), increasing the probability of successful development of digital innovations. This may lead to higher expected returns, managerial flexibility, and thus higher growth option value. Therefore, we state the following hypothesis:

Hypothesis 3: Digital innovations developed in alliances are associated with higher market value effects compared to digital innovations developed in-house.

Accordingly to our second research question, we explore how innovation type and institutional arrangement may interact. As argued in hypothesis 2, digital process innovations are more complex to develop and implement as well as require a high number of applications building on them to realize the high growth and cost reduction potential. Therefore, digital process innovations may be better developed in alliances, since such settings reduce risks and enable knowledge and capability sharing to bring complex digital process innovations to success and enable third-party developer cooperation. For example, an alliance partner may provide knowledge regarding the analysis of huge production data to enable predictive maintenance of crucial machinery (Porter and Heppelmann 2014). Moreover, alliances may lead to the establishment of the specific digital process innovation in different settings and firms, enabling a higher growth potential than the limited development in-house. Therefore, digital process innovations developed in alliances can lead not only to high cost reduction potential, but also to valuable options for developing additional digital innovations beyond the digital process innovation in question. As a consequence, this may lead to higher growth option value and hence abnormal returns, since the expected returns and managerial flexibility increase considerably.

Considering digital product innovations, they are usually built on successful established digital process innovations developed in alliances, such as internal data platforms (Gunday et al. 2011). Therefore, many companies may already have gained a certain level of knowledge regarding the management of huge amounts of data and thus the development of digital innovations. This may enable them to use the established digital capabilities to develop digital product innovations in-house without the inherent need for alliances. Moreover, we argue that the in-house

development of digital product innovations ensures the creation of an organization that may be able to fully absorb the potential future revenues and create competitive advantage (Barney 1991). Specifically, since in digital markets that tend to create monopolistic conditions due to network effects (Argenton and Prüfer 2012), proprietary digital product innovations may lead to considerable growth potential and higher expected returns. Having said this, alliances in the development of digital product innovations are time-consuming and complex due to several agreements on the common usage of proprietary knowledge, patents, and the sharing of revenues. Therefore, long-standing and trusting relationships between the different alliance partners need to be established before developing digital product innovations (Mosch et al. 2021). This may hinder rapid development through prototyping or piloting, and overall reduce expected returns and, most importantly, management flexibility, leading to a more advantageous in-house development of digital product innovations.

Hypothesis 4: Institutional arrangements moderate the relationship between innovation type and market value, so that the market value effect is higher for digital process innovations developed in alliances and for digital product innovations that are developed in-house.

4. Empirical methodology

The aim of this research is twofold: to investigate (1) whether digital innovations create added market value for companies and (2) to what extent digital innovation and institutional arrangement type influence it. In doing so, we used financial data and adopted event study methodology, which was originally developed and established by Fama et al. (1969) and Ball and Brown (1968). The event study methodology offers researchers a powerful tool to examine the link between manager's actions – as in our case the decision to invest in digital innovation projects – and companies' value creation (Subramani and Walden 2001). Event study methodology is generally based on the well-established assumption of semi-efficient financial markets, i.e., new information is immediately incorporated into stock prices when publicly available (Fama 1970, 1991). In our approach, we followed six different steps based on MacKinlay (1997) and Konchitchki and O'Leary (2011) for conducting rigorous event study research: (1) identifying the event of interest, (2) defining the event and

estimation window, (3) selecting the given sample firms, (4) estimating the abnormal return over the event period, (5) testing whether the abnormal return is statistically significant, i.e., significantly different from zero, and (6) applying cross-sectional regression analysis to address the stated hypotheses.

4.1 Identification of event of interest

Since we are interested in announcements about digital innovations, we have focused on publications that deal exclusively with this topic. For example, an announcement may represent a digital product innovation, introducing a new digital industrial Internet-of-Things platform that involves alliances with third-party developers. The example here is consequently coded as digital product innovation developed in alliance (see Appendix A for more details on our coding approach). Since an in-house development is usually not explicitly mentioned in the announcement, we assume that when no other company is mentioned in the text. To confirm this assumption, we researched additional information on 20 randomly selected announcements of in-house developments, confirming our approach. In case that the information about the digital innovation is considered as beneficial for the respective company, a positive market reaction is expected and vice versa. In other words, the change in stock prices reflects the discounted future cash flow expected by investors, and thus the net present value of the underlying digital innovation, considering the past performance of the company, the competitive situation and the company's future potential (Fama 1991). In our study, we relied on common daily stock returns to ensure a precise measurement of the abnormal returns of a given event (Brown and Warner 1985; MacKinlay 1997).

4.2 Definition of event, estimation, and buffer period

In order to calculate the abnormal returns, we defined three different time periods: (1) event period, (2) estimation period, and (3) buffer period. The event period represents the time window in which we measure the abnormal returns of digital innovations. The event period initially includes the date of the event in $t = 0$. In a semi-efficient capital market, the reaction to the release of a new piece of information is usually

fast, but not always immediate, taking one or two trading days to be received, understood, and acted upon (Konchitchki and O'Leary 2011). Furthermore, information may also be leaked to capital market participants before publication or insider trading may take place. Therefore, in addition to the event day $t = 0$, we included up to two days before and after the digital innovation announcement (Sorescu et al. 2017). An event period of no more than five days is short enough to provide solid results, but long enough to account for the specifics of semi-efficient capital markets (Park 2004). Similar to the procedure by Geyskens et al. (2002) and Raasens et al. (2012), we then selected the event period over five days [-2;2], as it exhibited the highest absolute t-value among different event periods (see Table 1).

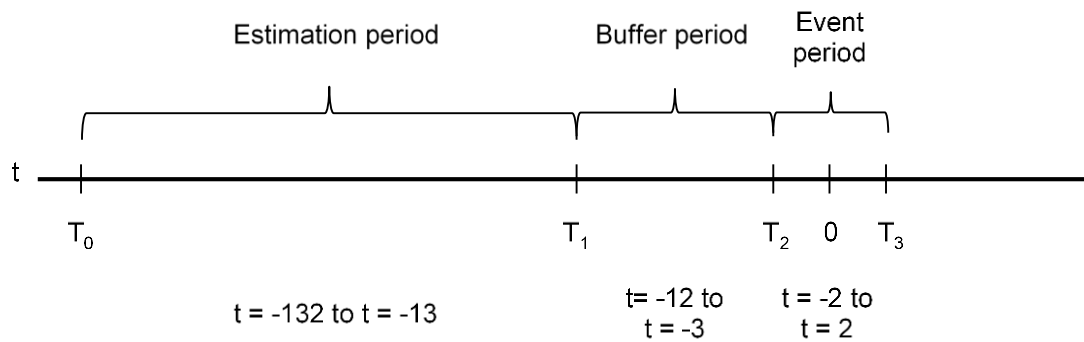
Table 1. Comparison of different event periods.

Event period	t-value	N
[-2;2]	-1,95**	578
[-1;1]	-1,07	578
[-1;2]	-1,48*	578
[-2;1]	-1,62*	578

*p<0.1, **p<0.05, ***p<0.001 (one-tailed Brown and Warner t-test of significance)

Abnormal returns are calculated by the difference between the expected and actual return (Brown and Warner 1985). Therefore, we determined an estimation period to compute the expected return. In general, an estimation period of more than 100 trading days prior to the event day is considered sufficient, as it can also ensure a normal distribution of the estimation parameters. In this study, we followed MacKinlay (1997) who uses – as do many other event studies (Dewan and Ren 2007; Subramani and Walden 2001) – 120 trading days to calculate the estimation parameters. Lastly, in most event studies, an additional buffer period is inserted between the estimation and the event period in order to exclude any influence of the event on the estimation period. 10 trading days are considered sufficient, a longer period does not lead to any significant advantage (Hendricks and Singhal 2003). The breakdown of the different previously defined periods is summarized in Figure 2.

Figure 2. Overview of different periods.



4.3 Selection of given sample firms

We used the Nexis database to obtain digital innovation announcements from the largest publicly traded German companies listed in Prime Standard and the 50 largest U.S. companies by market value within our investigation period between 2011 and 2016. The Nexis database contains any business news from various newspapers, magazines and other sources worldwide – mainly in English, but also in German. It is therefore very well suited as a search basis for our two-country setting, laying the foundation for a high-quality empirical analysis (Borah and Tellis 2014; Park 2004). We constructed a complex search string with several key terms that are related to digital innovation, such as Industry 4.0, Big Data, Digitalization or Internet of Things leading to overall 40,953 announcements (see Appendix B for the full search string). Thereby, the information must be made available to the public for the first time (McWilliams and Siegel 1997). Otherwise, the information is already priced into the share price and the abnormal return cannot be isolated to the specific event. To ensure that, we used not only the Nexis database, but also Google search to include sources that may not be covered in the Nexis database. In addition, when examining events, it is important to consider events that were published within the event period of the digital innovation announcement, having the potential to impact the share price and thus the abnormal return. In case such confounding events have been identified, the announcement was removed from our sample (MacKinlay 1997). Examples of relevant confounding events include stock splits, damage suits, dividends, executive changes, merger and acquisitions, or earnings announcements (Konchitchki and

O'Leary 2011; Ding et al. 2018). Finally, we excluded announcements for which there were not enough trading days to cover estimation, buffer, and event period. Overall, we have identified 578 suitable digital innovation announcements from 97 firms. Table 2 shows the overall sampling procedure.

Table 2. Sampling procedure.

Steps	Description	Sample
1	Initial sample using set of keyword searches in the period from 01/01/2011 to 31/12//2016	40,953
2	Less: <ul style="list-style-type: none"> • Announcements with too generic information • Announcements that contain information irrelevant to digital innovation • Announcements that contain other information relevant for investors (e.g., financial performance figures) • Announcements influenced by other confounding events within the event period (e.g., CEO change) 	(40,371)
3	Less: <ul style="list-style-type: none"> • Announcements without enough trading days 	(4)
Final sample size		578

Our sample is spread across a wide range of industries, with a focus on manufacturing and services, such as software (see Table 3).

Table 3. Sample distribution across industries.

Two-digit SIC code	Industry	Sample	Percentage (%)
15-17	Construction	1	0.2
20-39	Manufacturing	258	44.6
40-49	Transportation & Utilities	88	15.2
50-51	Wholesale	7	1.2
52-59	Retail Trade	6	1.0
60-67	Finance, insurance, real estate	19	3.4
70-89	Service	199	34.4
Total		578	100

In addition, Table 4 provides information on the distribution over time of our sample, where there is a clear trend toward an increasing number of announcements from year to year, illustrating the growing importance of digital innovations for companies' investment decisions.

Table 4. Sample distribution across time.

Year	Sample	Percentage (%)
2011	41	7.1
2012	51	8.8
2013	82	14.2
2014	110	19.0
2015	134	23.2
2016	160	27.7
Total	578	100

4.4 Estimation of abnormal return

We applied the commonly used financial database Refinitiv Eikon Datastream (RED) to obtain all relevant financial data. It is particularly well-suited to the setting of our German-U.S. dataset, since it covers a broad range of financial parameters in high quality from both countries (Park 2004)⁷. According to previous literature (Brown and Warner 1985; MacKinlay 1997), the common daily return is calculated based on the market model:

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it} \quad (1)$$

where

R_{it} = Daily return of firm i at time t

R_{mt} = Daily return of market portfolio m at time t

α_i & β_i = Market model parameters for firm i

ε_{it} = Disturbance (error) term for firm i at time t

For the market portfolio, we used national indices from both Germany and USA, i.e., the CDAX and the S&P 500, which are recommended for multi-country settings (Campbell et al. 2010). Moreover, we refrained from converting the returns into a

⁷ We followed the recommendations by Ince and Porter (2006) and Brückner (2013) to account for two specific issues when using the RED database. First, RED repeats the same value by default when it is missing, potentially distorting the measurement of returns. We addressed this by removing the repeated value from the dataset, applying the trade-to-trade method as also suggested by Campbell et al. (2010). Second, RED provides only two decimal places by standard when using the return index (RI), which can lead to rounding problems. Therefore, we used the return index (RI) measure with up to four decimal places for our calculations to account for this.

common currency (Campbell et al. 2010), mainly due to the fact that we only computed and used relational figures based on the national currencies. Using the estimated parameter values from Equation (1) and assuming that $\varepsilon_{it} = 0$ (MacKinlay 1997), we then calculated the abnormal return:

$$AR_{it} = R_{it} - (\alpha_i + \beta_i R_{mt}) \quad (2)$$

where

- AR_{it} = Abnormal return of i th firm for time period t
- R_{it} = Actual daily return of i th firm for time period t
- R_{mt} = Actual daily return of market portfolio m at time t
- α_i & β_i = Estimated market model parameters for firm i

Subsequently, the daily ARs were then summed up over the days -2 to +2 in the event period to form the cumulative abnormal returns (CAR) for firm i , yielding:

$$CAR_i = \sum_{i=-2}^{+2} AR_{it} \quad (3)$$

Lastly, we aggregated the CARs over the respective coding (e.g., digital process or product innovation) or the overall sample to calculate the cumulative average abnormal return (CAAR):

$$CAAR = \frac{1}{N} \sum_{i=1}^N CAR_i \quad (4)$$

4.5 Significance tests of abnormal return

To measure the statistical significance of the effect of the announcement on the market value in terms of CAAR, we applied parametric and non-parametric tests, namely the t-test according to Brown and Warner (1985) and the Wilcoxon signed-rank test developed by Wilcoxon (1945). In this study, we considered the parametric

t-test as the main instrument to determine whether the CAARs are significantly different from zero, as it accounts for event clustering and cross-sectional correlation (Ding et al. 2018). Furthermore, we based this decision on the fact that the prerequisite of normal distribution of parametric tests can be assumed across our coding samples, since they all exhibit sample sizes greater than 100 and the proportion of positive and negative abnormal returns tends to be equal in our sample (Sorescu et al. 2017) (see Table 8 in the result chapter). However, to ensure robustness of the CAARs' significance tests, we further conducted the Wilcoxon signed-rank test, that is widely used in event studies (McWilliams and Siegel 1997) and not dependent on the normal distribution assumption in the population (Shieh et al. 2007). For detailed information on the statistical procedures used in event study research, see, for example, the studies by McWilliams and Siegel (1997), Peterson (1989), or Ding et al. (2018).

4.6 Cross-sectional regression analysis

We ran an OLS regression with heteroskedasticity-robust standard errors clustered by company to test the stated hypotheses (Goldstein et al. 2011; Bastin and Hübner 2006). The regression model includes three independent variables from our hypotheses and seven control variables relevant to the topic of digital innovation. Table 5 provides a detailed overview of the operationalization of our variables.

Measures

The dependent variable in the regression is the CAR from firm *i*, reflecting the investor's response to the digital innovation announcement during the event period. Accounting for variations in the outcomes of CARs, we regressed the three independent variables (*innovation type*, *institutional arrangement* and the interaction term between both variables) as well as the seven control variables on the CARs. Operationalizing the different variables, we either conducted content analysis of the digital innovation announcements following the coding scheme described below and in Appendix A or applied secondary data from the RED database to construct proxies for the respective variable (Yang et al. 2012).

Table 5. Operationalization of variables.

	Variable	Operationalization	Assumed direction	Sources
Dependent variable	Cumulative abnormal return (CAR)	The cumulative abnormal return for firm <i>i</i> over the event period [-2; 2].		Brown and Warner (1985); MacKinlay (1997)
Independent variables	Innovation type (INNT)	Digital product innovations are coded as 1, whereas digital process innovations are coded as 0.		Yoo et al. (2010); Fichman et al. (2014)
	Institutional arrangement (IA)	Digital innovations developed in-house are coded as 1, whereas digital innovations developed in alliance are coded as 0.		Fichman et al. (2014); Borah and Tellis (2014)
	Innovation type (INNT) * Institutional arrangement (IA)	Interaction term between innovation type and institutional arrangement.		
Control variables	Radicalness (RAD)	Radical digital innovations are coded as 1, whereas incremental digital innovations are coded as 0.	+	Henderson (1993); Henderson and Clark (1990); Fichman (2004b)
	IT intensity (ITI)	All firms with SIC codes 4800-4899 (telecommunications), 6211-6799 (financial services) and 6000-6159 (banking institutions) are considered as having high IT intensity and coded as 1, whereas firms with one of the remaining SIC codes are considered as having low IT intensity and coded as 0.	+	Bharadwaj et al. (2009); Triche and Walden (2018)
	Firm size (FS)	Natural log-transformed number of employees _{<i>t</i>} , where <i>t</i> represents the fiscal year ending prior to the event date.	+	Bharadwaj et al. (1999); Kohli et al. (2012); Fichman (2004b)
	Firm growth (FG)	Percentage increase in sales from year _{<i>t-1</i>} to year _{<i>t</i>} , where <i>t</i> represents the fiscal year ending prior to the event date	+	Triche and Walden (2018); Bharadwaj et al. (2009)
	Region (REG)	All firms listed in Germany are coded as 1, whereas all firms listed in the USA are coded as 0.	-	Roztock (2012)
	Industry type (INDT)	All firms from the manufacturing sector (SIC code 10-39) are coded as 1, whereas firms from the service sector (SIC code 40-99) are coded as 0.	-	Bharadwaj et al. (2009)
	Time (TIME)	Year dummy variable		

Ensuring reliability in our content analysis and the subsequent coding of the independent variables (*innovation type* and *institutional arrangement*) as well as one control variable (*radicalness*), we asked another independent researcher familiar with the topic of digital innovation, but not involved in the research project, to code a

random sample of 50 announcements from our dataset. To assess the overall inter-rater reliability, we applied the Cohen's (1960) Kappa, which yielded a value of 0.81, indicating a high level of agreement and thus suggesting that the coding scheme appears to be very robust (Landis and Koch 1977). An overview of all announcements can be obtained from Appendix C.

Following hypothesis 2, we distinguished the *innovation type (INNT)* into digital process innovation and digital product innovation (Yoo et al. 2010; Fichman et al. 2014). Taking the perspective of a provider, a digital product innovation is the development or implementation of a new technology, product, service or business model aiming to increase revenue or market share of the respective firm. Taking the perspective of a user, digital process innovation is the development or implementation of a new process equipment, methods or procedures, aiming to increase efficiency and reduce costs.

With regard to hypothesis 3, the *institutional arrangement (IA)* is differentiated into the in-house development of a digital innovation and the alliance setting while developing a digital innovation (Borah and Tellis 2014; Fichman et al. 2014). A digital innovation is developed in-house in the own R&D department and thus lacks involvement of third-parties. However, many digital innovations are developed in alliance with other actors, thereby sharing knowledge, risk, and profits.

Accounting for hypothesis 4, we further built an interaction term of both previous independent variables *innovation type (INNT) * institutional arrangement (IA)* to find out how both independent variables are related and influence each other.

In addition, we used seven different firm- and industry-specific control variables related to digital innovation to account for the many different influencing factors that can affect abnormal returns. First, we included the variable *radicalness (RAD)* with which we distinguished into radical and incremental digital innovations (Yang et al. 2012; Henderson 1993). A radical innovation (1) replaces existing innovations or technologies or (2) improves existing products, services, or processes in a revolutionary manner, and (3) may have wide-ranging impact on the organizational structure, thereby offering tremendous revenue and profit growth options. In other words, it alters the core concepts of the product or service

(Henderson and Clark 1990)⁸. However, it may also increase the variance and uncertainty of digital innovation investments, as complementary changes to organizational structures, routines, and policies need to be made (Fichman 2004b). An incremental innovation rather builds on the continuous improvement of existing innovations and technologies. Therefore, radical digital innovations may have a more positive impact on the option value of digital innovation investments and subsequently the CARs than incremental digital innovations (Fichman 2004b).

Second, we included a variable of how intensive IT is used in the respective industry (Triche and Walden 2018; Bharadwaj et al. 2009). The IT intensity variable (ITI) thus represents the average IT spending per industry, assuming that companies with a high IT intensity may have advantages in exploiting the growth opportunities of real options for digital innovation investments, as digital-related innovation capabilities may be better developed or more advanced than in companies with a low IT intensity.

Third, we considered *firm size (FS)* by including the natural logarithm of the number of employees (Bharadwaj et al. 1999). The variable accounts for effects due to scale operation (Kohli et al. 2012) and the experience in developing innovations. We assume that the larger the firm, the higher is the expected return and thus the real option value and CARs. This is especially true, since larger firms may be better able to take large investments and exploit potential network effects associated with digital innovations (Fichman 2004b).

Fourth, we included *firm growth (FG)* (Bharadwaj et al. 2009; Triche and Walden 2018). Thereby, we considered the potential effect firms with high growth that may receive more attention and confidence by investors, assuming that digital innovation of fast-growing companies may exhibit greater network effects and higher

⁸ Due to simplicity reasons and lack of information, we only distinguish into incremental and radical innovations following established innovation literature (e.g., Dewar and Dutton 1986; Tushman and Anderson 1986). It is well within our awareness that Henderson and Clark (1990) formulate four different types of innovations: incremental, modular, architectural, and radical. They differentiate them first by their changes in core concepts and second by their changes in the links between core concepts and components. However, categorization into both variables is hardly possible with the information obtained from the announcements. Therefore, we focus on changes in core concepts, which are more observable than changes in the links between concepts and components, leading to the distinction between incremental and radical innovations mentioned earlier.

expected returns. This may lead to higher real option value and hence higher CARs than the ones from firms with rather low growth.

Fifth, we included *region (REG)* that distinguishes between the two different countries (Germany and USA) to account for potential differences in economy, culture and market potential (Roztocki 2012). In doing so, we assume that the environment with large tech companies in the U.S. may be more conducive to digital innovation and better helps unleash the full potential of digital innovations. Therefore, digital innovations from U.S. companies may lead to higher expected returns and managerial flexibility, thus to higher real option values and CARs than those from German companies. The variable further accounts for the potential language and stock exchange variances in our dataset.

Sixth, we constructed the dummy variable *industry type (INDT)*, in which we differentiated firms from the manufacturing and the service sector based on their SIC codes (Bharadwaj et al. 2009). Thereby, we assumed that firms from the service sector may generate higher CARs than from the manufacturing industry due to the fact that services are better transferable to and scalable in the digital age than physical products (Vendrell-Herrero et al. 2017), overall resulting in a higher expected returns and thus option value and CARs.

Finally, for the seventh variable, we considered potential time effects to account for learning effects and changing environments. The full regression formula reads accordingly:

$$CAR_{-2,2} = \beta_0 + \beta_1 INNT + \beta_2 IA + \beta_3 INNT * IA + \beta_4 RAD + \beta_5 ITI \quad (5)$$

$$+ \beta_6 FS + \beta_7 FG + \beta_8 REG + \beta_9 INDT + \beta_{10-16} TIME + \varepsilon$$

5. Empirical results

The summary statistics are exhibited in Table 6. Around 81% of the announcements are digital product innovations and 60% are developed in alliance with partners.

Table 6. Summary statistics.

Variable	Mean	Std. dev.	Min	Max
CAR	-0.0023	0.0011	-0.1834	0.1013
Innovation type (INNT) (H2)	0.8097	0.0163	0	1
Institutional arrangement (IA) (H3)	0.4048	0.0204	0	1
Radicalness (RAD)	0.7734	0.0174	0	1
IT intensity (ITI)	0.1626	0.0153	0	1
Firm size (FS)	11.0258	0.0719	6.1225	14.6484
Firm growth (FG)	0.0536	0.0047	-0.2209	0.6690
Region (REG)	0.5104	0.0208	0	1
Industry type (INDT)	0.4481	0.0207	0	1

Table 7 illustrates the Pearson correlation matrix. The highest average variance inflation factor (VIF) of our four regression models is 2.57, which is well below the multicollinearity problem threshold of 10 (Marquardt 1980; Yang et al. 2012). The results exhibit that the dependent variable CAR_i is correlated with the variables that measure *INNT* ($0.067, p < 0.1$), *RAD* ($0.072, p < 0.05$), *ITI* ($0.071, p < 0.05$), and *FS* ($0.112, p < 0.01$), providing a first indicator for the later regression results.

Table 7. Correlation matrix.

Variables	1	2	3	4	5	6	7	8	9
1 CAR	1.000								
2 INNT (H2)	0.067*	1.000							
3 IA (H3)	-0.040	-0.013	1.000						
4 RAD	0.072**	-0.189***	-0.294***	1.000					
5 ITI	0.071**	-0.025	-0.106***	0.059*	1.000				
6 FS	0.112***	-0.026	-0.087**	0.025	0.095**	1.000			
7 FG	-0.033	0.078**	0.087**	-0.102***	-0.019	-0.236***	1.000		
8 REG	-0.020	-0.043	-0.144***	0.181***	0.160***	-0.368***	0.080**	1.000	
9 INDT	0.033	-0.042	0.015	-0.027	-0.397***	-0.029	0.075**	0.020	1.000

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.001$ (one-tailed tests of significance)

In Table 8, we illustrate the results of estimating the cumulative average abnormal returns (CAAR) overall and per variable relevant to our hypotheses. Here, we do not specify the average abnormal returns (AAR) for the individual event days because we observed during our data sampling that announcements are often distributed across different media platforms with a delay of one or two days. The explanatory power of the AARs on the specific event days is therefore limited (Drechsler et al. 2019). Instead, we only report the CAARs over the event window for each variable. In doing so, we specifically follow the procedure of Yang et al. (2012) and Sabherwal and Sabherwal (2005) that also focused their analysis on event periods without reporting individual event days. In addition to information on the magnitude of CAARs in the

event period, we also provide the percentage of positive and negative CAARs in each subsample (McWilliams and Siegel 1997; Chatterjee et al. 2002).

Table 8. Estimated CAARs.

Variables	Coding categories	N	Mean CAAR [-2;2] (% pos., neg.)	Median CAAR [-2;2]	Brown and Warner t-test	Wilcoxon signed-rank test
Full sample	Digital innovation	578	-0.0023 (47, 53)	-0.0008	-1.95**	-1.60*
	Product	468	-0.0015 (49, 51)	-0.0004	-1.11	-0.68
Digital innovation type (INNT)	Process	110	-0.0058 (42, 58)	-0.0047	-2.21**	-2.49***
	In-house	234	-0.0036 (47, 53)	-0.0017	-1.96**	-1.48*
Institutional arrangement (IA)	Alliance	344	-0.0014 (48, 52)	-0.0006	-0.91	-0.83

*p<0.1, **p<0.05, ***p<0.001 (one-tailed tests of significance)

The results of the estimated CAARs show that capital market investors react significantly negatively to the announcement of digital innovations. The CAAR of the whole sample shows a significant negative value effect of -0.23% on the announcement of digital innovations. Taking a more differentiated look at the innovation type of digital innovation, digital process innovations in particular may drive the negative value effects, yielding a total of -0.47% and showing a 58% share of negative CAARs. When considering the institutional arrangement, the in-house development of digital innovations is also not perceived as adding value to the announcing company, which is reflected in a significant CAAR of -0.36% and a percentage of 53% that account for negative CAARs. For all variables, there are no differences in the results when considering the type of significance test (Brown and Warner t-test (parametric) vs Wilcoxon signed-rank test (non-parametric)), indicating that our results are not driven by outliers. In addition, we also replicated the results by performing two robustness checks with respect to a variation in the estimation period (120 to 200 trading days) and the benchmark index (national indices DAX30 and S&P500 to MSCI World) for the overall sample to increase the reliability of our results (see Table 9). Both robustness checks lead to almost the same negative results and significance levels, so that H1a can be clearly rejected and H1b confirmed.

Table 9. Robustness checks of full sample CAARs.

	Estimation period (-132 to -13)	Estimation period (-212 to -13)	Benchmark index (MSCI World)
CAAR	-0.0023	-0.0026	-0.0025
Brown and Warner t-test	-1.95**	-2.16**	-1.88**
Wilcoxon signed-rank test	-1.60*	-1.85**	-1.85**

*p<0.1, **p<0.05, ***p<0.001 (one-tailed tests of significance)

With respect to hypotheses 2 (innovation type), 3 (institutional arrangement), and 4 (interaction term), we ran an OLS regression to examine whether the first results in Table 8 remain robust when including the aforementioned control variables (see Table 10). We also ran the same regression with winsorized CARs at the 1% and 99% level, which produced very similar results, providing further confirmation that the results are not influenced by a few outliers (see Appendix D).

Both the coefficient of determination (R^2) and the adjusted R^2 range from 0.03 to 0.04 and 0.01 to 0.02, respectively. This is comparable to prior studies in the IS (Dehning et al. 2003; Dos Santos et al. 2012) and innovation field (Chaney et al. 1991; Sorescu et al. 2007; Sood and Tellis 2009). In addition, all models have significant F-statistics ($F = 2.10$ to 2.81), reflecting an effective model to explain CARs.

Overall, we created four different regression models, thereby following a procedure of adding step by step further variables to the initial regression model. Model 1 includes only the control variables, exhibiting that radical (*RAD*) innovations, firm from IT-intense (*ITI*) industries, large (*FS*) firms, or companies operating in the manufacturing sector (*INDT*) yield significant higher CARs than the respective other coding. Firm growth (*FG*) and region (*REG*) fail to exhibit significant results. In model 2, we added dummy variable innovation type (*INNT*) related to hypothesis 2, thereby showing that digital product innovations exhibit significantly higher CARs than digital process innovation. Model 3 additionally contains the variable institutional arrangement (*IA*) from hypothesis 3. However, the coefficient does not exhibit a significant difference between alliances and in-house developments of digital innovations.

Table 10. Regression results.

Variables	Model 1	Model 2	Model 3	Model 4
Constant	-0.0266** (-2.35)	-0.0329*** (-2.90)	-0.0334*** (-2.87)	-0.0317*** (-2.80)
H2: Innovation type (INNT)		0.0061*** (2.68)	0.0062*** (2.75)	0.0016 (0.62)
H3: Institutional arrangement (IA)			0.0004 (0.21)	-0.0085** (-1.80)
H4: Innovation type * Institutional arrangement (INNT * IA)				0.0112** (2.15)
Radicalness (RAD)	0.0039** (1.76)	0.0049** (2.16)	0.0051** (2.18)	0.0056** (2.37)
IT intensity (ITI)	0.0060** (2.23)	0.0062** (2.30)	0.0063** (2.32)	0.0060** (2.28)
Firm size (FS)	0.0015** (1.70)	0.0015** (1.76)	0.0015** (1.76)	0.0017** (1.85)
Firm growth (FG)	-0.0024 (-0.20)	-0.0036 (-0.30)	-0.0037 (-0.30)	-0.0032 (-0.26)
Region (REG)	-0.0006 (-0.34)	-0.0006 (-0.37)	-0.0006 (-0.34)	-0.0003 (-0.18)
Industry type (INDT)	0.0039** (1.69)	0.0042** (1.89)	0.0042** (1.90)	0.0039** (1.79)
Time dummy	Included	Included	Included	Included
R ²	0.03	0.04	0.04	0.04
Adjusted R ²	0.01	0.02	0.01	0.02
F-statistic (p-value)	2.10 (0.03)	2.81 (0.00)	2.60 (0.00)	2.45 (0.01)
Number of observations	578	578	578	578

Notes. Variables are defined in detail in section 4.6 and Table 5. Dependent variable CAR. t-statistic is shown in parentheses *p<0.1, **p<0.05, ***p<0.001 (one-tailed tests of significance); linear OLS regression with robust standard errors, clustered by firms

In the last model 4, we further included the interaction term between *INNT* and *IA*. The results here are interesting in two respects. First, the interaction term itself is significant, showing that *IA* moderates the relationship between *INNT* and CARs. Second, the main effect of innovation type vanishes to insignificance, while institutional arrangement shifts toward a significant coefficient. Therefore, when including potential interaction effects and all other variables, hypothesis 2 must be rejected. There are no significant differences in value effects between digital product and digital process innovations. Thereby, hypothesis 3 can be supported, showing that in-house developments of digital innovations exhibit a significant decline in the value effect compared to alliances. With regard to hypothesis 4, it can be confirmed that the institutional arrangement type moderates the relationship between innovation type and market value. Table 11 and Figure 3 illustrate that digital process innovations developed in-house have a significant additional negative CAR of -1.23% compared to all other announcements. Digital process innovations developed in alliances still exhibit additional negative CARs of -0.38%, but compared to in-house developed

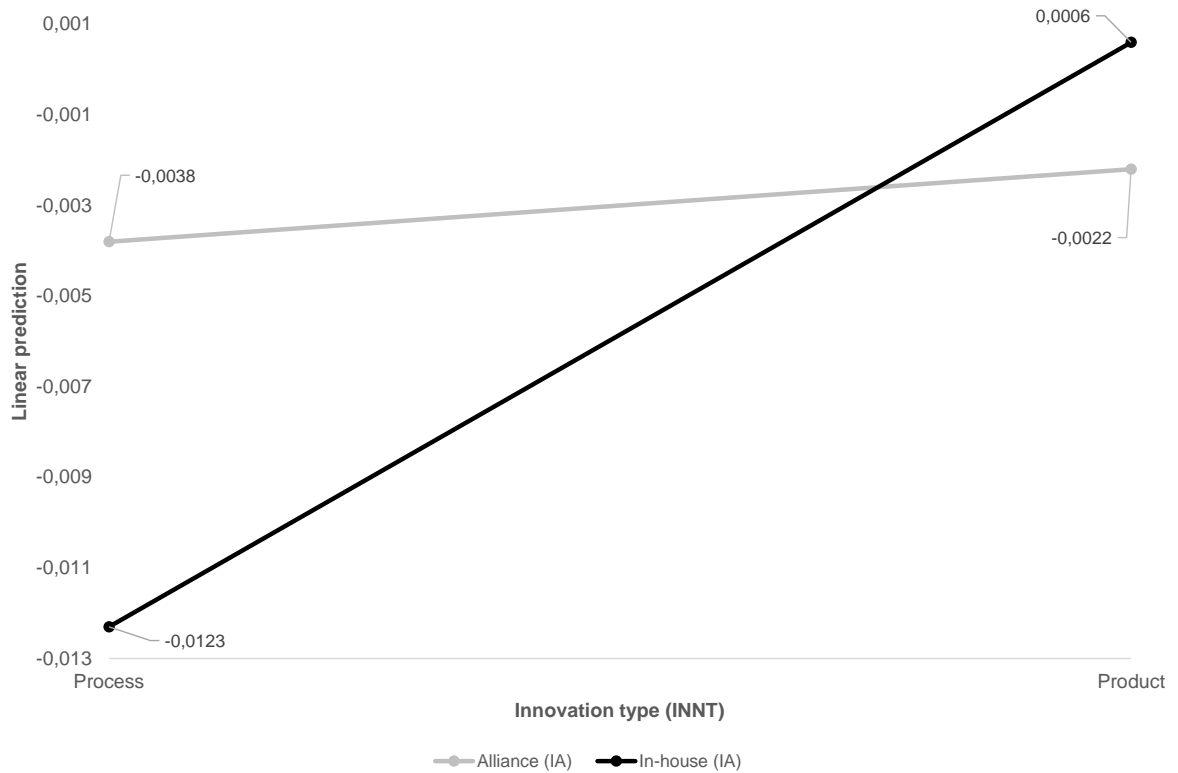
digital process innovations, the negative CAR is significantly lower. Digital product innovations exhibit an additional significantly negative CAR when developed in an alliance.

Table 11. Margins of interaction variable.

Coding	Margin	t-value
Digital process innovation in alliance (INNT = 0; IA = 0)	-0.0038**	-1.86
Digital process innovation in in-house development (INNT = 0; IA = 1)	-0.0123***	-3.05
Digital product innovation in alliance (INNT = 1; IA = 0)	-0.0022*	-1.46
Digital product innovation in in-house development (INNT = 1; IA = 1)	0.0006	0.34

*p<0.1, **p<0.05, ***p<0.001 (one-tailed tests of significance)

Figure 3. Predictive margins of interaction variable with 95% confidence intervals.



Overall, the institutional arrangement plays a more decisive role for investors in assessing the potential future cash flows of digital innovations than the innovation type. However, the innovation type matters when it comes to which institutional arrangement to choose for which innovation type. In essence, digital process

innovations are better developed in alliances, while digital product innovations are better developed in-house.

6. Discussion and implications

In the following, we discuss the results of our study and its implications for academia, using the two guiding research questions as an organizing structure. Subsequently, we point out important implications for practice and the study's limitations that should to be addressed by future research.

6.1 Implications for academia

RQ 1: What effect do digital innovation announcements have on the market value of firms?

In the IS and innovation literature, there is an increasing interest in the methodological instrument of an event study (Wang and Ngai 2020). However, previous event studies have largely ignored the emergence of digital innovations, focusing instead on innovation activities in general while generating inconclusive results (Konchitchki and O'Leary 2011; Sorescu et al. 2017). By building on real options and extending RBV theory, we extend existing IS and innovation research by shedding light on the particularly uncertain and dynamic period of the initial years of Industry 4.0 and examining digital innovation announcements through event study research. Thereby, we specifically follow the call of Fichman (2004b) for more research using the aforementioned theories. Our results show that, on average, digital innovation announcements lead to significant negative abnormal returns, thus diminishing the market value of firms. This is surprising, since prior qualitative research emphasizes the expected positive implications of digital innovations on the overall firm performance (Fichman et al. 2014; Parker et al. 2016). Instead, investors seem to be skeptical about the future cash-flows of digital innovations. However, it is important to note that the generally negative reaction to digital innovation announcements does not necessarily mean that the digital innovation will not be a source of positive cash-flows (Sorescu et al. 2017); it is rather the collective opinion of investors that relates to the unmet expectations and uncertainty associated with

successfully implementing and bringing digital innovations to market (Warren and Sorescu 2017; Oler et al. 2008). In short, investors may be anticipating the return of the modern Solow Paradox with regard to digital innovations, at least under certain circumstances. But when and why do investors perceive this way?

Potential explanations could be that investors on average simply may not have the confidence in companies developing digital innovations in the early stages of the Industry 4.0 movement we studied from 2011 to 2016. Many of the digital technologies underlying the digital innovations may not have been mature and robust enough in this phase. In addition, there is a lack of the necessary digital knowledge and skills at the employee and manager level, meaning that use cases associated with digital innovations may not yet have unleashed their full value potential (Benitez et al. 2020). This mismanagement may lead to adaptation delays and time lags in the positive impact of digital innovation on productivity, profitability and cash flow (Schweikl and Obermaier 2020). Investors may therefore consider a discount when investing in companies developing digital innovations.

However, our results do not only provide some support for the findings from previous research on the revival of the modern Solow Paradox (Schweikl and Obermaier 2020), but also extend them by considering firm- and industry-specific factors, thereby painting a more nuanced picture in a threefold way. First, our study shows that firms with high IT intensity exhibit higher abnormal returns than firms with low IT intensity. In the first half of Industry 4.0, it seems that the more the firms invest into IT the better. High initial investments into IT and thus into digital innovation are simply necessary to build the foundation on which further digital innovations can be developed, specifically when it comes to digital process innovations. This is also in line with real options theory, which emphasizes the importance of fundamental initial digital innovations, on which further digital innovations with high growth potential can be developed (Fichman 2004b). An initially high IT intensity seems therefore to be associated with better capabilities in exploiting digital innovations.

Second, our study's results show that the same applies to firm size: the bigger the better. Larger companies are simply better able to invest a significant investment amount due to their richer body of resources that may reach a certain threshold

needed to assume effects on the future cash-flows. This also applies to the acquisition of critical resources necessary for the development of digital innovations, such as end-user interaction or data access. After all, the larger the company, the better it is able to acquire such critical resources and the more power it can potentially exercise over other actors (Mosch et al. 2021). The danger of over-investment does not yet seem to be an issue for investors. Instead, following the narrative built by the political actors to invest into digital innovation, e.g., through the initiatives “Industrie 4.0” or “Industrial Internet Consortium”, seemed to be favorable for large firms from the perspective of investors, at least in the investigated time period.

Third, our results show interesting nuances in the industry types. The manufacturing industry exhibits higher abnormal returns than service industry. This was not expected, as previous studies state that the service industry may be better positioned in the digital age due to its better transferability to digital offerings and higher scalability (Vendrell-Herrero et al. 2017). However, the implications of Industry 4.0 specifically in the initial years are unequally higher for manufacturing industries, since their value creation traditionally took place in the physical world (Yoo et al. 2010). Therefore, investors may value digital innovation announcements by manufacturing companies at higher premiums, as their potential competitive advantage over rivals may be greater than for service sector companies.

RQ 2: To what extent do innovation and institutional arrangement types influence the market value effect of digital innovation announcements and how do they interact?

Examining the type of digital innovation and institutional arrangement as event-specific information, we generate additional important implications for existing event study research in IS and innovation literature.

First, we find that the type of innovation alone does not influence the market value effect of digital innovation announcements. Interestingly, the higher abnormal return of radical digital innovations remains significant in Model 4. Thus, it does not seem to make a difference whether a company develops a digital process or a digital product innovation, but how radical the digital innovation is. In the initial phase of Industry 4.0, investors seem to prefer digital innovations that not only digitally enrich

and gradually improve existing products and services, but rather create new product and service categories and are capable of changing entire organizational structures (Henderson 1993). This adds to the recent research call by Lee et al. (2020), who demand more insights into how radicalness of innovations influences firm performance. Additionally, and more importantly, investors consider the nature of the institutional arrangement as more critical to the success of digital innovation. Alliances are found to generate higher market value in the development of digital innovations than in-house developments. The sharing of knowledge and risks while developing digital innovations significantly have the potential to reduce the overall negative market reaction of investors to digital innovation announcements. This finding adds to a rich body of qualitative research regarding the increasing importance of alliances in the digital age (Pagani and Pardo 2017). It is important to note that previous event studies examining non-digital innovations already point to the fact that alliances generate higher abnormal returns (Das et al. 1998; Oxley et al. 2009). In the same respect, Borah and Tellis (2014), who examine different types of institutional arrangements, view alliances as market value adding. However, they cannot show differences between alliances and in-house developments. Based on the significant difference between the two institutional arrangement types in our study, we therefore conclude that the importance of alliances, and thus the value gap between them and in-house developments, is increasing in the digital age. Finally, network resources that span enterprise boundaries play a critical role in scaling digital innovations and realizing profits from them by creating entire innovation ecosystems (Benitez et al. 2020; Mosch et al. 2021). In doing so, we complement the statement of the study by Sorescu and Schreier (2021), who emphasize that digital innovations are not only about what is offered, but how, by showing that it is also important in which setting they are developed.

Second, we discover a strong interaction effect between the type of innovation and institutional arrangement. In other words, the institutional arrangement significantly moderates the relationship between innovation type and market value. This finding is specifically valuable, since – to the best of our knowledge – previous event studies investigate only one specific innovation type or focus on institutional arrangements without considering different innovation types. Here, the type of digital

innovation comes into play again, as our study uncovers that digital process innovations are better developed in alliance and digital product innovations in-house. It seems that the complexity and scalability hurdles of digital process innovations can be managed much better in alliances, especially in the first half of the Industry 4.0 from 2011 onwards. The lack of knowledge and experience regarding the successful implementation of digital process innovations simply makes alliances indispensable. Since process innovations are seen as crucial to develop new products and business models due to their fundamental nature (Oke 2007), digital process innovations may appear as the driving force of digital product innovations. Thereby, we argue in a similar vein such as Gunday et al. (2011) that find that the higher the level of process innovation, the higher the level of product innovation. The success of digital product innovations may therefore considerably depend on the successful implementation of digital process innovations. This also links to our finding that digital product innovations are better developed in-house. Finally, the formation of alliances in the development of digital process innovations establishes knowledge and important tools that can be applied to the development of digital product innovations, assigning alliances a more marginal and less valuable character in this respect. More importantly, however, digital product innovations in particular require mutual trust between potential development partners, as processes need to be aligned, customer channels defined, and revenue-sharing agreements reached (Mosch et al. 2021). Such time-consuming process tends to drive companies toward the in-house development of initial digital product prototypes and pilot projects rather than the complex arrangement of alliances in the early stages of Industry 4.0. Ultimately, appropriation of value creation works better when proprietary knowledge is not shared or licensed (Barney 1991), making the creation of network effects and monopolistic markets that often occur in digital environments more feasible and likely. Overall, we provide crucial contextualization and explicit recommendation regarding which digital innovation type should be developed in which institutional arrangement. In doing so, we add to the dispersed knowledge in existing event studies that separately investigate (digital) innovation or institutional arrangement types (Borah and Tellis 2014; Sood and Tellis 2009; Yang et al. 2012) and contribute to dampening the

overall negative market value effects of digital innovations in the uncertain and dynamic first half of Industry 4.0.

6.2 Implications for practice

The path of Industry 4.0 and the successful development of digital innovations can be rocky and arduous for managers, especially when taking the first steps. Our results reinforce this view by showing an average negative reaction to the announcement of digital innovations. However, managers can dampen this negative effect and draw much more nuanced lessons from our study, as it states that small businesses with low IT intensity or service businesses should extend their digital innovation real option's waiting period or deliberately work toward more favorable circumstances (e.g., increase IT-intensity). In this regard, our study offers them a quantitatively oriented and comprehensive guide to where they should go and how they can achieve it. Executives may find it particularly useful to learn that the type of digital innovation only matters when it comes to how it should be developed: digital process innovations are better developed in alliances, while digital product innovations are better developed in-house. In short, it's not what you do, but how you do it that matters. For companies that are in the early stages of considering how to approach the Industry 4.0 of their business, our insights can be valuable in helping them align and combine their digital innovation and alliance strategies.

6.3 Limitations and future research

Although we are deeply convinced that our event study adds valuable insights to academia and practice, it is not without limitations. First, due to the nature of an event study, our dataset includes only publicly traded companies. However, this excludes many other companies that have important functions in the digital transformation of value creation systems, so the insights are somewhat limited to listed companies. We therefore recommend conducting empirical studies that use financial performance measures such as EBIT as the dependent variable to include unlisted companies and, in doing so, also better understand the potential realized profits of digital innovations after the initial phase we studied. Second, our dataset is limited to the countries

Germany and the USA. Although both countries play a leading role in the development of digital innovations, other important geographic contexts with special circumstances (e.g., China) remain unconsidered. Therefore, we believe additional event studies including other countries would be fruitful to achieve better transferability and generalization of our results. Third, the study only covers investors' short-term reaction to digital innovations in the first half of Industry 4.0, which may paint an incomplete picture. Thus, most importantly, we urge researchers to conduct event studies that focus specifically on the second half of Industry 4.0. Extending the period studied to subsequent years and comparing the results allows for a dynamic view in terms of context and time, ultimately leading to a better understanding of the complex topic of digital innovation in all its colors.

References

- Agrawal, Ajay; McHale, John; Oettl, Alexander (2019): Finding Needles in Haystacks: Artificial Intelligence and Recombinant Growth. In Ajay Agrawal, Joshua Gans, Avi Goldfarb (Eds.): *The Economics of Artificial Intelligence: An Agenda*. Chicago: University of Chicago Press, pp. 149–174.
- Amram, Martha; Kulatilaka, Nalin (1999): *Real options: Managing strategic investment in an uncertain world*. Boston: Harvard Business School Press.
- Argenton, Cédric; Prüfer, Jens (2012): Search engine competition with network externalities. In *Journal of Competition Law and Economics* 8 (1), pp. 73–105.
- Ball, Ray; Brown, Philip (1968): An empirical evaluation of accounting income numbers. In *Journal of Accounting Research* 6 (2), pp. 159–178.
- Barney, Jay (1991): Firm resources and sustained competitive advantage. In *Journal of Management* 17 (1), pp. 99–120.
- Bastin, Veronique; Hübner, Georges (2006): Concentrated announcements on clustered data: an event study on biotechnology stocks. In *Financial Management* 35 (1), pp. 129–157.
- Benitez, Guilherme Brittes; Ayala, Néstor Fabián; Frank, Alejandro G. (2020): Industry 4.0 innovation ecosystems: An evolutionary perspective on value cocreation. In *International Journal of Production Economics* 228, in press.
- Bharadwaj, Anandhi; El Sawy, Omar A.; Pavlou, Paul A.; Venkatraman, N. v. (2013): Digital business strategy: toward a next generation of insights. In *MIS Quarterly* 37 (2), pp. 471–482.
- Bharadwaj, Anandhi; Keil, Mark; Mähring, Magnus (2009): Effects of information technology failures on the market value of firms. In *The Journal of Strategic Information Systems* 18 (2), pp. 66–79.
- Bharadwaj, Anandhi S.; Bharadwaj, Sundar G.; Konsynski, Benn R. (1999): Information technology effects on firm performance as measured by Tobin's q. In *Management Science* 45 (7), pp. 1008–1024.
- Borah, Abhishek; Tellis, Gerard J. (2014): Make, buy, or ally? Choice of and payoff from announcements of alternate strategies for innovations. In *Marketing Science* 33 (1), pp. 114–133.
- Brown, Stephen J.; Warner, Jerold B. (1985): Using daily stock returns: The case of event studies. In *Journal of Financial Economics* 14 (1), pp. 3–31.
- Brückner, Roman (2013): *Important characteristics, weaknesses and errors in German equity data from Thomson Reuters Datastream and their implications for the size effect*. University of Mannheim (Working Paper).
- Brynjolfsson, Erik; Rock, Daniel; Syverson, Chad (2019): Artificial Intelligence and the Modern Productivity Paradox: A Clash of Expectations and Statistics. In Ajay Agrawal, Joshua Gans, Avi Goldfarb (Eds.): *The Economics of Artificial Intelligence: An Agenda*. Chicago: University of Chicago Press, pp. 23–57.

- Brynjolfsson, Erik; Rock, Daniel; Syverson, Chad (2021): The productivity J-curve: How intangibles complement general purpose technologies. In *American Economic Journal: Macroeconomics* 13 (1), pp. 333–372.
- Burmeister, Christian; Lüttgens, Dirk; Piller, Frank T. (2016): Business Model Innovation for Industrie 4.0: Why the 'Industrial Internet' Mandates a New Perspective on Innovation. In *Die Unternehmung* 70 (2), pp. 124–152.
- Campbell, Cynthia J.; Cowan, Arnold R.; Salotti, Valentina (2010): Multi-country event-study methods. In *Journal of Banking & Finance* 34 (12), pp. 3078–3090.
- Chan, Louis K. C.; Lakonishok, Josef; Sougiannis, Theodore (2001): The stock market valuation of research and development expenditures. In *The Journal of Finance* 56 (6), pp. 2431–2456.
- Chaney, Paul K.; Devinney, Timothy M.; Winer, Russell S. (1991): The impact of new product introductions on the market value of firms. In *Journal of Business* 64 (4), pp. 573–610.
- Chatterjee, Debabroto; Pacini, Carl; Sambamurthy, Vallabh (2002): The shareholder-wealth and trading-volume effects of information-technology infrastructure investments. In *Journal of Management Information Systems* 19 (2), pp. 7–42.
- Chen, Min; Mao, Shiwen; Liu, Yunhao (2014): Big data: A survey. In *Mobile Networks and Applications* 19 (2), pp. 171–209.
- Ciriello, Raffaele Fabio; Richter, Alexander; Schwabe, Gerhard (2018): Digital innovation. In *Business & Information Systems Engineering* 60 (6), pp. 563–569.
- Cohen, Jacob (1960): A coefficient of agreement for nominal scales. In *Educational and Psychological Measurement* 20 (1), pp. 37–46.
- Cohen, Wesley M.; Klepper, Steven (1996): Firm size and the nature of innovation within industries: the case of process and product R&D. In *Review of Economics and Statistics* 78 (2), pp. 232–243.
- Das, Somnath; Sen, Pradyot K.; Sengupta, Sanjit (1998): Impact of strategic alliances on firm valuation. In *Academy of Management Journal* 41 (1), pp. 27–41.
- Dehning, Bruce; Richardson, Vernon J. (2002): Returns on investments in information technology: A research synthesis. In *Journal of Information Systems* 16 (1), pp. 7–30.
- Dehning, Bruce; Richardson, Vernon J.; Zmud, Robert W. (2003): The value relevance of announcements of transformational information technology investments. In *MIS Quarterly* 27 (4), pp. 637–656.
- Dewan, Sanjeev; Ren, Fei (2007): Risk and return of information technology initiatives: Evidence from electronic commerce announcements. In *Information Systems Research* 18 (4), pp. 370–394.
- Dewar, Robert D.; Dutton, Jane E. (1986): The adoption of radical and incremental innovations: An empirical analysis. In *Management Science* 32 (11), pp. 1422–1433.

- Ding, Li; Lam, Hugo K. S.; Cheng, T. C.E.; Zhou, Honggeng (2018): A review of short-term event studies in operations and supply chain management. In *International Journal of Production Economics* 200, pp. 329–342.
- Dos Santos, Brian L.; Peffers, Ken; Mauer, David C. (1993): The impact of information technology investment announcements on the market value of the firm. In *Information Systems Research* 4 (1), pp. 1–23.
- Dos Santos, Brian L.; Zheng, Zhiqiang; Mookerjee, Vijay S.; Chen, Hongyu (2012): Are new IT-enabled investment opportunities diminishing for firms? In *Information Systems Research* 23 (2), pp. 287–305.
- Doukas, John; Switzer, Lorne (1992): The stock market's valuation of R&D spending and market concentration. In *Journal of Economics and Business* 44 (2), pp. 95–114.
- Drechsler, Katharina; Wagner, Heinz-Theo; Reibenspiess, Victoria Alexandra (2019): Risk and return of chief digital officers' appointment—An event study. In *Proceedings of the 40th International Conference on Information Systems*, pp. 1-17.
- Dreyer, Dirk (2004): Realloptionsansatz zur Bewertung von personalintensiven Dienstleistungsunternehmen. In Dirk Dreyer (Ed.): *Bewertung personalintensiver Dienstleistungsunternehmen. Die Integration von Intellektuellem Kapital in die Unternehmensbewertung*. Wiesbaden: Springer, pp. 228–278.
- Dyer, Jeffrey H.; Kale, Prashant; Singh, Harbir (2004): When to ally and when to acquire. In *Harvard Business Review* 82, pp. 108-115.
- Dyer, Jeffrey H.; Singh, Harbir (1998): The relational view: Cooperative strategy and sources of interorganizational competitive advantage. In *Academy of Management Review* 23 (4), pp. 660–679.
- Eberhart, Allan C.; Maxwell, William F.; Siddique, Akhtar R. (2004): An examination of long-term abnormal stock returns and operating performance following R&D increases. In *The Journal of Finance* 59 (2), pp. 623–650.
- Eddy, Albert R.; Saunders, George B. (1980): New product announcements and stock prices. In *Decision Sciences* 11 (1), pp. 90–97.
- Fama, Eugene F. (1970): Efficient Capital Markets: A Review of Theory and Empirical Work. In *Journal of Finance* 25 (2), pp. 383–417.
- Fama, Eugene F. (1991): Efficient Capital Markets: II. In *Journal of Finance* 46 (5), pp. 1575–1617.
- Fama, Eugene F.; Fisher, Lawrence; Jensen, Michael; Roll, Richard (1969): The adjustment of stock prices to new information. In *International Economic Review* 10 (1), pp. 1-21.
- Fichman, Robert G. (2004a): Going beyond the dominant paradigm for information technology innovation research: Emerging concepts and methods. In *Journal of the Association for Information Systems* 5 (8), pp. 341-355.

- Fichman, Robert G. (2004b): Real options and IT platform adoption: Implications for theory and practice. In *Information Systems Research* 15 (2), pp. 132–154.
- Fichman, Robert G.; Dos Santos, Brian L.; Zheng, Zhiqiang (2014): Digital innovation as a fundamental and powerful concept in the information systems curriculum. In *MIS Quarterly* 38 (2), pp. 329-A15.
- Gebauer, Heiko; Paiola, Marco; Saccani, Nicola; Rapaccini, Mario (2021): Digital servitization: Crossing the perspectives of digitization and servitization. In *Industrial Marketing Management* 93, pp. 382-388.
- Geyskens, Inge; Gielens, Katrijn; Dekimpe, Marnik G. (2002): The market valuation of internet channel additions. In *Journal of Marketing* 66 (2), pp. 102–119.
- Goldstein, James; Chernobai, Anna; Benaroch, Michel (2011): An event study analysis of the economic impact of IT operational risk and its subcategories. In *Journal of the Association for Information Systems* 12 (9), pp. 606-631.
- Gunday, Gurhan; Ulusoy, Gunduz; Kilic, Kemal; Alpkan, Lutfihak (2011): Effects of innovation types on firm performance. In *International Journal of Production Economics* 133 (2), pp. 662–676.
- Hauser, John; Tellis, Gerard J.; Griffin, Abbie (2006): Research on innovation: A review and agenda for marketing science. In *Marketing Science* 25 (6), pp. 687–717.
- Hayes, David C.; Hunton, James E.; Reck, Jacqueline L. (2001): Market reaction to ERP implementation announcements. In *Journal of Information Systems* 15 (1), pp. 3–18.
- Henderson, Rebecca (1993): Underinvestment and incompetence as responses to radical innovation: Evidence from the photolithographic alignment equipment industry. In *The RAND Journal of Economics* 24 (2), pp. 248–270.
- Henderson, Rebecca M.; Clark, Kim B. (1990): Architectural innovation: The reconfiguration of existing product technologies and the failure of established firms. In *Administrative Science Quarterly* 35 (1), pp. 9–30.
- Hendricks, Kevin B.; Singhal, Vinod R. (2003): The effect of supply chain glitches on shareholder wealth. In *Journal of Operations Management* 21 (5), pp. 501–522.
- Hommel, Ulrich; Pritsch, Gunnar (1999): Marktorientierte Investitionsbewertung mit dem Realloptionsansatz: Ein Implementierungsleitfaden für die Praxis. In *Finanzmarkt and Portfolio Management* 13 (2), pp. 121–144.
- Im, Kun Shin; Dow, Kevin E.; Grover, Varun (2001): A reexamination of IT investment and the market value of the firm—An event study methodology. In *Information Systems Research* 12 (1), pp. 103–117.
- Ince, Ozgur S.; Porter, R. Burt (2006): Individual equity return data from Thomson Datastream: Handle with care! In *Journal of Financial Research* 29 (4), pp. 463–479.

- Kagermann, Henning; Anderl, Reiner; Gausemeier, Jürgen; Schuh, Günther; Wahlster, Wolfgang (2016): *Industrie 4.0 im globalen Kontext: Strategien der Zusammenarbeit mit internationalen Partnern*. München: Herbert Utz Verlag.
- Kagermann, Henning; Lukas, Wolf-Dieter; Wahlster, Wolfgang (2011): Industrie 4.0: Mit dem Internet der Dinge auf dem Weg zur 4. industriellen Revolution. In *VDI Nachrichten* 13 (1), pp. 2–3.
- Kling, Gerhard; Ghobadian, Abby; O'Regan, Nicholas (2009): Organic growth and shareholder value: A case study of the insurance industry. In *International Journal of Research in Marketing* 26 (4), pp. 276–283.
- Kohli, Rajiv; Devaraj, Sarv; Ow, Terence T. (2012): Does information technology investment influence a firm's market value? A case of non-publicly traded healthcare firms. In *MIS Quarterly* 36 (4), pp. 1145–1163.
- Kohli, Rajiv; Melville, Nigel P. (2019): Digital innovation: A review and synthesis. In *Information Systems Journal* 29 (1), pp. 200–223.
- Konchitchki, Yaniv; O'Leary, Daniel E. (2011): Event study methodologies in information systems research. In *International Journal of Accounting Information Systems* 12 (2), pp. 99–115.
- Kumar, Ram L. (1999): Understanding DSS value: an options perspective. In *Omega* 27 (3), pp. 295–304.
- Landis, J. Richard; Koch, Gary G. (1977): The measurement of observer agreement for categorical data. In *Biometrics*, pp. 159–174.
- Lavie, Dovev (2006): The competitive advantage of interconnected firms: An extension of the resource-based view. In *Academy of Management Review* 31 (3), pp. 638–658.
- Lee, Byung Cheol; Moorman, Christine; Moreau, C. Page; Stephen, Andrew T.; Lehmann, Donald R. (2020): The past, present, and future of innovation research. In *Marketing Letters* 31, pp. 187–198.
- Lee, Ruby P.; Chen, Qimei (2009): The immediate impact of new product introductions on stock price: the role of firm resources and size. In *Journal of Product Innovation Management* 26 (1), pp. 97–107.
- Lee, Sang-Yong Tom; Lim, Kim Seng (2006): The impact of M&A and joint ventures on the value of IT and non-IT firms. In *Review of Quantitative Finance and Accounting* 27 (2), pp. 111–123.
- Liao, Yongxin; Deschamps, Fernando; Loures, Eduardo de Freitas Rocha; Ramos, Luiz Felipe Pierin (2017): Past, present and future of Industry 4.0-a systematic literature review and research agenda proposal. In: *International Journal of Production Research* 55 (12), pp. 3609–3629.
- Liao, Yongxin; Loures, Eduardo Rocha; Deschamps, Fernando; Brezinski, Guilherme; Venâncio, André (2018): The impact of the fourth industrial revolution: a cross-country/region comparison. In *Production* 28, pp. 1-18.

- MacKinlay, A. Craig (1997): Event studies in economics and finance. In *Journal of Economic Literature* 35 (1), pp. 13–39.
- Marquardt, Donald W. (1980): Comment: You should standardize the predictor variables in your regression models. In *Journal of the American Statistical Association* 75 (369), pp. 87–91.
- McWilliams, Abigail; Siegel, Donald (1997): Event studies in management research: Theoretical and empirical issues. In *Academy of Management Journal* 40 (3), pp. 626–657.
- Mosch, Philipp; Schweikl, Stefan; Obermaier, Robert (2021): Trapped in the supply chain? Digital servitization strategies and power relations in the case of an industrial technology supplier. In *International Journal of Production Economics* 236, in press.
- Mowery, David C.; Rosenberg, Nathan (1989): *Technology and the pursuit of economic growth*. New York: Cambridge University Press.
- Nambisan, Satish; Lyytinen, Kalle; Majchrzak, Ann; Song, Michael (2017): Digital Innovation Management: Reinventing innovation management research in a digital world. In *MIS Quarterly* 41 (1), pp. 223–238.
- Nordhaus, William D. (2021): Are we approaching an economic singularity? information technology and the future of economic growth. In *American Economic Journal: Macroeconomics* 13 (1), pp. 299–332.
- Obermaier, Robert (2019): Industrie 4.0 and Digitale Transformation als unternehmerische Gestaltungsaufgabe. In Robert Obermaier (Ed.): *Handbuch Industrie 4.0 and Digitale Transformation. Betriebswirtschaftliche, technische and rechtliche Herausforderungen*. Wiesbaden: Springer Gabler, pp. 3–46.
- Obermaier, Robert; Mosch, Philipp; Schweikl, Stefan (2021): Controlling der digitalen Transformation. Planung and Monitoring der Strategieumsetzung. In *Controlling - Zeitschrift für erfolgsorientierte Unternehmensführung* 33 (1), pp. 21–28.
- Obermaier, Robert; Wagenseil, Victoria (2019): Betriebswirtschaftliche Wirkungen digital vernetzter Fertigungssysteme—Eine Analyse des Einsatzes moderner Manufacturing-Execution-Systeme in der verarbeitenden Industrie. In Robert Obermaier (Ed.): *Handbuch Industrie 4.0 and Digitale Transformation. Betriebswirtschaftliche, technische and rechtliche Herausforderungen*. Wiesbaden: Springer Gabler, pp. 205–233.
- Oke, Adegoke (2007): Innovation types and innovation management practices in service companies. In *International Journal of Operations & Production Management* 27 (6), pp. 564–587.
- Oler, Derek K.; Harrison, Jeffrey S.; Allen, Mathew R. (2008): The danger of misinterpreting short-window event study findings in strategic management research: An empirical illustration using horizontal acquisitions. In *Strategic Organization* 6 (2), pp. 151–184.

- Osterloh, Margit; Rota, Sandra (2007): Open source software development—Just another case of collective invention? In *Research Policy* 36 (2), pp. 157–171.
- Oxley, Joanne E.; Sampson, Rachelle C.; Silverman, Brian S. (2009): Arms race or détente? How interfirm alliance announcements change the stock market valuation of rivals. In *Management Science* 55 (8), pp. 1321–1337.
- Pagani, Margherita; Pardo, Catherine (2017): The impact of digital technology on relationships in a business network. In *Industrial Marketing Management* 67, pp. 185–192.
- Park, Namgyoo K. (2004): A guide to using event study methods in multi-country settings. In *Strategic Management Journal* 25 (7), pp. 655–668.
- Park, Namgyoo K.; Mezias, John M.; Song, Jaeyong (2004): A resource-based view of strategic alliances and firm value in the electronic marketplace. In *Journal of Management* 30 (1), pp. 7–27.
- Parker, Geoffrey G.; van Alstyne, Marshall W.; Choudary, Sangeet Paul (2016): *Platform revolution: How networked markets are transforming the economy and how to make them work for you*. New York: WW Norton & Company.
- Peppard, Joe; Rylander, Anna (2006): From value chain to value network:: Insights for mobile operators. In *European Management Journal* 24 (2-3), pp. 128–141.
- Peterson, Pamela P. (1989): Event studies: A review of issues and methodology. In *Quarterly Journal of Business and Economics* 28 (3), pp. 36–66.
- Porter, Michael E.; Fuller, Mark B. (1986): Coalitions and global strategy from. In Michael E. Porter (Ed.): *Competition in Global Industries*. Boston: Harvard Business Press, pp. 315–344.
- Porter, Michael E.; Heppelmann, James E. (2014): How smart, connected products are transforming competition. In *Harvard Business Review* 92 (11), pp. 64–88.
- Raassens, Néomie; Wuyts, Stefan; Geyskens, Inge (2012): The market valuation of outsourcing new product development. In *Journal of Marketing Research* 49 (5), pp. 682–695.
- Rabetino, Rodrigo; Harmsen, Willem; Kohtamäki, Marko; Sihvonen, Jukka (2018): Structuring servitization-related research. In *International Journal of Operations & Production Management* 38 (2), pp. 350-371.
- Ranganathan, CVBC; Brown, Carol V. (2006): ERP investments and the market value of firms: Toward an understanding of influential ERP project variables. In *Information Systems Research* 17 (2), pp. 145–161.
- Rifkin, Jeremy (2014): *The Zero Marginal Cost Society: The Internet of Things, the Collaborative Commons, and the Eclipse of Capitalism*. New York: Palgrave Macmillan.
- Rothaermel, Frank; Hess, Andrew (2010): Innovation strategies combined. In *MIT Sloan Management Review* 51 (3), pp. 13-15.

- Roztocki, Narcyz (2012): Stock market reaction to information technology investments in the USA and Poland: a comparative event study. In *Proceedings of the 45th Hawaii International Conference on System Sciences 2012*, pp. 4868–4872.
- Roztocki, Narcyz; Weistroffer, Heinz Roland (2009): Event studies in information systems research: an updated review. In *Proceedings of the 15th Americas Conference on Information*, pp. 1–10.
- Sabherwal, Rajiv; Sabherwal, Sanjiv (2005): Knowledge management using information technology: Determinants of short-term impact on firm value. In *Decision Sciences* 36 (4), pp. 531–567.
- Sambamurthy, Vallabh; Bharadwaj, Anandhi; Grover, Varun (2003): Shaping agility through digital options: Reconceptualizing the role of information technology in contemporary firms. In *MIS Quarterly* 27 (2), pp. 237–263.
- Schweickl, Stefan; Obermaier, Robert (2020): Lessons from three decades of IT productivity research: towards a better understanding of IT-induced productivity effects. In *Management Review Quarterly* 70 (4), pp. 461–507.
- Shapiro, Carl; Varian, Hal R. (1999): *Information rules: a strategic guide to the network economy*. Boston: Harvard Business Press.
- Shieh, Gwopen; Jan, Show-Li; Randles, Ronald H. (2007): Power and sample size determinations for the Wilcoxon signed-rank test. In *Journal of Statistical Computation and Simulation* 77 (8), pp. 717–724.
- Solow, Robert (1987): *We'd better watch out*. New York Times. New York.
- Sood, Ashish; Tellis, Gerard J. (2009): Do innovations really pay off? Total stock market returns to innovation. In *Marketing Science* 28 (3), pp. 442–456.
- Sorescu, Alina; Schreier, Martin (2021): Innovation in the digital economy: a broader view of its scope, antecedents, and consequences. In *Journal of the Academy of Marketing Science* 49, pp. 627–631.
- Sorescu, Alina; Shankar, Venkatesh; Kushwaha, Tarun (2007): New product preannouncements and shareholder value: Don't make promises you can't keep. In *Journal of Marketing Research* 44 (3), pp. 468–489.
- Sorescu, Alina; Warren, Nooshin L.; Ertekin, Larisa (2017): Event study methodology in the marketing literature: an overview. In *Journal of the Academy of Marketing Science* 45 (2), pp. 186–207.
- Sorescu, Alina B.; Spanjol, Jelena (2008): Innovation's effect on firm value and risk: Insights from consumer packaged goods. In *Journal of Marketing* 72 (2), pp. 114–132.
- Strassmann, Paul (1997): Will big spending on computers guarantee profitability? In *Datamation* 43 (2), pp. 75–82.
- Su, Meng; Rao, Vithala R. (2010): New product preannouncement as a signaling strategy: An audience-specific review and analysis. In *Journal of Product Innovation Management* 27 (5), pp. 658–672.

- Subramani, Mani; Walden, Eric (2001): The impact of e-commerce announcements on the market value of firms. In *Information Systems Research* 12 (2), pp. 135–154.
- Sun, Mengqi (2018): *Businesses Predict Digital Transformation to Be Biggest Risk Factor in 2019. Board members and executives are particularly focused on potential operational risks.* Wall Street Journal. Available online at <https://www.wsj.com/articles/businesses-predict-digital-transformation-to-be-biggest-risk-factor-in-2019-1544005926?tesla=y>.
- Swanson, E. Burton (1994): Information systems innovation among organizations. In *Management Science* 40 (9), pp. 1069–1092.
- Tabrizi, Behnam; Lam, Ed; Girard, Kirk; Irvin, Vernon (2019): *Digital Transformation Is Not About Technology.* Harvard Business Review. Available online at <https://hbr.org/2019/03/digital-transformation-is-not-about-technology>.
- Taudes, Alfred; Feurstein, Markus; Mild, Andreas (2000): Options analysis of software platform decisions: A case study. In *MIS Quarterly* 24 (2), pp. 227–243.
- Tidd, Joe (2001): Innovation management in context: environment, organization and performance. In *International Journal of Management Reviews* 3 (3), pp. 169–183.
- Tilson, David; Lyytinen, Kalle; Sørensen, Carsten (2010): Research commentary—Digital infrastructures: The missing IS research agenda. In *Information Systems Research* 21 (4), pp. 748–759.
- Triche, Jason H.; Walden, Eric (2018): The Use of Impression Management Strategies to Manage Stock Market Reactions to IT Failures. In *Journal of the Association for Information Systems* 19 (4), pp. 333-357.
- Trigeorgis, Lenos (1993): Real options and interactions with financial flexibility. In *Financial Management* 22 (3), pp. 202–224.
- Tsai, Shih-Chuan (2001): Valuation of R&D and advertising expenditures. In *Journal of Contemporary Accounting* 2 (1), pp. 41–76.
- Tushman, Michael L.; Anderson, Philip (1986): Technological discontinuities and organizational environments. In *Administrative Science Quarterly* 31 (3), pp. 439–465.
- Utterback, James M.; Abernathy, William J. (1975): A dynamic model of process and product innovation. In *Omega* 3 (6), pp. 639–656.
- Vendrell-Herrero, Ferran; Bustinza, Oscar F.; Parry, Glenn; Georgantzis, Nikos (2017): Servitization, digitization and supply chain interdependency. In *Industrial Marketing Management* 60, pp. 69–81.
- Wang, Ping (2021): Connecting the Parts with the Whole: Toward an Information Ecology Theory of Digital Innovation Ecosystems. In *MIS Quarterly* 45 (1), pp. 397–422.

- Wang, Qian; Ngai, Eric W. T. (2020): Event study methodology in business research: a bibliometric analysis. In *Industrial Management & Data Systems* 120 (10), pp. 1863-1900.
- Wang, Quan; Li, Beibei; Singh, Param Vir (2018): Copycats vs. original mobile apps: A machine learning copycat-detection method and empirical analysis. In *Information Systems Research* 29 (2), pp. 273–291.
- Warren, Nooshin L.; Sorescu, Alina (2017): Interpreting the stock returns to new product announcements: How the past shapes investors' expectations of the future. In *Journal of Marketing Research* 54 (5), pp. 799–815.
- WEF (2019): *The Global Competitiveness Report 2019*. Edited by Klaus Schwab. World Economic Forum. Cologne.
- Wernerfelt, Birger (1984): A resource-based view of the firm. In *Strategic Management Journal* 5 (2), pp. 171–180.
- Wilcoxon, Frank (1945): Individual Comparisons by Ranking Methods. In *Biometrics* 1 (6), pp. 80–83.
- Yang, Sung-Byung; Lim, Jee-Hae; Oh, Wonseok; Animesh, Animesh; Pinsonneault, Alain (2012): Research note—Using real options to investigate the market value of virtual world businesses. In *Information Systems Research* 23 (3-part-2), pp. 1011–1029.
- Yoo, Youngjin; Boland Jr, Richard J.; Lyytinen, Kalle; Majchrzak, Ann (2012): Organizing for innovation in the digitized world. In *Organization Science* 23 (5), pp. 1398–1408.
- Yoo, Youngjin; Henfridsson, Ola; Lyytinen, Kalle (2010): Research commentary—the new organizing logic of digital innovation: an agenda for information systems research. In *Information Systems Research* 21 (4), pp. 724–735.
- Zmud, Robert W. (1982): Diffusion of modern software practices: influence of centralization and formalization. In *Management Science* 28 (12), pp. 1421–1431.
- ZoBell, Steven (2018): *Why Digital Transformations Fail: Closing The \$900 Billion Hole In Enterprise Strategy*. Forbes. Available online at <https://www.forbes.com/sites/forbestechcouncil/2018/03/13/why-digital-transformations-fail-closing-the-900-billion-hole-in-enterprise-strategy/?sh=4418e3f47b8b>.

Appendix

Appendix A.

Coding rules of the two independent variables (*INNT* and *IA*) and the control variable *RAD*.

Variable	Definition	Criteria	Examples (Keywords or cases)
Innovation type (INNT)	Type of digital innovation that is developed or implemented by the firm.	<p><i>Digital process innovation</i></p> <ul style="list-style-type: none"> - Digital innovation is developed and implemented in processes of each type of the respective company that publishes the announcement - Goal is to reduce costs, increase speed or improve overall efficiency and profitability - Perspective of the user of a digital innovation 	<p><i>Keywords</i></p> <p>Implementation, integration, efficiency, process improvement, optimization, process, factory, production</p> <p><i>Exemplary case from dataset</i></p> <p>Optimized packaging line to increase production efficiency in facility through data analysis (announcement #53).</p>
		<p><i>Digital product innovation</i></p> <ul style="list-style-type: none"> - Digital innovation is developed or launched as a new product or service by the company publishing the announcement, often involving the change of the respective business model - Goal is to increase sales, improve customer retention or enhance overall profitability - Perspective of the provider of a digital innovation 	<p><i>Keywords</i></p> <p>Launch, market, unveil, release, availability, service, product, customer, consumer, client</p> <p><i>Exemplary case from dataset</i></p> <p>Release of Connected Field Service solution for organizations seeking to provide maintenance services in the IoT era (announcement #8).</p>

(continued)

Variable	Definition	Criteria	Examples (Keywords or cases)
Institutional arrangement (IA)	Type of institutional arrangement in which the digital innovation is developed or implemented by the firm.	<p><i>In-house</i></p> <ul style="list-style-type: none"> - Digital innovation is developed within the R&D department of the firm that publishes the announcement - Exclusive provision or implementation of the digital innovation <p><i>Alliance</i></p> <ul style="list-style-type: none"> - Digital innovation is developed with at least one other party in cooperative setting by the company publishing the announcement - Knowledge and risk sharing as well as joint market penetration 	<p><i>Keywords</i></p> <p>Self-development, in-house, proprietary technology</p> <p><i>Exemplary case from dataset</i></p> <p>Announcement of a new self-developed platform that makes it easy for devices - cars, turbines, sensor grids, light bulbs, and more - to connect to services so that companies can store, process, analyze, and act on the volumes of data generated by connected devices on a global scale (announcement #55).</p> <p><i>Keywords</i></p> <p>Alliance, cooperation, collaboration, strategic alliance, agreement, joint development</p> <p><i>Exemplary case from dataset</i></p> <p>Implementation of secure industrial Internet-of-Things architecture together with different cooperation partners to connect people with all communications devices, creating of a unified emergency notification system (announcement #24).</p>

(continued)

Variable	Definition	Criteria	Examples (Keywords or cases)
Radicalness (RAD)	The extent of potential improvements in digital process or product innovations	<p><i>Radical</i></p> <ul style="list-style-type: none"> - Aim to replace existing products, services, processes or technologies or revolutionary improvements of existing products, services, processes or technologies - Often associated with wide-ranging effects on the organizational structure of the publishing firm <p><i>Incremental</i></p> <ul style="list-style-type: none"> - Aim to considerably improve existing products, services, processes or technology - Often emerging from regular product or process development 	<p><i>Keywords</i></p> <p>New category, first product generation, revolutionary</p> <p><i>Exemplary case from dataset</i></p> <p>New category of device designed around the topics of voice-“it’s always on”, hands-free, and fast-“just ask for information”, music, news, weather, and more that you can use from across the room and get instant answers (announcement #56).</p> <p><i>Keywords</i></p> <p>Upgrade, critical added feature, advancement</p> <p><i>Exemplary case from dataset</i></p> <p>Product builds on company’s enterprise networking expertise and existing Industrial Ethernet family of switches, delivering reliable and highly secure network connectivity to manufacturing equipment (announcement #171).</p>

Appendix B.

Search string in Lexis database.

1. Part HEADLINE	AND	2. Part HLEAD (OR)	3. Part NOT (OR)		
Company name		Big Data Digitalisierung Digitalization Digitalisation Digitization Digitisation Digital Technology Internet der Dinge Internet of Things Internet of Everything IoT Industrie 4.0 Industry 4.0 Industrial Internet Smart Manufacturing Advanced Manufacturing Web-Connected Manufacturing Web Connected Manufacturing Machine to Machine Machine-to-Machine M2M Automation Industrial Automation Intelligente Fabrik Smarte Fabrik	Smart Factory Smarte Produktion Intelligente Produktion Smart Production Smart Objects Smart Things Smart Device Intelligent Production Networked Production Network Connected Production Network-Connected Production Network Connected Devices Network-Connected Devices Cyber-physische Systeme Cyber-Physical Systems Cyber-Physical-Systems Cyber Physical Systems Cloud MES Manufacturing Execution System Fog Computing Industrial IT Internet Industry Robotik Robotics	Jahresabschluss Annual Accounts Ergebnis I/3 Quartal! Result I/3 Quarterly! Figures I/3 Quarterly Geschäftszahlen Business Figures Geschäftsbericht Annual Report Financial Statement Quartalszahlen Quarterly Figures Quartalsberich Quarterly Result Zwischenergebnis Intermediate Result Zwischenbericht Interim Report Halbjahresbericht Half-Year Report Semi-Annual Report Vorläufige! Zahlen Preliminary Figures Kaufempfehlung Buy Recommendation	Hold Buy Sell Wechsel im Vorstand Change within the Board Vorstandswechsel Change of the Board Änderung im Vorstand Change in the Board

Appendix C.

Overview of all announcements.

No.	Company name	Title of announcement
1	Apple Inc.	Project Titan: Apple to rival Google with smart car
2	Apple Inc.	Apple to launch HomeKit smart-home devices in June
3	Apple Inc.	Apple unveils details about Apple Watch and latest MacBook
4	Apple Inc.	Apple and IBM Deliver First Wave of IBM MobileFirst for iOS solutions
5	Apple Inc.	Apple's iOS 7 and OS X Mavericks API details reveal notification center support coming to Bluetooth enabled smart device
6	Apple Inc.	Apple makes move to digitalize academic learning
7	Microsoft Corp.	Microsoft Previews Common Data Model for Workflow Automation
8	Microsoft Corp.	Microsoft Sets the Stage for IoT-Enabled CRM
9	Microsoft Corp.	Microsoft, Samsung, Intel unite in smart home alliance
10	Microsoft Corp.	Samsung and Microsoft partner to sync IoT with real life
11	Microsoft Corp.	Microsoft Reportedly Partners with Jasper to Launch New IoT Services
12	Microsoft Corp.	Canonical teams with Microsoft, DataArt, GE and Acer on Ubuntu-based IoT products
13	Microsoft Corp.	Microsoft Widens IoT Net in ConnectTheDots.io
14	Microsoft Corp.	Microsoft's Big Data Cloud Broadens Support
15	Microsoft Corp.	Microsoft leaks its own new fitness band and health software
16	Microsoft Corp.	Microsoft Unleashes Apache Storm on Its Analytics Cloud
17	Microsoft Corp.	Microsoft gives peek at coming Windows 10 software
18	Microsoft Corp.	Microsoft delivers data platform for the era of ambient intelligence
19	Microsoft Corp.	Microsoft opens car tech centre
20	Microsoft Corp.	Microsoft's Siri based on Halo's Cortana
21	Johnson & Johnson Corp.	Johnson & Johnson overhauls office automation with Oxbow and Bytes Document Solutions
22	Johnson & Johnson Corp.	Google and Johnson & Johnson partner up for hi-tech surgery
23	Berkshire Hathaway Inc.	Realtors First to Deploy Real Estate's Most Advanced Automated Marketing System
24	Chevron Corp.	Chevron Nigeria Protects Personnel and Strengthens Escravos Plant Security With Networked Crisis Communication Platform
25	Chevron Corp.	Chevron uses Big Data to cut exploration costs
26	Wells Fargo Corp.	Commonwealth Bank and Wells Fargo claim first interbank blockchain trade
27	Alphabet Inc. (Google)	Google Working on Amazon Echo Competitor
28	Alphabet Inc. (Google)	Google Launches Service for Managing Hadoop
29	Alphabet Inc. (Google)	Avere Systems Teams With Google to Deliver Data Processing and Storage in the Cloud
30	Alphabet Inc. (Google)	Google and Johnson & Johnson partner up for hi-tech surgery
31	Alphabet Inc. (Google)	Google Lifts Curtain on 3D Mapping 'Project Tango' Phone
32	AT&T Inc.	AT&T and Sierra Wireless Pilot LTE-M Modules for Internet of Things
33	AT&T Inc.	AT&T Unveils Powerful New Security Platform
34	AT&T Inc.	AT&T Partner Exchange Fuels Mobility Momentum in the Channel, Adding IoT Platform
35	AT&T Inc.	AT&T reveals Ericsson and Intel 5G collaboration
36	AT&T Inc.	AT&T and CSC Revolutionize Hybrid Cloud Management
37	AT&T Inc.	RACOWireless teams with AT&T to connect Audi's A3 cars with LTE
38	AT&T Inc.	Tesla Picks AT&T for In-Car Wireless Service
39	AT&T Inc.	AT&T and IBM Create Breakthrough Global Cloud Service for Businesses
40	AT&T Inc.	INFOSYS and AT&T unveil customer service solution
41	Pfizer Inc.	Pfizer teams up with AdChina on data management

No.	Company name	Title of announcement
42	Facebook Inc.	Google, Facebook quietly move toward automatic blocking of extremist videos
43	Verizon Communications Inc.	Verizon this week added a Private Network Traffic Management solution
44	Verizon Communications Inc.	Cognizants Vice President of CRM Solutions Says the Verizon-Cognizant Alliance Enables Clients to Visualize Their Customer Experience Transformation Journey
45	Verizon Communications Inc.	Verizon Delivers Smart Energy As-A-Service
46	Verizon Communications Inc.	Verizon Launches New Portal Geared at Securing Large-Scale Deployments of Internet of Things
47	Verizon Communications Inc.	Verizon Launches New Security Suite to Protect IoT
48	Verizon Communications Inc.	Verizon Adds Cloudera's Cloud-Based Big Data Analytics Solution to Verizon Cloud Ecosystem
49	Verizon Communications Inc.	Verizon Creating Cloud That Lets Customers Dial Performance Up or Down
50	Verizon Communications Inc.	Verizon Telematics Platform Tracks Emergency, Utility Vehicles
51	Verizon Communications Inc.	Verizon Wireless and Encore Networks Deliver Secure Machine to Machine Solutions for Seamlessly Converting Legacy Protocols for Cellular Transport
52	Verizon Communications Inc.	Verizon Wireless and Pedigree Technologies Reroute Traditional Fleet and Field Service Management Through Tablet-Based Applications
53	Coca-Cola Company	Coca-Cola implements Siemens automation technology to increase bottling line capacity
54	Amazon.Com Inc.	AT&T Announces New Strategic Relationship with Amazon Web Services to Integrate Cloud and Networking Capabilities
55	Amazon.Com Inc.	Amazon Web Services Announces AWS IoT
56	Amazon.Com Inc.	Amazon Echo Now Available to All Customers
57	Amazon.Com Inc.	AWS Moving Into Internet of Things Business With Kinesis Service
58	Amazon.Com Inc.	Amazon Web Services unveils memory-intensive cloud service
59	Merck & Company	Merck puts big data to work to solve vaccine manufacturing concern
60	Intel Corp.	Advantech, Intel, Microsoft launch joint IoT Gateway Starter Kit with links to the cloud
61	Intel Corp.	Intel to Bring Heavy Dose of IoT Offerings to Embedded World
62	Intel Corp.	Intel develops open-source analytics software
63	Intel Corp.	Intel, Amazon, and seed collaborate on new IoT starter kit
64	Intel Corp.	Intel details Xeon E3-1200 v4 and new 5th Gen Core chips with Iris Pro graphics
65	Intel Corp.	Intel, eASIC Collaborate on Customized Intel-Based Solutions for the Cloud
66	Intel Corp.	Ingenico Group and Intel to Bring Payments to the IoT
67	Intel Corp.	Intel IoT developer kit v1.0 is here
68	Intel Corp.	Intel Unveils First 14nm, Xeon D SoCs
69	Intel Corp.	Databricks and Intel Collaborate to Optimize Apache Spark-Based Analytics for Intel(R) Architecture
70	Intel Corp.	Intel touts in-house cloud and Internet of Things use to boost business
71	Intel Corp.	Intel details end-to-end platform to drive IoT ecosystem
72	Intel Corp.	Intel and Mitsubishi Electric Collaborate to Create Next-Generation Factory Automation Systems
73	Intel Corp.	Ford and Intel partner to bring facial recognition and gesture control to cars
74	Intel Corp.	Intel launches 15-core Xeon E7 v2 family for big data and mission-critical computing
75	Intel Corp.	Intel Data Platform Helps Businesses Uncover Hidden Value in Big Data with Faster, Easier Analysis
76	Intel Corp.	Intel Brings Supercomputing to Big Data Analytics

No.	Company name	Title of announcement
77	Intel Corp.	Intel unveils products to accelerate adoption of IoT
78	Intel Corp.	Intel Announces Intel SSD DC S3700 Series -- Next-Generation Data Center Solid-State Drive (SSD)
79	Intel Corp.	Intel and NextBio seek Big Data upgrades in genomics
80	Intel Corp.	Intel ships new Atom processors to PC makers
81	Cisco Systems Inc.	AT&T in deal with Cisco, Avnet for IoT developer kit
82	Cisco Systems Inc.	IBM and Cisco Combine the Power of Watson Internet of Things with Edge Analytics
83	Cisco Systems Inc.	Rockwell Automation Collaborates With Cisco to Enhance Industrial Internet of Things Security
84	Cisco Systems Inc.	Hyundai Motor and Cisco Collaborate for Global Connected Car Project
85	Cisco Systems Inc.	Philips and Cisco Form Global Strategic Alliance to Address EUR 1 Billion Office Lighting Market
86	Cisco Systems Inc.	Collaboration with Cisco Delivers Highly-Secure Operations Monitoring and Analysis
87	Cisco Systems Inc.	Cisco Integrates ACI with FirePOWER to Deliver Automated Real-time Threat Protection for Data Centers
88	Cisco Systems Inc.	ABB, Bosch and Cisco establish open-software venture to unify smart home technology
89	Cisco Systems Inc.	Cisco openBerlin IoE Innovation Center
90	Cisco Systems Inc.	Cisco New Offerings Help Unlock Industrial Value of IoT
91	Cisco Systems Inc.	CISCO, Asystec in big data joint venture
92	Cisco Systems Inc.	Cisco Unveils Analytics Strategy to Help Customers Access, Analyze and Act on Data
93	Cisco Systems Inc.	Cisco Expects To Invest USD2bn In Manufacturing
94	Cisco Systems Inc.	Cisco Doubles Down to Accelerate IoT Use Cases by Expanding Application Deployment Possibilities With Expanded Fog Computing Portfolio
95	Cisco Systems Inc.	Ping Identity Teams with Cisco
96	Cisco Systems Inc.	Cisco Delivers Two New Industry Solutions to Protect Against Security Threats and Enhance Collaborative Decision Making
97	Cisco Systems Inc.	Cisco Launches Managed Threat Defense Service
98	Cisco Systems Inc.	Cisco Expands Videoscape TV Platform Into the Cloud
99	Cisco Systems Inc.	Cisco Helps Enterprises Lower Energy Usage With New Software and Services Offerings
100	Cisco Systems Inc.	Cisco and NetApp tackle Hadoop with offering integrated FlexPod server, storage, switching architecture for big data
101	Cisco Systems Inc.	Cisco's Data Center Strategy Takes Sharp Turn Toward Applications
102	Cisco Systems Inc.	Cisco and Nice Unveil Connected Boulevard
103	Cisco Systems Inc.	iRobot teams up with Cisco for telepresence robot
104	Cisco Systems Inc.	Cisco Drives Security in Modernizing the Connected Grid
105	Cisco Systems Inc.	Cisco launches cloud-based remote education platform for Indian classrooms
106	Cisco Systems Inc.	Cisco Builds All-Digital Wireless-Based Home Security and Automation Control Panel for AT&T
107	Cisco Systems Inc.	Cisco Updates Scheduler to Automate Hadoop Big Data Analysis Systems
108	Cisco Systems Inc.	Cisco's new, smarter network for the Internet of things
109	Cisco Systems Inc.	Cisco Brings Intelligent Networks to Industrial Automation
110	Cisco Systems Inc.	New Cisco Unified Computing System Innovations Help Customers Build Clouds, Deploy Business Apps Faster
111	Oracle Corp.	GE Tags Oracle as Industrial Internet Partner
112	Oracle Corp.	Oracle Launches New SaaS, PaaS, IaaS Cloud Services to Help Organizations in their Journey to Cloud
113	Oracle Corp.	Oracle Unleashes New Innovations in Data Analytics with Free, Open Interfaces to On-Chip Accelerators
114	Oracle Corp.	Oracle Communications Launches Oracle Communications Analytics Product Portfolio
115	Oracle Corp.	Oracle Helps Retailers Turn Data Into Insight With New Cloud Services

No.	Company name	Title of announcement
116	Oracle Corp.	Oracle Big Data Appliance X5-2 with Big Data SQL for the DBA
117	Oracle Corp.	Oracle Expands Data Integration Portfolio With Oracle Enterprise Metadata Management 12c
118	Oracle Corp.	Oracle Value Chain Execution App Improves Supply Chain Visibility & Operational Efficiency for Yard & Service Facilities
119	Oracle Corp.	Imagination and Oracle collaborate to enhance Java for embedded and the Internet of Things
120	Oracle Corp.	Oracle Utilities Analytics 2.5 Helps Utilities Improve Storm Response and Manage Smart Devices
121	Oracle Corp.	Oracle Announces Oracle Big Data Appliance X4-2
122	Oracle Corp.	Oracle Announces Latest Release of Oracle RightNow Cloud Service, Offering Rapid Response to Complex Customer Issues
123	Oracle Corp.	Oracle Announces Availability of Oracle Enterprise Taxation and Policy Management Self Service
124	Oracle Corp.	Oracle Unveils Oracle RightNow CX Cloud Service Combined With Oracle Fusion CRM in the Cloud
125	Comcast Corp.	Comcast Launches Enterprise IoT Trial Venture
126	Comcast Corp.	Comcast and Earth Networks Bring Big Data Intelligence to Xfinity Home
127	Comcast Corp.	Comcast adds Kwikset e-deadbolt to Xfinity home platform
128	Walmart Inc.	IBM made big cloud moves in China--delivering blockchain and internet of things services on its Bluemix platform and partnering with Walmart
129	Qualcomm Inc.	Qualcomm Snapdragon 600E and 410E Designed for Embedded Computing, IoT Applications Now Available
130	Qualcomm Inc.	Qualcomm and OSIssoft collaborate with San Diego Padr.
131	Qualcomm Inc.	Intel, Qualcomm Partner on WiGig Interoperability
132	Qualcomm Inc.	Qualcomm Expands Intelligent Connectivity Solutions for the Internet of Everything
133	Qualcomm Inc.	Qualcomm Announces New Development Board Based on Snapdragon 410 Processor
134	Qualcomm Inc.	Qualcomm, CH2M HILL and The City of Cincinnati Collaborate on Integrated Water Communications Solutions, A Step in Delivering Smart Cities
135	Qualcomm Inc.	Qualcomm unveils new SoCs for the next big growth markets - TVs and cars
136	Qualcomm Inc.	Qualcomm Unveils Low-Power Wi-Fi Platform for Major Home Appliances and Consumer Electronics
137	Qualcomm Inc.	Qualcomm Atheros Hybrid Networking Chipset Enables AVM Combination Range Extender and Energy Management Device
138	Qualcomm Inc.	Qualcomm Technologies, Inc. and Oracle Collaborate on Platform for Machine-to-Machine Applications
139	Qualcomm Inc.	Qualcomm Atheros Announces New High-Performance, Low-Energy Wi-Fi System-in-Package for the Intelligent Home and Building Markets
140	Visa Inc.	MineralTree and Visa Ink Strategic Alliance to Streamline Commercial AP Payments
141	Visa Inc.	Visa Brings Secure Payments to the Internet of Things
142	Visa Inc.	Visa opens its doors to disrupters
143	Visa Inc.	Bottomline Technologies and Visa to Offer Solution for Business Payment Automation
144	Visa Inc.	MasterCard, Visa and American Express Propose New Global Standard
145	3M Corp.	3M, SGI and Intel Showcase Advanced Cooling Technology for the "Data Center of the Future"
146	3M Corp.	New Sensored Termination from 3M Enables Real-time Monitoring to Support Grid Automation in Underground Distribution Networks
147	3M Corp.	3M Unitek Launches 3M True Definition Scanner for Orthodontic Practice
148	The Boeing Company Corp.	Stratasys Partners with Siemens, Boeing and Ford on New 3-D Technology

No.	Company name	Title of announcement
149	The Boeing Company Corp.	Microsoft and Boeing team up to streamline aviation through big data and AI
150	The Boeing Company Corp.	KUKA Systems develops robotic riveting system for Boeing 777 wide-body fuselage assembly
151	The Boeing Company Corp.	Boeing testing new way to build 777X
152	The Boeing Company Corp.	BMW Group, Boeing To Join Hands For Carbon Fiber Recycling
153	Abbott Laboratories	Abbott Focuses on the Importance of Information Management and Automation
154	General Electric Corp.	GE's SCADA Edge Industrial PC Turns Data Into Results in Brilliant Machines
155	General Electric Corp.	GE Unveils Predix Cloud
156	General Electric Corp.	Technology Leaders Unite Around 'Open Data Platform' to Increase Enterprise Adoption of Hadoop and Big Data
157	General Electric Corp.	GE and Panattoni Break Ground on US\$54 Million Brilliant Factory and Customer Experience Center in Poland
158	General Electric Corp.	GE Opens New Advanced Manufacturing Lab in Connecticut
159	General Electric Corp.	GE to build advanced manufacturing facility in Pennsylvania
160	General Electric Corp.	GE Announces First Data Lake Approach for Industrial Internet to Better Access, Analyze and Store Industrial-Strength Big Data
161	General Electric Corp.	GE Launches Handheld Electromagnetic Technology
162	General Electric Corp.	GE Extends Software Suite to Facilitate Manufacturing Transformation Enabled by the Industrial Internet
163	General Electric Corp.	GE's New High Performance Communications Modules Help OEMs Make the Connection for Intelligent Electrical Devices
164	General Electric Corp.	GE Software Solution Takes Discrete Manufacturing Execution to Next Level
165	General Electric Corp.	GE's Proficy Vision Allows Better, Faster Decision Making through Anytime, Anywhere Access Enabled by the Industrial Internet
166	General Electric Corp.	GE's Advanced Manufacturing Software Solutions Drive Lower Costs, Faster Production and Tighter Control on Quality
167	General Electric Corp.	Hamilton Robotics in Partnership with GE Healthcare Revolutionizes Automated Biological Sample Card Punching
168	General Electric Corp.	GE's PACSystems RSTi Standards-Based Distributed I/O Delivers High Performance and System Flexibility
169	General Electric Corp.	GE Advances Wind Turbine Inspection Through Successful Robotic Trial
170	General Electric Corp.	GE, MIT Building Crowdsourcing Software Platform to Revolutionize Product Design and Manufacturing
171	General Electric Corp.	GE Energy Announces Two New WiFi Enabled Submeters and a New Compact Industrial Ethernet Switch
172	General Electric Corp.	GE Launches Enterprise Historian Solution Accelerating Access to Big Data Across the Enterprise
173	General Electric Corp.	GE to hire 400 engineers for \$1 billion software hub in San Ramon
174	General Electric Corp.	GE and Microsoft partner to Bring Predix to Azure
175	General Electric Corp.	GE enters strategic partnership with Schindler Group
176	General Electric Corp.	GE and Engro Sign Digital Industrial Alliance to Accelerate the Transformation of Industries
177	General Electric Corp.	FLSmidth and GE to cooperate on data platform
178	IBM Corp.	NextUser, IBM Watson team to deliver 'truly personalized marketing'
179	IBM Corp.	IBM Announces Major Commitment to Advance Apache Spark, Calling it Potentially the Most Significant Open Source Project of the Next Decade
180	IBM Corp.	Skillsoft And IBM Research Unveil New Applications For Big Data And Talent Development At The 2015 Global Skillsoft Perspectives Customer Event
181	IBM Corp.	IBM Introduces Twitter-fueled Data Services for Business

No.	Company name	Title of announcement
182	IBM Corp.	EY expands collaboration with IBM to support clients' adoption of big data, analytics and enterprise solutions
183	IBM Corp.	Cisco and IBM Speed Data Center Transformation with New Integrated Infrastructure Solution Delivered by Business Partners
184	IBM Corp.	STFC and IBM form Big Data Innovation Hub for Small Businesses
185	IBM Corp.	IBM and City of Melbourne have signed a three-year partnership use big data with big fashion
186	IBM Corp.	CSC, IBM expand alliance to accelerate customers transition to the cloud
187	IBM Corp.	IBM, AT&T Partner on Cloud-to-Cloud Networking
188	IBM Corp.	IBM collaboration harnesses power of Big Data to help manage complex watersheds
189	IBM Corp.	Russia's Rostelecom, IBM to cooperate on Big Data, cloud computing
190	IBM Corp.	IBM Promotes Cloud Delivery in Africa with New Mainframe Innovation Hubs
191	IBM Corp.	IBM and EarlySense Use Big Data to Help Improve Sleep Patterns and Promote Good Health
192	IBM Corp.	IBM and Datawatch Transform Enterprise Content Management Systems Into Big Data Analytics
193	IBM Corp.	IBM and Libelium Launch Internet of Things Starter Kit
194	IBM Corp.	IBM Looks to Human Brain to Devise New Programming Model
195	IBM Corp.	IBM opens new services centre in city of Magdeburg
196	IBM Corp.	IBM introduces workforce Big Data analytics software
197	IBM Corp.	UCB and IBM Collaborate to Personalize Care for Epilepsy Patients
198	IBM Corp.	IBM Drives Flash Technology Deeper into the Enterprise to Speed Big Data Analytics
199	IBM Corp.	IBM Announces Creation of 800-Job Technology Center in Downtown Baton Rouge
200	IBM Corp.	Dt.Telekom and IBM Collaborate to Help Build Smarter Cities
201	IBM Corp.	IBM, STMicroelectronics & Shaspa Advance Smart Home
202	IBM Corp.	IBM Opens Advanced Analytics Center in Columbus, Ohio
203	IBM Corp.	Hainan Airlines Group signs MOU with IBM
204	IBM Corp.	IBM Redefines Social Business with the Power of Analytics
205	IBM Corp.	IBM Smarter Cities Technology Helps NYC Envision Solar Energy Leadership through CUNY Ventures
206	IBM Corp.	IBM launches self-managing PureSystems platform for cloud computing and enterprise apps
207	IBM Corp.	IBM advances security int. to help companies combat threats
208	IBM Corp.	IBM and GLOBALFOUNDRIES Begin First Production at New York's Latest Semiconductor Fab
209	IBM Corp.	IBM plans to open IOT center in Taiwan
210	IBM Corp.	Industry Leaders Join to Provide Open Source Tools and Protocols to Simplify Development of M2M
211	IBM Corp.	Siemens Healthineers & IBM Watson Health Forge Global Alliance for Population Health Management
212	IBM Corp.	Hortonworks, IBM Collaborate to Offer Open Source Distribution on Power Systems
213	IBM Corp.	IBM Scientists Imitate the Functionality of Neurons with a Phase-Change Device
214	IBM Corp.	IBM to Open Blockchain Innovation Center in Singapore to Accelerate Blockchain Adoption for Finance and Trade
215	IBM Corp.	True and IBM partner on Bangkok innovation centre
216	IBM Corp.	IBM, AMD, ARM, Others Look to Unite CPUs, Accelerators
217	IBM Corp.	IBM Touts Phase-Change Memory Breakthrough
218	IBM Corp.	FHI and IBM Japan Team Up for Advanced Driver Assist System
219	IBM Corp.	Precision Agriculture Gets More Precise as Farmers Edge, The Weather Company, IBM Business, Leverage Micro-Weather Data for Predictive Modeling in Field

No.	Company name	Title of announcement
220	IBM Corp.	Ford and IBM partner to accelerate big data use in vehicles
221	IBM Corp.	Rogers offers IoT app development platform with IBM
222	IBM Corp.	Ionics, IBM team up on high-tech products
223	IBM Corp.	IBM Opens Watson IoT Global Headquarters, Extends Power of Cognitive Computing to a Connected World
224	IBM Corp.	Guizhou, IBM cooperate on cloud computing, big data
225	3M Corp.	New 3D Handheld Display from IEE Integrates 3M's Autostereoscopic Technology
226	Comcast Corp.	Comcast Introduces Metro Ethernet Services to Address Bandwidth, Application and Reliability Requirements of Mid-Sized Businesses
227	General Electric Corp.	GE Plans To Build Its New Solar Panel Factory
228	General Electric Corp.	GE Energy Announces Distribution Automation Controllers to Maximize Grid Efficiency and Reliability
229	General Electric Corp.	GE and EnOcean Announce Partnership on Buildings Automation Technology
230	Alphabet Inc. (Google)	A twist in Google's algorithm: 'standout' stories
231	Alphabet Inc. (Google)	Google launches 'GigaPan Time Machine'
232	IBM Corp.	IBM Unveils New Hybrid Cloud Solution for the Enterprise World
233	IBM Corp.	IBM Develops Full-text Digitization System for National Diet Library of Japan
234	IBM Corp.	IBM Announces New Analytics Technology That Helps Clients Unlock Big Data
235	IBM Corp.	IBM and Tulane University Usher in a New Era for Smarter Buildings in New Orleans
236	IBM Corp.	Karmasphere Joins IBM to Help Clients Adopt Big Data Analytics
237	IBM Corp.	Red Hat and IBM Push Open Virtualization into the Enterprise
238	Intel Corp.	Intel eyes wireless, device markets
239	Intel Corp.	DeTe launches M2M Toolkit, partners with Intel'
240	Microsoft Corp.	Microsoft adds Hadoop support to SQL Server
241	Microsoft Corp.	HP, Microsoft partner for SMEs
242	Oracle Corp.	Oracle Delivers Oracle's Primavera Portfolio Management 9 to Help Organizations Achieve Portfolio Value Quicker and More Precisely
243	Oracle Corp.	Oracle Introduces Oracle Exadata Storage Expansion Rack
244	Oracle Corp.	Oracle's PeopleSoft Enterprise Projects Integration with Oracle's Primavera P6 Enterprise Project Portfolio Management Now Available
245	Oracle Corp.	Oracle Application Development Framework Mobile Client Now Available
246	Oracle Corp.	Oracle Introduces Oracle(R) Health Sciences Central Coding 3.0
247	Qualcomm Inc.	Qualcomm Showcases Innovations in Cellular Communications for Smart Grid
248	Qualcomm Inc.	Qualcomm Atheros Unveils Industry's First FCC-Certified Wi-Fi System-in-Package Fueling the Smart Home/Building/Grid Markets
249	Verizon Communications Inc.	Verizon Wireless to support M2M network
250	Apple Inc.	Apple Reportedly Plans To Use Drones To Improve Its Maps Service
251	The Boeing Company Corp.	Tapestry Solutions Launches IoT Enterprise Sensor Integration Solution
252	Cisco Systems Inc.	Cisco Launches Initiatives for Digital Gujarat
253	Cisco Systems Inc.	Cisco Introduces UCS S-Series Storage Optimized Servers, Next Generation Cisco Enterprise Cloud Suite, and Cisco ASAP Data Center for Secure Hybrid Cloud
254	Alphabet Inc. (Google)	Google partners with Intel to build machine learning cloud chips and adds a new exec
255	IBM Corp.	Schaeffler - IBM Join Hands for Digital Transformation
256	IBM Corp.	IBM package brings Watson smarts to everything IoT
257	Intel Corp.	Intel Sets Up Robotics Innovation Ecology Center

No.	Company name	Title of announcement
258	Oracle Corp.	Oracle and Western Sydney University team up on visual analytics research
259	Oracle Corp.	Oracle opens innovation center in Argentina
260	Qualcomm Inc.	Qualcomm Intends to collaborate with Google to add support for the new Android Things operating system (OS) in Qualcomm(R) Snapdragon (TM) processors
261	Qualcomm Inc.	Qualcomm Announces 5G NR Spectrum Sharing Prototype System
262	Qualcomm Inc.	Qualcomm to Set up Tech Lab in Taiwan
263	Verizon Communications Inc.	Verizons LTE CAT-M IoT Network is Live in Limited Markets
264	Visa Inc.	Poland: Innovation incubator to be launched by Visa and Polish banks
265	American Express Corp.	American Express Creates New Tech Hub in Silicon Valley
266	American Express Corp.	MasterCard, Visa and American Express Propose New Global Standard to Make Online and Mobile Shopping Simpler and Safer
267	Mastercard Inc.	Mastercard Partners With Fit Pay to Accelerate Development of Payments-Enabled Devices, Wearables
268	Mastercard Inc.	New Mastercard App Streamlines Purchase Process
269	Mastercard Inc.	MasterCard Empowers Local Businesses With Big Data, Digital Tools
270	Mastercard Inc.	MasterCard Powers First Commerce Application within SoftBank Robotics' Humanoid Robot "Pepper"
271	Mastercard Inc.	IBM, MasterCard team up to bring big data to small busin.
272	Mastercard Inc.	MasterCard and WISeKey to Bring Payments to Luxury Brand Watches and Wearables
273	Mastercard Inc.	MasterCard and NXP Partner to Bring Payments to Any Device
274	Mastercard Inc.	MasterCard Identity Check to Simplify and Strengthen Online Shopping
275	Mastercard Inc.	MasterCard Launches Digital Enablement Express Program to Speed the Global Rollout of Digital Payment Services for Consumers
276	Mastercard Inc.	MasterCard and Cubic to Make Mobile Devices the Remote Control for Global Cities
277	Mastercard Inc.	MasterCard to build restaurant reviews site using customer payment data
278	Mastercard Inc.	Etisalat and MasterCard debut potential Google Glass payment solution
279	Mastercard Inc.	MasterCard, Visa and American Express Propose New Global Standard to Make Online and Mobile Shopping Simpler & Safer
280	Mastercard Inc.	MasterCard opens new data analytics centre in India
281	Mastercard Inc.	MasterCard streamlines expense management for corporate cardholders
282	Mastercard Inc.	MasterCard Advisors Announces Agreement with Data Analytics Firm Mu Sigma
283	Mastercard Inc.	Mastercard, Experian, BehavioSec, and LivePerson among First Wave of Businesses to Join New Monitise FINKit Partner Programme to Accelerate Digital Transformation in Financial Services
284	Adidas AG	Fußballschuhe nach 4.0-Muster; adidas will in der Produktion schneller and regionaler sein
285	Adidas AG	Collaboration: Adidas implementiert Dropbox für Mitarbeiter
286	Adidas AG	Adidas Shows Off First Shoe Made In Its German Smart Factory
287	Adidas AG	Tools from IAR Systems Selected by Adidas for Smart Personal Physiological System
288	Adva Optical Networking SE	ADVA, Saguna to showcase future of mobile edge computing with Bezeq
289	Adva Optical Networking SE	ADVA Optical Networking Unveils All-New Data Center Interconnect Solution
290	Adva Optical Networking SE	ADVA Optical Networking Launches ConnectGuard for Ultimate Data Protection

No.	Company name	Title of announcement
291	Adva Optical Networking SE	ADVA Optical Networking Launches New Era of Data Center Connectivity
292	Adva Optical Networking SE	ADVA Optical Networking and HEAnet zeigen SDN gesteuerte 4K-Video
293	Adva Optical Networking SE	ADVA Optical Networking Launches Industry First with 100G Metro and Built-In-Encryption
294	Adva Optical Networking SE	ADVA Optical Networking, Juniper Networks and die University of Michigan zeigen auf der Supercomputing 2013 die Zukunft von Big Data Transport
295	Adva Optical Networking SE	ADVA Optical Networking Pioneers OpenFlow in the Optical Domain
296	Airbus S.A.S	UK firm key to tracking Mhl70 will fit 'cloud black box' on Airbus jets
297	Airbus S.A.S	Airbus Defense and Space and Hexagon Geospatial Sign Content Agreement for Smart M.App
298	Airbus S.A.S	Airbus Defence & Space Bullish on Mustang Project's IoT Potential
299	Airbus S.A.S	Airbus Defence and Space and Cisco seal global agreement on defense, security and satellite communication market
300	Airbus S.A.S	Airbus Defence and Space and its partners to launch the MUSTANG project for global connectivity
301	Airbus S.A.S	Airbus Defence and Space together with Sapura to establish long-term partnership in the field of C4ISR
302	BASF SE	BASF wählt Office 365 and Windows Phones
303	Bauer AG	Baustein für Industrie 4.0-Pläne: Bauer optimiert WLAN
304	Bayer AG	Bayer and CUBE open cooperation space in Berlin
305	Bayer AG	Bayer Spain Automates the Processing of Its Inbound Customer Orders with Esker
306	BMW AG	BMW erhöht die Sicherheit in der Produktion
307	BMW AG	Industrie 4.0: BMW plant sich selbst abstimmende Maschinen
308	BMW AG	BMW testet im Presswerk Leipzig neueste Fabrikssoftware des Spezialisten Forcam mit Echtzeitauswertung von Daten
309	BMW AG	amap.com and BMW reach cooperation
310	BMW AG	BMW Connected now integrated with Alexa in U.K. & Germany
311	BMW AG	BMW to launch real-time traffic app
312	BMW AG	BMW packt Container anders
313	BMW AG	CarCharging And BMW Enter Data Licensing Agreement
314	BMW AG	HomePlug Expands Globally with New Members to the Alliance: BMW Technology Corporation, Hisense, Texas Instruments, CATR, UL and ASTRI Join HomePlug
315	BMW AG	Amazon Cloud Player Now Available in BMW and MINI Vehicles
316	BMW AG	BMW Group Technology Office USA Partners with Tendril to Demonstrate the Power of Electric Vehicle and Smart Energy Home Integration
317	Cancom SE	PLUMgrid Welcomes Channel Partners Awnix and CANCOM - HPM Networks to Global Partner Program
318	Cancom SE	CANCOM establishes subsidiary in the U.S.
319	Cewe Stiftung & Co. KGaA	Fotodienstleister Cewe Color präsentiert fotozentrierte Cloud Samsung
320	Commerzbank AG	Multikanalbank: Commerzbank stellt Digitalisierungsstrategie für ihr Firmenkundengeschäft vor
321	Commerzbank AG	Commerzbank baut IT-Architektur um
322	Continental AG	Continental Uses vAnalytics to Connect Dealers, Fleet Owners and Auto Repair Shops to Customers' Vehicles
323	Continental AG	Continental Presents Holistic Connectivity Demo Car
324	Continental AG	Vinli Introduces Carport and Announces Partnership with Continental
325	Continental AG	CES 2015: Continental to demonstrate dynamic eHorizon
326	Continental AG	Airbiquity and Continental Collaborate to Deliver Global Connected Car Service Solutions to Vehicle Manufacturers
327	Continental AG	Continental sucht weitere Partner für Zukunftsthema vernetztes Auto

No.	Company name	Title of announcement
328	Continental AG	Continental: New remote diagnostic system uses Bluetooth and a smartphone
329	Continental AG	From 360° surround view to lifestyle apps: Networked infotainment from Continental
330	Continental AG	Continental And Cisco Show The Future Of Connected Vehicles
331	Daimler AG	Daimlers kleine Helferlein
332	Daimler AG	Daimler Trucks North America Collaborates with AT&T, Microsoft on New Connectivity Solutions
333	Daimler AG	Daimler gets IOT smart by linking cars to enterprise systems
334	Daimler AG	Germany : T-SYSTEMS inks IT systems integration agreement with DAIMLER
335	Daimler AG	BYD-Daimler and ABB partner to solve charging challenge
336	Daimler AG	Daimler nutzt verstärkt Google-Dienste
337	Deutsche Bank AG	Deutsche Bank gründet Innovationszentrum in Berlin
338	Deutsche Bank AG	Deutsche Bank to focus on big data
339	Deutsche Bank AG	Deutsche Bank baut digitale Services aus
340	Deutsche Börse AG	Solinea Supports Deutsche Börse to Leverage OpenStack Technology to Maximize Business Agility and IT Efficiency
341	Deutsche Börse AG	Deutsche Börse Market Data + Services startet mit Virtualised Private Simulation einen neuen Service
342	Deutsche Börse AG	Deutsche Boerse Cloud Exchange AG - neue Dimension fuer die Datenwolke
343	Deutsche Post AG	Neuer digitaler Landverkehr-Marktplatz: Mit dem virtuellen B2B-Marktplatz Cillox will DHL Freight Versender and Transportunternehmen zusammenbringen.
344	Deutsche Post AG	Deutsche Post sieht Datenbrillen als Chance
345	Deutsche Post AG	New DHL Asia Pacific Innovation Center in Singapore Develops Game-Changing Logistics Solutions and Promotes Collaborative Innovation in the Region
346	Deutsche Telekom AG	Cumulocity and ihr strategischer Partner die Deutsche Telekom vereinfachen die Industrie 4.0 Einsätze mit ihren einzigartigen Cloud Fieldbus-Lösungen
347	Deutsche Telekom AG	Infineon and Deutsche Telekom Demonstrate Security Technology 'Made in Germany' at IT Summit 'Nationaler IT-Gipfel 2014'
348	Deutsche Telekom AG	Telekom baut groesstes Rechenzentrum Deutschlands
349	Deutsche Telekom AG	Deutsche Telekom adds new software to Business Marketplace'
350	Deutsche Telekom AG	eZ Systems and Deutsche Telekom Announce Partnership for Telekom Business Marketplace
351	Deutsche Telekom AG	Deutsche Telekom sets up USD52m Chinese development center
352	Deutsche Telekom AG	Deutsche Telekom launches marketplace for IoT
353	Deutsche Telekom AG	Telekom kooperiert mit United Internet: De-Mail geht an den Start
354	Deutsche Telekom AG	IBM and Deutsche Telekom Launch Mobile App Cloud Service for Midmarket Customers
355	Deutsche Telekom AG	Deutsche Telekom Showcases Future of In-Car Entertainment
356	Deutsche Telekom AG	ABB and Deutsche Telekom: Simple management of virtual power plants
357	Deutsche Telekom AG	Deutsche Telekom Launches Development Kits for Cloud-Based M2M Apps
358	Deutsche Telekom AG	Deutsche Telekom Announces New Multi-Device OTT Video Acceleration Platform LiveStream Perform With Octoshape
359	Deutsche Telekom AG	Telekom and Cisco kooperieren enger
360	Deutsche Telekom AG	Deutsche Telekom unveils optimisation solution
361	Deutsche Telekom AG	Deutsche Telekom signs research partnership with Siemens
362	Deutsche Telekom AG	China Mobile in connected car JV with Deutsche Telekom
363	Deutsche Telekom AG	Deutsche Telekom launches e-mobility M2M services
364	Deutsche Telekom AG	Cisco and Deutsche Telekom kooperieren bei Cloud-Diensten
365	Deutsche Telekom AG	Deutsche Telekom, Canyon develop smart bicycle
366	Deutsche Telekom AG	Telekom supports Continental cloud HGV fleet system

No.	Company name	Title of announcement
367	Deutsche Telekom AG	Deutsche Telekom and Pisa start Smart City project
368	Deutsche Telekom AG	Deutsche Telekom deploys NB-IoT to communicate with sensors
369	Deutsche Telekom AG	Huawei and Deutsche Telekom work on Digital Silk Road
370	Deutsche Telekom AG	Deutsche Telekom & Salesforce accelerate IoT driving experience
371	Deutsche Telekom AG	Deutsche Telekom and Huawei greifen gemeinsam auf europäischen Cloud-Markt an
372	Deutsche Telekom AG	Telekom and GE im Doppelpack
373	Deutsche Telekom AG	Deutsche Telekom presents IoT alliances and services
374	Deutsche Telekom AG	Deutsche Telekom and MobileIron partner to launch a new Cloud-Based Enterprise Mobility Management (EMM) platform
375	Deutsche Telekom AG	Deutsche Telekom ICSS partners with Nexmo to provide an A2P messaging solution for business critical cloud communications
376	Deutsche Telekom AG	Deutsche Telekom to launch Cloud PBX in Germany
377	Deutsche Telekom AG	Talend Announces Strategic Big Data Partnership with T-Systems
378	Deutsche Telekom AG	Deutsche Telekom launches cloud platform for multiple IoT systems
379	Deutsche Telekom AG	Auto- and Telekom-Bündnis will automatisches Fahren vorantreiben
380	Deutsche Telekom AG	Bosch, Nokia and Deutsche Telekom developing `local clouds` for improved road safety
381	Deutsche Telekom AG	Deutsche Telekom launches highly secure public cloud based on Cisco platform
382	Deutz AG	Deutz spart dank Cloud Computing
383	Dialog Semiconductor plc.	Dialog Semiconductor's Latest Bluetooth(R) Low Energy SoC Offers Unparalleled Integration and Flexibility
384	Dialog Semiconductor plc.	Dialog Semiconductor Releases the Lowest Power 12 Degrees-of-Freedom Bluetooth(R) Smart Sensor Development Platform
385	Dialog Semiconductor plc.	Dialog Semiconductor's Bluetooth(R) Smart SoCs Links Wearables to Apps for WeChat Users
386	Dialog Semiconductor plc.	Dialog Semiconductor and Bosch Sensortec Collaborate on Low Power Smart Sensor Wireless Platform for IoT Devices
387	Dialog Semiconductor plc.	Dialog Semiconductor Launches Drive into Smart Home Market with Bluetooth Support for Apple HomeKit
388	Dialog Semiconductor plc.	EQS-News: Dialog Semiconductor Plc.: Dialog Semiconductor Expands Bluetooth
389	Dialog Semiconductor plc.	Dialog Semiconductor Extends Bluetooth(R) Success into Growing Range of Smart Home - Human Interface Devices
390	Dialog Semiconductor plc.	Energous Corporation to Collaborate With Dialog Semiconductor to Develop Market for Energous' WattUp Wire-Free Charging Technology
391	Dürr AG	Duerr, Fraunhofer and iTAC beginnen Zusammenarbeit im Bereich „Big Data Analytics“
392	E.ON SE	Greenwave Reality expands partnership with E.ON
393	euromicron AG	euromicron Gruppe eröffnet Smart Industry Showroom
394	euromicron AG	euromicron unterstützt Innovationszentrum ‚openBerlin‘
395	euromicron AG	euromicron AG: ELABO Arbeitsplatzsysteme: euromicron-Tochter ermöglicht vernetzte Kleinserien-Fertigung
396	euromicron AG	euromicron Deutschland concludes strategic partnership with Advancis
397	Evonik Industries AG	Evonik is the first chemical company to join the Industrial Internet Consortium (IIC)
398	Fraport AG	Fraport plant Online-Einkaufsplattform
399	GEA Group	GEA Group Aktiengesellschaft: GEA & SAP arbeiten zusammen
400	GFT Technologies SE	GFT Joins Google Cloud Platform's Partner Programme to Drive Real-world Blockchain Testing
401	Gigaset AG	Gigaset pro and Kwebbl announce cooperation
402	Gigaset AG	Gigaset launches WLAN-based home surveillance camera
403	Gigaset AG	Gigaset to launch connected home system in Q2
404	Heidelberger Druckmaschinen AG	Unter dem Motto „Simply Smart“ stellt Heidelberg die digitalisierte Zukunft der Printmedien-Industrie vor

No.	Company name	Title of announcement
405	Henkel AG & Co. KGaA	Neues Hybrid-Netzwerk verbindet Henkel weltweit
406	Henkel AG & Co. KGaA	Henkel, Alibaba Team Up in Promoting Schwarzkopf
407	Henkel AG & Co. KGaA	Dax-Konzern Henkel steigt auf Office 365 um
408	HOMAG Group	HOMAG Group: Schöne neue Industrielwelt
409	Infineon Technologies AG	Infineon and Deutsche Telekom Demonstrate Security Technology 'Made in Germany' at IT Summit 'Nationaler IT-Gipfel 2014'
410	Infineon Technologies AG	Mocana Security of Things Platform Integrates Support for the Infineon OPTIGA
411	Infineon Technologies AG	ESCRYPT and GlobalSign to join Infineon Security Partner Network with smart factory solutions
412	Infineon Technologies AG	Infineon brings bank-level security to smart devices and mobile payment solutions
413	Infineon Technologies AG	Elektrobit, Infineon and NVIDIA stellen gemeinsame Plattform für automatisierte Fahren vor
414	Infineon Technologies AG	Infineon, Google Partner On Gesture Sensing And Presence Detection Applications
415	Infineon Technologies AG	Infineon Launches Intelligent Power Module MIPAQ Pro with Smart Protection
416	Infineon Technologies AG	Infineon Drives Advancement of Networked Industrial Automation
417	Infineon Technologies AG	Future Plans for the Villach Site Infineon Technologies to Create Pilot Space for Industry 4.0
418	Klöckner & Co SE	etventure entwickelt digitale Dienste fuer Stahlhaendler Kloeckner & Co
419	Klöckner & Co SE	Klöckner & Co establishes Group Center of Competence for
420	Klöckner & Co SE	Klöckner & Co expands steel trading over the internet even further & focus on the consistent digitalization of supply chains
421	Kontron S&T AG	Kontron Launches Kontron FusionClient
422	Kontron S&T AG	Arrow Electronics Teams with Kontron to Enable Intelligent Railroads
423	Kontron S&T AG	Kontron Box PC with IoT Gateway solutions from Intel
424	Kontron S&T AG	Kontron to give video operators 20 percent more channel density on next generation x86 GPU-accelerated SYMKLOUD Series
425	Kontron S&T AG	Kontron achieves another major IoT milestone in Malaysia
426	Kontron S&T AG	Kontron joins Rausch Netzwerktechnik in technology partnership
427	Kontron S&T AG	Kontron and Partner Vantrix at IDF to Showcase Live Cloud Demo in the Software Defined Infrastructure Community
428	Kontron S&T AG	Kontron launches SYMKLOUD, the new App-ready data centre platform for hosted service providers
429	Kuka AG	Siemens and KUKA announce cooperation
430	Kuka AG	KUKA Announces KUKA Connect at the International Manufacturing Technology Show 2016
431	Kuka AG	Kooperation zwischen Huawei and KUKA soll Entwicklungen in der intelligenten Produktion vorantreiben
432	Kuka AG	Auf zwei Hochzeiten: Kuka setzt auf Industrie 4.0 and IIC
433	Kuka AG	Microsoft lends Azure IoT platform to KUKA LBR iiwa robot
434	Deutsche Lufthansa AG	Lufthansa Focuses on Big Data and Analytics Technology
435	Deutsche Lufthansa AG	Lufthansa inks \$1.25bn IBM deal
436	Manz AG	Manz baut die Maschinen für adidas' Speedfactory
437	Merck KGaA	Merck KGaA teams with Pfizer to spotlight new lupus therapies
438	Münchener Rückversicherungs-Gesellschaft AG	Munich Re using big data to develop new coverage and services
439	Münchener Rückversicherungs-Gesellschaft AG	Munich Re opens innovation space 'The Lab Beijing'
440	Nemetschek SE	Nemetschek Vectorworks Announces Release of Vectorworks Nomad 2.0
441	Osram Licht AG	Belkin International And OSRAM SYLVANIA Announce Partnership For WeMo Home Automation And LIGHTIFY Smart Connected Lighting Ecosystems

No.	Company name	Title of announcement
442	ProSiebenSat.1 Media SE	ProSieben selects Magine as OTT partner in Germany
443	PSI Software AG	Industrie 4.0 aus einer Hand: Primetals Technologies and PSI
444	Qiagen N.V.	DNAnexus Partners With QIAGEN to Integrate Its Cloud Genomics Platform With Ingenuity Variant Analysis
445	QSC AG	QSC bringt mit der 'Pure Enterprise Cloud' ab sofort
446	QSC AG	QSC presents current development projects
447	QSC AG	QSC announces QSC-Cospace collaboration service
448	RIB Software AG	RIB Software AG (RIB) and Wipro Limited partners to form Global Alliance to deliver end-to-end Advanced enterprise 5D BIM Construction Management solution Energy, Utilities, Infrastructure and E&C Industry
449	RTL Group	RTL, Magine sign licensing deal for German market
450	RWE AG	RWE and Gardena Cooperate
451	RWE AG	Digitalisierung: AXA and RWE entwickeln Schutz vor Wasserschäden mit smarterer Haussteuerung
452	SAP AG	SAP and Bosch bündeln Kompetenzen
453	SAP AG	SAP ermöglicht In-Memory-OLAP über Hadoop-Data-Lakes
454	SAP AG	SAP Aligns New Solutions With "Industry 4.0" Innovation to Steer Customers Through Improved Production Process
455	SAP AG	SAP and DigitalRoute Join Forces to Enrich Customer Experience for Telcos
456	SAP AG	SAP and SuccessFactors Launch Presentations for Dynamic Talent Reviews
457	SAP AG	Accenture and SAP to Launch New Business Solutions Group to Accelerate Time to Value for Client- and Industry-Specific Cloud-Based Solutions
458	SAP AG	Etisalat teams with SAP for business mobility services
459	SAP AG	SAP HANA and Big Data Analytics; BMW kooperiert mit IBM and SAP
460	SAP AG	Mindtree and SAP Announce First Managed Mobility Offering in Australia; Partnership enables clients to adopt SAP mobile solutions based on consumption
461	SAP AG	SAP and Partners Co-Innovate to Connect Cars With Parking and Food Services in German Pilot Program
462	SAP AG	VMware, And Sap Collaborate To Deliver Mobile Security And Simplified User Experience For Mobile Applications
463	SAP AG	IBM takes SAP HANA to the cloud
464	SAP AG	SAP and Birst Collaborate to Deliver Instant Cloud Analytics on SAP HANA Cloud Platform
465	SAP AG	SAP Unveils Three New Services For IoT
466	SAP AG	SAP Unveils the Next Generation of Enterprise Software with a New Business Suite
467	SAP AG	SAP to Work Closely With Citi and The Royal Bank of Scotland to Co-Innovate a Cloud-Based Services Platform
468	SAP AG	SAP unveils Hybris as a Service, will take Salesforce and its cloud-only CRM platform head on
469	SAP AG	Mercer Joins Forces with SAP to Provide Advisory Services on Cloud-Based Human Capital Management
470	SAP AG	Newsbyte: SAP Launches SAP® Vehicles Network in Eur.
471	SAP AG	Inspur, SAP cooperate in intelligent manufacturing solutions
472	SAP AG	SAP and Vodafone Advance Internet of Things Platform Momentum
473	SAP AG	Deutsche Telekom Launches Open Telekom Cloud With SAP As Partner
474	SAP AG	Telstra and SAP sign cloud alliance with Accenture
475	SAP AG	Apple, SAP Partner on Mobile Cloud Apps
476	SAP AG	SAP China teams up with Alibaba Cloud
477	SAP AG	SAP and NTT Enhance Global Partnership
478	SAP AG	SAP takes HR solutions to the cloud
479	SAP AG	Atos joins forces with SAP to help customers achieve leadership in sustainability and profitable growth

No.	Company name	Title of announcement
480	Siemens AG	Das Apple der Maschinenwelt: Siemens etwa denkt über einen AppStore für Maschinenvernetzung nach
481	Siemens AG	Siemens to Put 'Industrie 4.0' into Realities with Chinese Partners
482	Siemens AG	Siemens cooperate with Tsai's government on I4.0
483	Siemens AG	Siemens offers concrete solution portfolio for Industrie 4.0 with Digital Enterprise
484	Siemens AG	Siemens Supports Guangdong's Intelligent Industrial Transformation, Upgrading
485	Siemens AG	Siemens and KUKA announce cooperation
486	Siemens AG	eMeter, A Siemens Business erweitert Angebot über die Cloud
487	Siemens AG	Siemens Enterprise Communications startet Project Ansible; SEN will die Business-Kommunikation revolutionieren
488	Siemens AG	Siemens and Teradata form global strategic partnership for big data in the utility sector
489	Siemens AG	Siemens Healthcare Unveils Two Cloud-based Solutions to Optimize Image Management and Radiology Workflow
490	Siemens AG	Deutsche Telekom signs three year research partnership with Siemens
491	Siemens AG	Erlangen soll Zentrum der Innovation für Siemens bleiben
492	Siemens AG	Siemens New RailFusion to Turn Big Data into Intelligence by Intuitively Monitoring and Analyzing Railroad Infrastructure to Improve System Operations, Safety
493	Siemens AG	Atos and Siemens plan to further expand their successful alliance
494	Siemens AG	Siemens Atos Strategic Alliance accelerating digitalization initiatives
495	Siemens AG	Siemens builds an open cloud platform for analyzing large datasets in industry
496	Siemens AG	Open Interconnect Consortium Membership Increases by a 1/3
497	Siemens AG	Maxnerva Technology, Siemens Shanghai Team Up
498	Siemens AG	Capgemini unterstützt Siemens bei der Implementierung einer IoT- Plattform für Gebäude-Energie-Management-Lösungen
499	Siemens AG	Siemens and TCS Expand Partnership to Deliver Product Performance Intelligence through Big Data Analytics
500	Siemens AG	Siemens to build intelligent manufacturing innovation center in China
501	Siemens AG	Atos and Siemens strengthen their global alliance
502	Sixt Leasing AG	Sixt Rent a Car Chose Nordic TeleCom's Cloud Communication Service
503	Sky Deutschland AG	Sky Deutschland, The Cloud partner for hotel TV, WiFi
504	SMA Solar Technology AG	TenneT and SMA kooperieren
505	Software AG	Software AG: Deutschland als führender Industriestandort vereint globale Führung bei Unternehmenssoftware Erfolgsrezept für Industrie 4.0
506	Software AG	Software AG & Loqate partner to enhance data quality solution
507	Software AG	Confiance and Software AG Partner to Deliver Cloud-based ARIS Training
508	Software AG	Software AG Launches Software AG Live: Agile and Integrated for the Digital Enterprise
509	Software AG	Software AG announces the availability of ARIS Version 9 at CeBIT 2013
510	Software AG	Software AG announces expanded webMethods capabilities for API amangement
511	Software AG	Software AG stellt Strategie für das In-Memory-Management von Big Data vor
512	Software AG	Software AG Highlights Progress in Cloud Strategy
513	Software AG	Software AG Reveals Major Enhancements to Hybrid Integration with latest webMethods Release
514	Software AG	Software AG Unveils webMethods Agile Process Platform
515	Software AG	Software AG Unveils Smart Logistics Blueprint for the Digital Business Platform

No.	Company name	Title of announcement
516	Software AG	Software AG and Mosaic Data Science Partner to Create Real-time Predictive Maintenance Analytics for the Internet of Things
517	Software AG	Wipro and Software AG Announce Joint Development of Internet of Things Solutions for Smart, Connected Products
518	Software AG	Software AG Launches ARIS Cloud
519	Software AG	Software AG Unveils Comprehensive Integration Cloud Portfolio
520	Software AG	Software AG Launches New Customer ExperienceManagement Solution Accelerator
521	Software AG	Software AG Unveils New Internet of Things Solution Accelerator
522	Software AG	Software AG Launches Open Source Internet of Things Analytics Kit
523	Software AG	Software AG and Cumulocity Announce Strategic IoT Partnership
524	Software AG	Software AG and MDI partner to boost digitalisation in the Philippines
525	Software AG	Software AG and Dell take Real-Time Streaming Analytics to the Edge and Revolutionize IoT Architecture
526	Software AG	Software AG brings new capabilities by partnering with loyalty card company Reward Technology
527	Software AG	Software AG Adds Predictive Analytics & New IoT Industry Standards to Apama
528	Axel Springer SE	Ringier and Axel Springer planen Gruendung eines Gemeinschaftsunternehmens in der Schweiz
529	Stada Arzneimittel AG	STADA wird Bitkom-Mitglied
530	Talanx AG	Talanx digitalisiert Schadengeschäft
531	Talanx AG	Talanx gains IBM as new data centre partner
532	Telefónica Deutschland Holding AG	Revolution des Mobile Banking: Fidor Bank and Telefónica Deutschland starten mit O2 Banking das erste komplett mobile Bankkonto
533	Telefónica Deutschland Holding AG	Telefonica Germany upgrades Smart Meter Connect platform
534	ThyssenKrupp AG	thyssenkrupp selects Vodafone as its connectivity partner for the Internet of Things
535	ThyssenKrupp AG	Thyssenkrupp steigt mit Online-Shop ins Privatkundengeschäft ein
536	ThyssenKrupp AG	ThyssenKrupp kicks off concept plant in Brazil
537	ThyssenKrupp AG	Telekomtochter T-Systems ergattert Cloud-Auftrag von ThyssenKrupp
538	TUI AG	Tui Schweiz mit neuem Reisebüro-Konzept
539	Volkswagen AG	VW forscht am Vertrieb der Zukunft
540	Volkswagen AG	Volkswagen Group inaugurates Data Lab in Munich
541	Volkswagen AG	SAP, Shell and Volkswagen join forces to drive a connected car ecosystem
542	Volkswagen AG	LG Electronics, Volkswagen To Develop Next Generation Of Connected Car Platform
543	Volkswagen AG	HTC, Volkswagen Join Forces on Internet of Vehicles
544	Wirecard AG	Wirecard ist SAP Software Solution and Technology Partner: Zahlungsplattform in SAP Business ByDesign integriert
545	Wüstenrot Bausparkasse AG	etventure unterstützt die Wuestenrot & Wuerttembergische-Gruppe (W&W) bei der digitalen Transformation
546	New Work SE (Xing)	Kooperation mit Abbyy; Xing scannt Visitenkarten ein
547	Carl Zeiss AG	ZEISS supports its customers' digital revolution
548	Bechtle AG	Mit VMware and Colt; Die hybride Cloud von Bechtle
549	Bechtle AG	Bechtle wird Public Cloud Provider
550	Deutsche Telekom AG	Deutsche Telekom adds SAP solution for the utilities industry to the cloud
551	Deutsche Telekom AG	The car in the cloud: Telekom presents Internet in the car
552	Deutsche Telekom AG	iPass Open Mobile Platform to Provide Foundation of New Enterprise Mobility Services from Deutsche Telekom
553	E.ON SE	Telekom partners with E.On, Miele for smart home platform'
554	SAP AG	HP and SAP Accelerate Cloud Deployments for Clients

No.	Company name	Title of announcement
555	SAP AG	SAP Makes Collaboration Core to Business Applications
556	Dialog Semiconductor plc.	Dialog Semiconductor Simplifies Smart Home Device Creation with New Apple HomeKit Bluetooth(R) Development Kit for iOS 10 and watchOS 3
557	freenet AG	freenet AG and Capita vereinbaren strategische Partnerschaft zur Entwicklung des Kundenservice in Richtung Customer Excellence and Digitalisierung
558	Kontron S&T AG	Kontron introduces SMARC 2.0 Computer-on-Module based on latest generation Intel Atom Pentium and Celeron processors
559	Kontron S&T AG	Kontron launches COM Express mini Computer-on-Module featuring latest generation Intel Atom Pentium and Celeron processors
560	Qiagen N.V.	Qiagen and CosmosID Launch New Plugin for Metagenomics Analysis
561	RIB Software AG.	Flex and RIB Software Join Forces to Transform Building and Housing Industry
562	Telefónica Deutschland Holding AG	Telefonica Germany launches data analysis arm
563	Carl Zeiss AG	Zeiss Triggers Next Step of Digital Transformation
564	BMW AG	BMW startet Online Shop für Ersatzteile, Zubehör and mehr
565	Commerzbank AG	Software AG to Support Digitalization at Commerzbank
566	Continental AG	Continental Navigates the Future of Connectivity at AutoMobility
567	Deutsche Post AG	Fujitsu Collaborates with DHL to Disrupt the Logistics Market with Innovative Technology
568	E.ON SE	E.ON and Viessmann vertiefen Kooperation: Modernisierung and Digitalisierung des deutschen Heizungsmarkts im Fokus
569	Merck KGaA	Merck and ESA vertiefen Partnerschaft
570	SAP AG	SAP rolls out new big data services suite
571	SAP AG	SAP Delivers Manufacturing Solution in the Cloud
572	SAP AG	SAP Enables Transformative Business Value with New IoT Offerings
573	Siemens AG	Siemens and IBM to bring Watson Analytics to MindSphere
574	GEA Group	GEA baut Plattform für Personaldaten
575	Schaeffler AG	Schaeffler and IBM enter strategic partnership
576	Tele Columbus AG	Tele Columbus and Espial Transform Viewing Experience in Germany
577	Villeroy & Boch AG	Villeroy & Boch migriert Server in die Cloud
578	VTG AG	VTG AG to digitalize its entire European wagon fleet

Appendix D.

Regression results with winsorized CARs.

Variables	Model 1	Model 2	Model 3	Model 4
Constant	-0.0235*** (-2.38)	-0.0300*** (-3.00)	-0.0300*** (-2.92)	-0.0286*** (-2.83)
H2: Innovation type (INNT)		0.0054*** (2.78)	0.0055*** (2.83)	0.0017 (0.69)
H3: Institutional arrangement (IA)			0.0008 (0.49)	-0.0065** (-1.77)
H4: Innovation type * Institutional arrangement (INNT * IA)				0.0093** (2.18)
Radicalness (RAD)	0.0044** (2.07)	0.0053*** (2.44)	0.0055*** (2.45)	0.0060*** (2.59)
IT intensity (ITI)	0.0056** (2.23)	0.0059** (2.31)	0.0059** (2.33)	0.0057** (2.28)
Firm size (FS)	0.0013* (1.65)	0.0013** (1.72)	0.0013** (1.73)	0.0014** (1.84)
Firm growth (FG)	-0.0041 (-0.35)	-0.0041 (-0.35)	-0.0053 (-0.46)	-0.0049 (-0.42)
Region (REG)	-0.0003 (-0.20)	-0.0003 (-0.20)	-0.0003 (-0.46)	-0.0000 (-0.02)
Industry type (INDT)	0.0037** (1.87)	0.0037** (1.87)	0.0040** (2.09)	0.0038** (1.98)
Year dummy	Included	Included	Included	Included
R ²	0.03	0.04	0.04	0.04
Adjusted R ²	0.01	0.02	0.02	0.02
F-statistic (p-value)	2.22 (0.02)	3.04 (0.00)	2.82 (0.00)	2.61 (0.00)
Number of observations	578	578	578	578

Notes. Dependent variable CAR. t-statistic is shown in parentheses

*p<0.1, **p<0.05, ***p<0.001 (one-tailed tests of significance); linear OLS regression with robust standard errors, clustered by firms

Trapped in the Supply Chain? Digital Servitization Strategies and Power Relations in the Case of an Industrial Technology Supplier

Philipp Mosch (philipp.mosch@uni-passau.de)
Chair for Business Economics, Accounting and Control
DE-94032 Passau, Germany

Stefan Schweikl
Chair for Business Economics, Accounting and Control
DE-94032 Passau, Germany

Robert Obermaier
Chair for Business Economics, Accounting and Control
DE-94032 Passau, Germany

Abstract

Digital servitization transforms value creation processes and subsequently affects relationships and power structures in supply chains. Yet, previous studies present insightful but incomplete views on how digital servitization changes power balances between supply chain actors. Specifically, little attention has been paid to upstream firms, although they are particularly vulnerable to becoming disadvantaged participants in a digitally servitized supply chain, as they are positioned far away from end-users. Addressing this research need, we performed an explorative single case study of an industrial supplier – using the resource dependence theory as theoretical framework – to investigate (1) the effects of digital servitization on the power balance between the supplier and its OEM customers and (2) the strategic responses of the supplier to these effects. We find that for an industrial supplier, the successful deployment of digitalized product-service systems (DPSS) depends not only on the development of digital capabilities, but also on the ability to establish close end-user connections, continuous access to product usage data, and a trustful relationship with OEM customers. In addition, we show that digital servitization shifts power towards the actor who is more dominant prior to its advent, refining the common notion that digital servitization favors per se downstream firms. We enrich existing literature by outlining five specific strategies that industrial suppliers can pursue to maintain critical resource access and regain power in a digitally servitized supply chain. Finally, we offer managers guidance in establishing DPSS offerings by providing a comprehensive picture of the industrial supplier’s digital servitization journey.⁹

Keywords: Digital Servitization; Digital Product-Service Systems; Power Structure; Supply Chain Relationships; Resource Dependence Theory; Case Study Research

⁹ Published in the International Journal of Production Economics, 236, in 2021, see here: <https://www.sciencedirect.com/science/article/abs/pii/S0925527321001171>

1. Introduction

Digital technologies are significantly changing the way how firms conduct their business, ranging from the adoption of novel operation processes to the emergence of new business models (Loebbecke and Picot 2015). This change becomes particularly visible in the manufacturing sector, where value is traditionally created through physical materiality (Yoo et al. 2010). In the wake of an Industry 4.0 (Obermaier 2019), manufacturers increasingly attempt to bundle sensor-equipped components of their industrial-age products with services based on digital technologies to gain a competitive edge with digitalized product-service systems (DPSS) (Lerch and Gotsch 2015; Porter and Heppelmann 2014; Rymaszewska et al. 2017). This transformation from the provision of physical products towards the offering of DPSS is commonly referred to as digital servitization (Vendrell-Herrero and Wilson 2017).

Gradually emerging over the last two decades due to the increasing attention to information capital (Rabetino et al. 2017), digital servitization expands the scope of servitization by an even stronger focus on end-user interaction (Vendrell-Herrero et al. 2017), the need to develop novel digital capabilities (Ardolino et al. 2018), closer collaboration with other actors involved in the value creation process (Pagani and Pardo 2017), and a more data-centric business culture (Cenamor et al. 2017). Given the far-reaching effects of this transformation, digital servitization may not only lead to major organizational changes for manufacturing firms (Coreynen et al. 2017), but disrupt the entire supply chain (Holmström et al. 2019).

While a supply chain generally includes a variety of different actors, those involved in the production of a given complex physical product can generally be divided into two broad categories: suppliers and original-equipment manufacturers (OEM). Suppliers provide materials, components, and systems to OEMs, which assemble and integrate the supplied parts into products of higher complexity and offer them to distributors or directly to end-users. Therefore, OEMs typically control the downstream part of a supply chain (Lee and Berente 2012). While downstream firms have already dominated the supply chain through close communication with end-users (Wise and Baumgartner 1999), this circumstance may become even more severe in the context of digital servitization due to the increasing reliance on end-user data

required to develop DPSS offerings (Neely 2008; Porter and Heppelmann 2014). As a result, the control over end-user ties and data may shift the power balance within a supply chain in favor of downstream firms (Vendrell-Herrero et al. 2017), potentially isolating upstream firms from end-users and leaving them trapped in their respective supply chain position. Nevertheless, suppliers might try to overcome the barrier set by OEMs and seize the novel opportunities provided by digital servitization. Specifically, they may equip their components with sensors or connectivity devices for collecting data and thus deliver services directly and self-sufficiently to end-users (Porter and Heppelmann 2014; Huikkola et al. 2020). This strategy, however, challenges the OEM's power position, potentially resulting in conflicts between suppliers and OEMs (Paiola and Gebauer 2020).

Surprisingly, the literature has so far remained largely silent on such disruptive potentials of digital servitization on the power structure in different sections of a supply chain (Kohtamäki et al. 2019). Only recently, Vendrell-Herrero et al. (2017) have indicated that upstream firms are becoming more dependent on downstream firms due to their control of link channels. Huikkola et al. (2020) have added to this finding by outlining that upstream firms are forced to vertically reposition themselves and by-pass intermediary actors to improve their power position. However, the extant literature in digital servitization has so far neglected that alterations in the power structure between upstream and downstream actors generally depend on different context-contingent factors such as control over critical resources (Ireland and Webb 2007), leading to a potentially incomplete understanding of the disruptions digital servitization has on power relations in supply chains. Therefore, a more in-depth empirical investigation is needed to analyze the formation of power structures in digitally servitized supply chains (Huikkola et al. 2020) and explore the power disruptions that arise between suppliers that want to get closer to end-users and OEMs that strive to isolate other actors from end-users. In this regard, suppliers are of particular interest (Kohtamäki et al. 2019), as they need to identify adequate strategies to overcome the barriers placed by OEMs to profit from digital servitization efforts without adversely affecting the business relationships to OEMs and subsequently physical component sales.

Thus, we approach these research needs and aim to extend prior literature on power structures in digital servitization (Vendrell-Herrero et al. 2017; Huikkola et al. 2020) by conducting an in-depth single case study at a large European industrial supplier of powertrain technology. In particular, we address the following research questions:

(1) How does digital servitization affect the power structure between an industrial supplier and its OEM customers?

(2) Which response strategies does an industrial supplier undertake to counteract the power structure effects of digital servitization?

To answer our research questions, we build on insights from 18 in-depth expert interviews at the case firm, extensive access to internal documentations, meetings, and workshops over a three-year period, and external archival records to triangulate our results. Based on this unique dataset and by drawing on resource dependence theory, we make the following contributions to the literature on power structures in digital servitization: First, we find that for an industrial supplier the successful development and provision of DPSS is not only dependent on the development of digital capabilities, but also relies on the control of close end-user interactions, continuous access to product usage data, and inter-organizational trust with OEM customers. Second, while prior literature argues that upstream firms become more dependent on downstream organizations due to digital servitization (Vendrell-Herrero et al., 2017), we find that in fact even the contrary might be true depending on the ex-ante power constellation between supply chain members, as powerful actors can exercise their influence to gain control over emerging resource needs at the network level. Third, we provide five specific strategic responses for industrial suppliers to regain power within a digitally servitized supply chain: leverage tacit component knowledge, initiate data-exchange specific investments, signal relationship commitment, use end-users to pull own DPSS into OEM products, and move downstream in OEM-unserved markets.

The remainder of this article is organized as follows: in the next section, we shortly review the digital servitization literature. In section 3, we present the theoretical foundation of our work. Subsequently, we outline our research

methodology in section 4 and describe our results in section 5. In the sixth section, we discuss our findings before we indicate our contributions to the literature on digital servitization in the last section.

2. Literature review

2.1 Servitization

The objective of achieving higher profitability, stable revenue streams, and in particular to counteract the increasing competition of low-cost manufacturers in recent decades (Baines et al. 2009), have brought servitization (Vandermerwe and Rada 1988) and the related concept of product-service systems (PSS) (Baines et al. 2007; Tukker and Tischner 2006) to the forefront in the manufacturing sector. In relation to both concepts, we define servitization as the transformation of companies from focusing on products or services to providing PSS that combine both in an integrative way (Baines et al. 2009; Baines et al. 2007). In this regard, we understand “product” as a material artefact (e.g. transmission or axle) and “service” as an economic activity (e.g. maintenance, repair advice) that is not necessarily resulting in the ownership of a tangible asset (Baines et al. 2009). In some instances, servitization can also result in the replacement of original product sales by availability-based contracts (Baines et al. 2011). A prominent example of this is the aero-engine manufacturer Rolls-Royce with its Power-by-the-hour offering. For upstream firms such as Rolls-Royce, the adoption of service offerings often results in vertical repositioning towards end-user (airlines) to bypass intermediaries (airplane manufacturer) and improve the standing within the supply chain (Wise and Baumgartner 1999; Stabell and Fjeldstad 1998). The competitive advantage of servitization is thereby considered to be more sustainable, less visible, more dependent on employee skills, and consequently more difficult to replicate (Oliva and Kallenberg 2003). Therefore, servitization is seen as a critical aspect to provide product-centric firms with a competitive edge, particularly in mature markets with cost-based competition to avoid being caught in the commodity trap (Chesbrough 2011).

2.2 Digital servitization

For many manufacturing firms the move towards servitization has steadily intensified with the increasing digitization, i.e. the convergence of analog into digital data (Ritter and Pedersen 2020; Rabetino et al. 2017), and is driven by the need for higher operational efficiency and offering customization (Cenamor et al. 2017; Opresnik and Taisch 2015). Digital technologies such as Internet of Things (IoT) solutions or data analytics are therefore seen as enablers and driving factors of servitization (Baines et al. 2020; Kohtamäki et al. 2020), leading to the emergence of DPSS. Consequently, servitization in conjunction with digital technologies has emerged as a new field of interest (Suppatvech et al. 2019) and is commonly described as digital servitization (Vendrell-Herrero and Wilson 2017). In our work, we understand digital servitization as the evolutionary transformation from pure products offerings, add-on services, and PSS towards DPSS that enable value creation, delivery, and capture through monitoring, control, optimization, and autonomous function via digital technologies (Kohtamäki et al. 2019; Porter and Heppelmann 2014; Lerch and Gotsch 2015).

However, DPSS are not simply traditional PSS in digitized form, but rather involve the digitalization of the manufacturer's entire service business model (Ritter and Pedersen 2020) and provide novel business opportunities (Rymaszewska et al. 2017). Thus, digital servitization considerably differs from the servitization understanding in some aspects. First, digital services underlying DPSS exhibit higher scalability as they can be replicated with marginal costs close to zero (Rifkin 2014). Second, whereas traditional services are usually added to physical product sales in a complementary way (e.g. repair), digital services reinforce the trend to replace physical product sales via outcome-based contracts (Vendrell-Herrero et al. 2017), further undermining the value contribution of physical materiality (Yoo et al. 2010). Third, the provision of DPSS requires a more centralized organization encompassing data-driven platforms to efficiently manage decision-making and related strategic actions (Sklyar et al. 2019). Fourth, the relevance of cooperations between different stakeholders operating in a network is significantly higher, since companies are often unable to offer DPSS on their own due to a lack of competencies (Benitez et al. 2020). Fifth, the novel capabilities required in digital servitization offer new market

entry opportunities to established actors (e.g. suppliers) or new actors (e.g. software developers), which may lead to changing power structures in supply chains and entire industry segments (Coreynen et al. 2020; Porter and Heppelmann 2014).

2.3 Empirical research in digital servitization

As digital servitization literature is still in its emerging phase (Gebauer et al. 2020; Paschou et al. 2020), particularly with regard to the industrial sphere, research efforts are mostly qualitative and inductive to gain a deeper understanding of the phenomenon (Rabetino et al. 2018). Thereby, studies show that digital servitization has considerable implications on business models and value creation through novel key partner networks and the extension of value chains (Arnold et al. 2016; Rymaszewska et al. 2017). Others focus on digital capabilities that facilitate digital servitization strategies (Ardolino et al. 2018; Coreynen et al. 2017) or indicate that a digital platform approach supports customization, operational efficiency, and resource sharing (Cenamor et al. 2017; Eloranta and Turunen 2016).

More recently, studies have also started to investigate the effect of digital servitization on dyadic relationships, particularly between downstream actors. Kamalaldin et al. (2020) analyze relationships between service providers and customers by showcasing that, along with other factors, complementary digital capabilities and knowledge-sharing routines are key components to succeed in digital servitization settings. Likewise, Sjödin et al. (2020) show that the implementation of relational governance strategies such as high service innovation, perceived switching costs, and the use of explicit contracts enables service providers to profit from servitization. In a further study, Boehmer et al. (2020) find that the adoption of IoT-based solutions draws OEMs and end-users (operators) closer together via increasing trust, self-enforcing safeguards like mutual specific investments, and risk sharing.

While it appears that digital servitization forges closer ties between downstream actors such as OEMs and end-users, not every actor in the supply chain seems to be able to benefit from these novel revenue-generating opportunities. In particular, upstream firms may have difficulties creating and capturing value by DPSS due to an inherent lack of close end-user ties (Porter and Heppelmann 2014). Affirming this

notion, Vendrell-Herrero et al. (2017) indicate that digital servitization empowers downstream firms (e-commerce retailers), as they are in control of link channels to consumers. However, upstream companies (publishers) are able to re-gain power if they can leverage organizational resources such as copyrights to counteract the dominant position of downstream firms. Huikkola et al. (2020) extend these insights and offer a diverging strategic response by outlining that upstream firms must move downstream and bypass intermediary actors via acquisitions, joint ventures, or strategic alliances in order to establish closer connections to end-users and improve their power position.

In spite of these research efforts, there is still an inadequate understanding on how context-contingent factors affect the formation of power structures in digitally servitized supply chains, indicating an eminent need for a more in-depth empirical investigation (Huikkola et al. 2020). In addition, the literature remains silent on how digital servitization impacts bargaining power of firms positioned far upstream the supply chain, such as component suppliers (Kohtamäki et al. 2019), although these actors may have a disadvantaged position in the supply chain and may fear adverse consequences from OEMs if they adopt strategies to move downstream. Therefore, it seems crucial to identify specific strategies they can undertake to address potential power disruptions caused by digital servitization. In our study, we address these research needs (1) by examining how digital servitization initiatives impact the power structure between an industrial supplier and its OEM customers, and (2) by outlining potential strategic responses an industrial supplier can undertake to extend or re-gain power in a digitally servitized supply chain.

3. Theoretical background

To investigate these research needs, we take a resource dependence theory (RDT) perspective (Pfeffer and Salancik 1978) as it provides an explanatory framework for the formation of power structures in exchange relationships and has a well-established tradition in the evaluation of power relations (Hillman et al. 2009). Since we focus in our research on buyer-supplier relationships, we also apply the power regimes perspective (Cox et al. 2002), as it constitutes a specific application of RDT

in a supply chain context and enables us to clearly assess the disruptions digital servitization has on power structures in supply chains.

3.1 Resource dependence theory

According to RDT, a firm's need for scarce and critical resources results in a dependence on its trading partners and can be a potential source of conflicts for an organization (Pfeffer and Salancik 1978). Therefore, the success of a firm is indispensably linked with the resources and behavior of other organizations and beyond the control of a focal firm (Pfeffer and Salancik 1978). This leads to uncertainties, as a firm's ability to maintain access to vital resources is unclear, forcing a firm to manage inter-organizational relationships and reduce environmental uncertainty in order to ensure the long-term survival of the organization (Hillman et al. 2009; Pfeffer and Salancik 1978). Accordingly, firms engage in different arrangements such as mergers and acquisitions, joint ventures, strategic alliances, or supplier-buyer relationships to gain access to the required resources (Hillman et al. 2009). Thus, the key proposition of RDT lies in the primary aim of a firm to gain and preserve access to critical resources in order to ensure survival, which leads to a complex network of varying inter-firm dependencies (Pfeffer and Salancik 1978).

In this network, firms in control over critical and unique resources hold power over others (Pfeffer 1981; Crook and Combs 2007), which is the ability to influence the behavior of another actor contrary to its interests (Weber 1922; Emerson 1962). Consequently, a concentration of critical resources generally entails a concentration of power (Nienhüser 2008). In order to maintain continued viability, firms strive to minimize their dependence and maximize their power (Ulrich and Barney 1984). To increase power, firms can reduce their dependence on providers of critical resources by acquiring different sources of the resource or lower their need for a critical resource. Alternatively, a firm's power can increase if other actors become more dependent on its resources (Drees and Heugens 2013; Nienhüser 2008). This may also lead to interdependencies and fairly balanced power relations, if different actors have control over critical resources that the other party desires (Casciaro and Piskorski 2005).

3.2 Power structures in supply chains

The necessity to manage inter-organizational relationships and ensure effective coordination with other actors is particularly prevalent in supply chains (Paulraj and Chen 2007). Although firms act jointly in supply chains, they strive to increase their individual power to obtain greater value for themselves (Cox 1999). Addressing this issue, Cox et al. (2002) extend the RDT by offering the power regime framework to map the different power constellations as well as outline key attributes and consequences of supplier and buyer power in supply chains.

The power regime perspective proposes that power in buyer-supplier relationships is contingent on the resource utility, i.e. the resource's operational and commercial importance to the firm's activities to generate revenues and resource scarcity, i.e. the availability of alternative resource sources (Cox et al. 2002). Thereby, power can emerge from three different resource levels: organization-specific power sources, relationship-specific power sources, and network-specific power sources (Kähkönen and Virolainen 2011). Organization-specific power sources are internal to the organization such as capabilities and expertise (Cox et al. 2002), size (Porter 1985), or brand (Cox 2001). Relationship-specific power sources are tied to the dyadic relationship with another organization such as switching costs (Hart and Saunders 1997) or the volume of sales and purchases (Cox et al. 2002). Network-specific power sources are related to actors outside the dyadic relationship such as the control over strategic relationships within a network¹⁰ (Bustinza et al. 2013; Bigdeli et al. 2018). The power structure between supplier and buyer relies on the interplay of all these power sources (Kähkönen and Virolainen 2011) and the resulting difference in dependencies between both actors (Caniëls and Gelderman 2007).

That said, it is important to note that either actor can have options outside the focal network (Malhotra and Gino 2011), as they may belong to other supply chains or are part of diverging ecosystems. This is a relevant consideration, as an actor with access to multiple outside options is less reliant on a specific supply chain and, accordingly, less dependent on other actors in that network (Falkowski 2015).

¹⁰ Following Carter et al. (2015), we view a supply chain as a network.

In sum, if the buyer is more dependent on the supplier than the other way around, a power imbalance emerges (et vice versa) (Cox et al. 2002). Within an imbalanced supplier-buyer relationship, the dominant firm can utilize its ability to influence the trading partner and behave in a way to preserve its power, whereas the inferior firm often has to comply in order to maintain its access to vital resources (Kumar et al. 1995; Touboulic et al. 2014). Consequently, firms with more power can capture a disproportionate share of the value created in an exchange relationship due to their dominant position (Cox 1999; Porter 1985).

However, the possession of power does not necessarily imply that power is also exerted (Kumar 2005). One reason is that the use of coercive power has been found to foster mistrust and inefficiencies in supply chains (Benton and Maloni 2005; Hingley et al. 2015; Maloni and Benton 2000). Thus, while a power imbalance can impede close cooperation as the dominant actor wants to maintain his position of power (Kähkönen 2014), there are also instances where dominant actors refrain from using their power to increase trust and establish highly functioning exchanges (He et al. 2013). This provides opportunities for less powerful firms, as they can demonstrate trustworthiness and pursue trust-based strategies to compensate power differences and maintain critical resource access (Jones et al. 2014; Ireland and Webb 2007).

3.3 Digital servitization disruption on power structures in supply chains

Digital servitization has opened up new opportunities for value creation and appropriation, particularly for manufacturing firms (Rymaszewska et al. 2017). Thereby, manufacturers pursuing a digital servitization strategy are likely confronted with changing critical resources, as they must not only shift from largely product-centric to user-centric business models, as in the case of traditional servitization, but further transform towards more data-centric business models (Cenamor et al. 2017; Kohtamäki et al. 2019; Tian et al. 2021). Yet, attempts to gain control over emerging critical resources can have unintentional consequences, such as the formation of novel dependencies (Pfeffer and Salancik 1978). Accordingly, the disruptions caused by digital servitization may affect the power base of manufacturing firms and result in a consequent recalibration of supply chain interdependencies (Bustinza et al. 2013).

Along with digital capabilities (Ardolino et al. 2018), one of the vital resources for successful DPSS deployment is access to end-users (Porter and Heppelmann 2014). While close end-user relationships have already played an important role in traditional PSS offerings (Wise and Baumgartner 1999; Stabell and Fjeldstad 1998), its relevance for the provision of DPSS appears to further increase (Vendrell-Herrero et al. 2017). First, in order to develop DPSS in the first place, manufacturers need to understand how and in which conditions their product is utilized by its users (Naik et al. 2020). Second, having closer connections to end-users is important in establishing a trustful relationship that facilitates data sharing (Kamp et al. 2017) and gain the opportunity to harness and analyze large quantities of user data (Neely 2008). A prominent example that demonstrates the benefits of owning end-customer interactions when transforming from a producer of physical products to a provider of DPSS is John Deere. In 2012, the farm equipment manufacturer introduced its open platform MyJohnDeere, where machine, attachment, and position data are centralized via telematics solutions and combined with historical data on soil conditions, weather, etc. to provide farmers with a comprehensive virtual management system (Perlman 2017). By offering the digital service free of charge and leveraging its direct access to a large end-user network, MyJohnDeere has quickly become one of the dominant platforms in the agricultural sector, whereby the equipment manufacturer obtained control over end-user data and reinforced its dominant market position (Pham and Stack 2018). Consequently, downstream firms are in a prominent position to capture additional value from the new possibilities provided by digital servitization, as they control the strategically important relationship with end users and, subsequently, also have easier access to product usage and related customer data (Vendrell-Herrero et al. 2017).

In contrast, the development of DPSS seems to be far more challenging for manufacturing firms further up in the supply chain, as they are positioned far away from end-users. While upstream firms such a component suppliers can respond to these disruptions by trying to leverage organization-based power sources like superior knowledge in the development and production of physical components (Finne et al. 2015), the relevance of physical materiality and with it the basis of the associated power sources is deteriorating in a digitally servitized supply chains and being

replaced by an increasing importance of software solutions (Porter and Heppelmann, 2014, 2015). This also results in the entrance of new and powerful suppliers from the information technology sector like Google that possess the critical software know-how (e.g. for autonomous driving applications), further diminishing the power position of traditional suppliers (Porter and Heppelmann, 2014).

4. Methodology

4.1 Research design

Given the nature of our research questions, we employed an exploratory single case study approach. Case study research is an increasingly popular qualitative research approach in management literature (Piekkari et al. 2009) and ideally suited for the investigation of important emerging phenomena, which have not yet been comprehensively studied (Gebauer et al. 2020; Gibbert et al. 2008; Yin 2018). Following Yin (2018, p. 15), a case study “investigates a contemporary phenomenon (the ‘case’) in depth and within its real-world context.” Gerring (2004, p. 342) further specifies the single case study as “an intensive study of a single unit for the purpose of understanding a larger class of (similar) units.” The choice of a single case study enables a profound investigation of the underlying case and offers the possibility to describe the procedure in great detail, resulting in a high degree of transparency and comprehensibility (Dyer Jr and Wilkins 1991). Applied to our case, it offers a deeper understanding and more persuasive way (Siggelkow 2007) to discuss the mechanisms of power formation in supply chains against the background of RDT than broad empirical research methods do.

We followed the process of inductive theory building from case studies (Eisenhardt 1989; Welch et al. 2011), which is rooted in grounded theory (Glaser and Strauss 1967). The theory is grounded, as it derives from data and emerges out of the interplay between researchers and data (Strauss and Corbin 1998). Placing the grounded theory concept of constantly comparing data and theory throughout data collection and analysis at the center of attention, inductive theory building is ideally suited to develop novel theory that is testable and empirically valid (Eisenhardt 1989).

4.2 Research setting and case description

The impact of digital servitization is particularly visible in manufacturing, where value was traditionally created by physical materiality (Yoo et al. 2010). New digital technologies, which enable autonomous driving or platforms gain increasing attention and diffuse into industrial mobility applications (Pham and Stack 2018). Thereby, not only OEMs, but also material and component suppliers strive to participate in this new business field.

Consequently, we investigated a division of a large European industrial supplier of powertrain technology (hereafter labelled as PowerTrain SE) covering a multitude of industrial mobility and stationary applications within different business units in order to holistically grasp the digital servitization phenomenon and its impact on the power structure in an industrial supply chain. Due to its extensive product portfolio and diverse customer base, the findings from PowerTrain SE may be applicable to a larger group of suppliers within the industrial sector. In addition, PowerTrain SE enabled us to investigate the digital servitization phenomenon in an industrial supplier's organization previously inaccessible to researchers, which made it an ideal and revelatory case study subject (Seuring 2008; Yin 2018). While the business units are quite heterogeneous, they possess common characteristics like mature customer markets, long established customer relations, and mostly large OEM customers. The traditional business model of PowerTrain SE presents itself as a buy-and-sell relationship to OEMs. For the majority of the business units, aftermarket occupies a noteworthy share of the overall revenues. Thus, end-user interaction with fleet operators and consumers partially exists, but is mainly limited to reactive service activities. Starting in 2016, efforts to digitally servitize were intensified with the launch of various projects to develop software add-ons for their physical products, enabling DPSS offerings.

4.3 Dataset

Following Yin (2018), our results are based on three different data sources. First, we gathered our main results from 18 semi-structured expert interviews in German and English language conducted between June 2019 and March 2020. Second, we

included internal documentations such as e-mails, presentations, and other records related to DPSS projects as well as protocols from direct observations over a three-year period from seven workshops, 19 project meetings, and two fair visits to enrich our interview data. Third, we integrated archival records (i.e. annual reports and media reports) in our analysis to view the phenomenon comprehensively from different angles (Gibbert et al. 2008).

The selection process of our interview partners followed the approach of purposeful sampling (Lincoln and Guba 1985; Corley and Gioia 2004). We chose our informants based on the assumption about who would be most appropriate to answer our research questions. We started our interviews with key informants – two employees from the corporate strategy department – who had a profound overview and insight into all DPSS projects within PowerTrain SE. Additionally, by using snowballing technique, we asked them to recommend further suitable interlocutors from ongoing DPSS development projects. All representatives were required to have a detailed understanding of the case firm’s digital servitization projects, act in a responsible position, and be aware of the underlying interaction with OEMs and other relevant stakeholders. In order to draw an encompassing picture, we chose interviewees with diverse backgrounds and from different business units, ranging from project and sales managers over head of communication to head of engineering (see Table 1). Central to our study were managers who headed data analytics or digitalization departments in the various business units, as they were able to provide detailed insights into data-specific topics in DPSS projects that are particularly relevant to our research questions. In addition, we paid special attention to the executive board since top managers are critical actors in the perception of organizational change (Corley and Gioia 2004).

Table 1. Overview of interview partners.

Expert	Department	Position	Expert	Department	Position
1	Executive board	Head of division	10	Business unit A	Head of data analytics
2	Executive board	Head of division	11	Business unit A	Project manager
3	Central department	Head of strategy	12	Business unit A	Sales manager
4	Central department	Corporate strategist	13	Business unit A	Head of communication
5	Central department	Corporate strategist	14	Business unit B	Business developer
6	Central department	Business developer	15	Business unit B	Head of digital engineer.
7	Central department	Head of project house	16	Business unit C	Head of pre-development
8	Central department	Head of project house	17	Business unit D	Head of digitalization
9	Aftermarket	Head of Connectivity	18	Business unit D	Head of data analytics

Each interview was executed and subsequently coded by the first two authors and lasted on average 50 minutes. The majority of the interviews were conducted face-to-face. As the workplaces of informants were spread all over Europe, some interviews were carried out by telephone. We stopped expanding our dataset when we reached theoretical saturation (Strauss and Corbin 1998). We used a self-developed template with five thematic blocks to guide through the interview. Each interviewee was asked to describe (1) the current business model, (2) the drivers of digital servitization, (3) how digital servitization affects power structures in the supply chain, (4) which associated problems and disruptions occur during the process of digital servitization, and (5) which strategic responses are being applied. We often adapted the questions within these five thematic blocks in order to let the phenomenon itself surface. All interviews were recorded and transcribed verbatim. We used the software MAXQDA 2018 for the documentation of the coding process consisting of 318 full text interview pages, 92 full text pages of internal documentations, and 81 full text pages of external archival records relevant to digital servitization efforts, containing overall 1167 single codings.

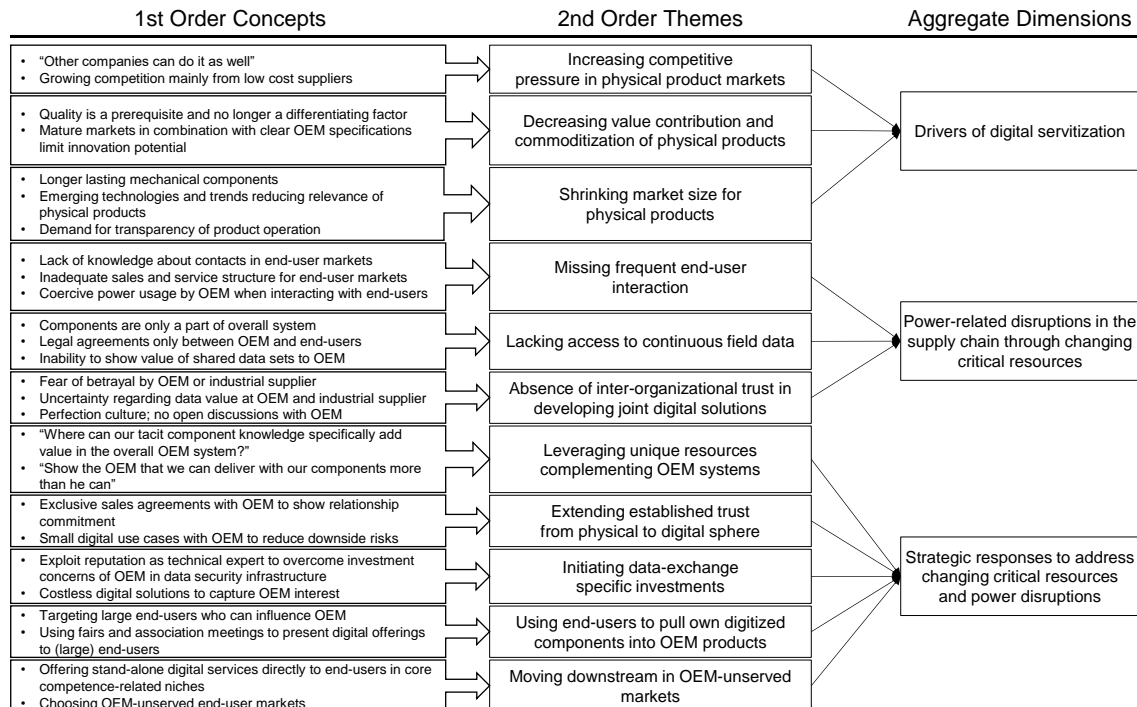
4.4 Data analysis

We applied the widely used three step procedure proposed by Gioia et al. (2013) to progress systematically from raw data to theoretical constructs while executing qualitative rigor. First, both researchers read through the transcribed interviews and protocols without any pre-coding scheme and generated codes of statements that were considered relevant with regard to our stated research questions. The open and inductive coding has led to the creation of in-vivo codes, meaning that words and terms of the interviewees are so remarkable that they are used as codes (Corbin and Strauss 2008). During this first step of analysis, deviations in our coding were discussed until agreement was reached in order to create a common first-order concept scheme, which emerges from the data itself. We coded each interview immediately after conducting and constantly adjusted our coding scheme throughout the whole data collection (Smith et al. 1996). Second, we searched for commonalities and variations among the first-order concepts using axial coding to generate second-

order themes, which are the results of the researcher’s interpretations and emerge, therefore, from the researchers themselves. Third, we aggregated the elaborated second-order themes to create distilled dimensions.

In order to lay the foundation for analysing the power structures in supply chains through digital servitization and its associated changing critical resources, we first had to understand why the case firm decided to strategically invest into digital servitization efforts. Therefore, we structured our data into three parts: (1) drivers of digital servitization, (2) change in critical resources, and (3) response strategies to address those changing critical resources (see Figure 1).

Figure 1. Process of abstracting from raw data to insights.



In order to ensure validity and reliability of our data, we followed a threefold approach: First, similar to Ulaga and Reinartz (2011), we asked two independent researchers from our faculty to review our coding structure and verbatim transcripts. For this purpose, they first assigned randomly sorted first-order constructs to second-order themes. Then they coded fifteen randomly selected passages relevant for our data structure from varying interviews by using the second-order themes. In assessing

the reliability between judgements, we applied the index developed by Perreault Jr and Leigh (1989), which reached .89 for the data structure assessment and .85 for the coding evaluation, both well above the threshold of .70 required for exploratory studies. Any disagreements were discussed until consensus was reached. Second, throughout the whole data analysis process, we debated the data structure with two corporate developers from our case firm in order to avoid an over-interpretation of our results. Third, we discussed our framework in a workshop setting with the board of directors and other senior executives after the completion of data collection in order to further strengthening the validity of our data construct.

5. Results

5.1 Initial situation and drivers of digital servitization

PowerTrain SE is regarded as a premium provider of industrial technology equipment. However, low-cost providers have started to catch up and have reached a level of quality that partially rivals that of premium suppliers. While the industrial supplier is still an innovation leader for most of its physical industrial components, parts of the product portfolio seem to have a decreasing value contribution. In most customer markets of PowerTrain SE, there has already been some form of consolidation, resulting in concentrated markets with a few large and dominating OEM customers. Thereby, OEMs exert their power advantage by trying to keep their suppliers interchangeable via the definition of clear component requirements. Consequently, the potential to differentiate becomes increasingly limited, leading to a commoditization of physical products.

“Our field of innovation is rather limited because of the relation with the [OEM] customer. [...] It is our [OEM] customers that say what they want and it’s hard to compete then. In the end they want to pay certain euros per kilogram powertrain component and then differentiating is difficult so it becomes a price game and you become a commodity.” (Expert 17)

Among other trends, the emergence of monitoring systems and predictive maintenance solutions, ensures that components are operated and maintained at an optimal capacity, which results in a longer product lifetime. This in turn would cause a significant reduction in the sales of spare parts, which represents one of the most

profitable business segments. In conjunction with longer lasting components due to technological advances, it is evident that the market size of physical products is shrinking, further reinforcing competitive pressure. Accordingly, knowledge in the development of physical components is becoming less valuable.

“Well, it's like this, if you talk about value now, the knowledge in the traditional field is becoming less valuable. So you have to compensate in some way. [...] If I have nothing there, I can't sell anything and my company is worth nothing. Novel know-how has to be generated for new trends [...] such as connectivity, Internet of Things [...], and also the technologies around autonomous driving and everything that is connected to it. That fills our asset base again at the end of the day.” (Expert 7)

In order to avoid being trapped in a vicious cycle of increasing competition in physical markets in conjunction with a diminishing value contribution and shrinking market size, the management of PowerTrain SE has decided to launch systematically different projects in which DPSS are developed. Thereby, PowerTrain SE strives to compensate the decreasing revenue from physical component sales by introducing new digital service add-ons.

“The change is that we try to secure the traditional business and to market additional add-ons based on it, [...] e.g. in the direction of predictions, data analytics, there is already a lot to read out or provide [...]. All this is very service-intensive in order to have this compensatory effect.” (Expert 4)

5.2 Power-related disruptions in the supply chain through changing critical resources

However, during the development of DPSS, obstacles have emerged that were not necessarily linked to technological issues but rather to other actors within the supply chain. Contrary to the past, where PowerTrain SE would just sell components to OEMs, close and frequent end-user interaction now constitutes a critical resource to develop and launch DPSS. End-users must be involved early in the development process to identify their pain points and understand where a DPSS can add value. Besides, PowerTrain SE needs to be aware of the application areas in which the product is used in order to provide accurate and reliable digital service add-ons.

According to one Executive Board member, however, there is a lack of knowledge about end-customer markets despite sporadic end-user contact in the aftermarket.

“Do we need more end-customer contact when developing our digital products in order to better understand the end-customer? Then I say yes. Because we also offer analysis services with digital products, which of course are much closer to the end-customer. [...] We need to understand the application area of the product and the needs of the end customer.” (Expert 2)

However, the management of PowerTrain SE is reluctant to address this issue and engage with end-users on a large scale, as it fears the consequences this might have on the business relationship with its OEM customers.

“An OEM would react to that and say, ok, if you now serve end-users, which is actually my business, then I will deduct the project from your account. He wouldn't say that directly, but he would do it.” (Expert 4)

As PowerTrain SE still generates the vast majority of its revenue by selling physical products to OEMs, such adverse consequences are detrimental to its core business. This relates in particular to large OEM customers, who have the digital capabilities and resources to develop DPSS without being reliant on suppliers. On the contrary, for PowerTrain SE it is difficult to offer DPSS on its own, as it can provide digital services only for specific components and not for the entire end-product.

“It doesn't benefit the end user, if [our component] holds up well and the rest of the vehicle breaks all the time. So, it has to be an overall solution for the entire vehicle and we have the competence for just one piece of the puzzle. [...] We are simply one too low in the food chain.” (Expert 10)

By assembling the end-product, OEMs control another critical resource to be competitive in a digital market: continuous access to product usage data. Up to now, the industrial supplier has only been able to access product usage data in case of repair orders in the aftermarket. Although PowerTrain SE has the technical capabilities to transfer data from its components, it is not permitted to do so once they are in use, because OEMs generally hold exclusive legal rights for data usage and are generally unwilling to share data.

“Someone told them that data is the new gold. Well, and nobody likes to share gold. I think there's just a lot of emotion behind it [...] and of course, why should I [OEM] give away my data? I'd rather do it myself.” (Expert 8)

There are mainly three reasons why OEMs refrain from sharing data. First, OEMs can offer many digital services without necessarily depending on the involvement of a component supplier, as they have at least basic knowledge on the operability of most diagnosis-relevant components. Second, data exchange is a complex issue due to the specification of legal terms, alignment of data formats, and establishment of a reliable data connection. Thus, OEMs need to undertake costly efforts to set up a data-sharing infrastructure. Third, due to lack of experience and knowledge the value of data is still often difficult to determine for OEMs. This results in a dilemma, where access to data is not granted by OEMs, but necessary for the supplier to show OEMs the benefits of sharing data.

“To a certain extent we have a chicken-or-egg problem, because you can only develop a digital business model if you know what to do with the data. If you don't have any data, it's difficult to estimate in advance. In some places you go around in circles. [...] The common thing for us is that we are dependent on the vehicle manufacturer, which means that if he does not provide us with any data, we are completely powerless.” (Expert 10)

In addition, the uncertainty regarding data value leads to a latent fear that one party could benefit more from sharing data than the other, cumulating in reciprocal mistrust.

“[OEMs] do not really know what the value of the data is. [...] What if they give data to the supplier and he will use it to compete with them? How do they assure that they get enough back?” (Expert 17)

If OEMs mistrust PowerTrain SE or vice versa, the establishment of data exchange becomes impractical or very restrictive, which results in the inability of PowerTrain SE to offer digital services add-ons. Hence, trust plays an essential role in the development process of DPSS.

“If you want to develop analytics, the value is often in bringing different data sets together and doing an analysis on the combined data set. In that respect you both have to give something in and that involves trust.” (Expert 18)

However, this circumstance is not true for the entire OEM business. In the case of small OEM customers, PowerTrain SE is able to utilize digital servitization as a lever to become a system supplier of telematics solutions and hence sets the agenda

regarding the implementation of DPSS. Those generally lack digital competencies and financial means to develop DPSS without a strong business partner. Thus, small OEM customers are generally open to provide PowerTrain SE with end-user contacts and grant them data access in turn for assistance in digitizing their products and services. As a result, PowerTrain SE is able to improve its power position in these relationships. One member of the Executive Board describes the two different power constellations that are relevant for PowerTrain SE as follows.

“There are very large [OEMs] that are trying to expand their power and create an ecosystem where they fully captivate their customers [...]. They only let us participate as a suppressed player. And then there are also those who are not so dominant, who often operate in smaller markets, who cannot afford to do something like that and are very open to the idea of doing something together. This is where we can actually position ourselves even stronger than before. Thus, there are two cases [...].” (Expert 1)

5.3 Strategic responses to power-related disruptions of digital servitization

Two fundamentally different constellations between PowerTrain SE and its OEM customers have emerged. On the one hand, in relations with smaller OEMs, PowerTrain SE can increase its power through digital servitization. On the other hand, the dominance of already powerful OEM customers is reinforced, which is a major concern for the management of the case company.

To counteract this power shift in the latter of the two cases, PowerTrain SE has tried to systematically identify unique and critical resources that can be leveraged to re-gain power in a digital servitization context. While the ability to produce high-quality physical components has become less valuable, in-depth knowledge regarding the operability and permissible thresholds of its components may have become more important. To provide a predictive maintenance solution, the ability to accurately predict when a component is about to break is crucial. Thus, for components that are complex and critical to the overall system PowerTrain SE can utilize its knowledge and demonstrate its ability to enhance DPSS offerings of OEMs.

“[Our components] are often critical components that have a high thermal load during operation [...] and we have the deep know-how for thermal management on our side. Of course, the vehicle manufacturer has a certain basic idea about this, but only we know the components in detail, [e.g.] which temperature peaks are

permissible, that is our know-how, our competence. [...] Our approach is to show him that we can do much more with the data than what he [OEM] can do himself.” (Expert 10)

In order to demonstrate the value that PowerTrain SE can add to the service offerings of its OEM customers, it needs to establish trust in its abilities and intentions. Alongside long-standing partnerships, small scale use cases are particularly helpful to build bridges between the two parties. However, often the weaker actor has to take the first step to create a first delicate plant of trust. One measure to build such a first layer of trust is by entering into exclusive service contracts with specific OEMs in traditional markets.

“That’s their ambition in the partnership to get more exclusivity with us. We would not do that without them, nor would we do it with competitors or even alone. [...] That’s one potential way to hopefully overcome that [mistrust].” (Expert 17)

To further underline the commitment to a combined solution, the industrial supplier has decided to initially offer certain digital services free of charge to its OEM customers. Even though, the industrial supplier would offer digital services without receiving any initial compensation, OEMs still have to undertake relationship-specific investments in order to enable data exchange. While this might prevent some OEMs from committing to a cooperative solution, it strengthens the ties between the two parties, if successful. Only once the value is apparent to both parties, a discussion about a financial compensation may start.

“We are not yet discussing with the [OEM]-customer that we want to see money sometime when we offer services there. That is still completely out of question.” (Expert 10)

There are also some markets, where only a few, large end-users exist and have a dominant bargaining position vis-à-vis OEMs. Therefore, they possess power to influence the design of the end-product and which components it contains. In these markets, PowerTrain SE has decided to strategically approach end-users or actors with significant influence on end-users (e.g. federations) to promote its DPSS. If end-users are convinced and demand the DPSS, uncooperative OEMs are forced to integrate these solutions into their offerings.

“If we manage to offer condition monitoring or other services to the end-user, then in future we will be able to influence them so that they will prefer our products [in the OEM’s overall system].” (Expert 14)

At the same time, PowerTrain SE tries to reduce the dependence on OEMs by moving downstream in business fields that are un-served by its OEM customers. These markets are mostly niche markets that are unattractive for large OEMs to enter, avoiding competition with current OEM customers. However, for PowerTrain SE these business relations constitute an important building block for gaining knowledge about end-user markets and positioning oneself as reliable partner to end-users. In doing so, PowerTrain SE seeks not only to offer digital service add-ons to its primary products, but rather to develop digital services that are unrelated to the existing product portfolio.

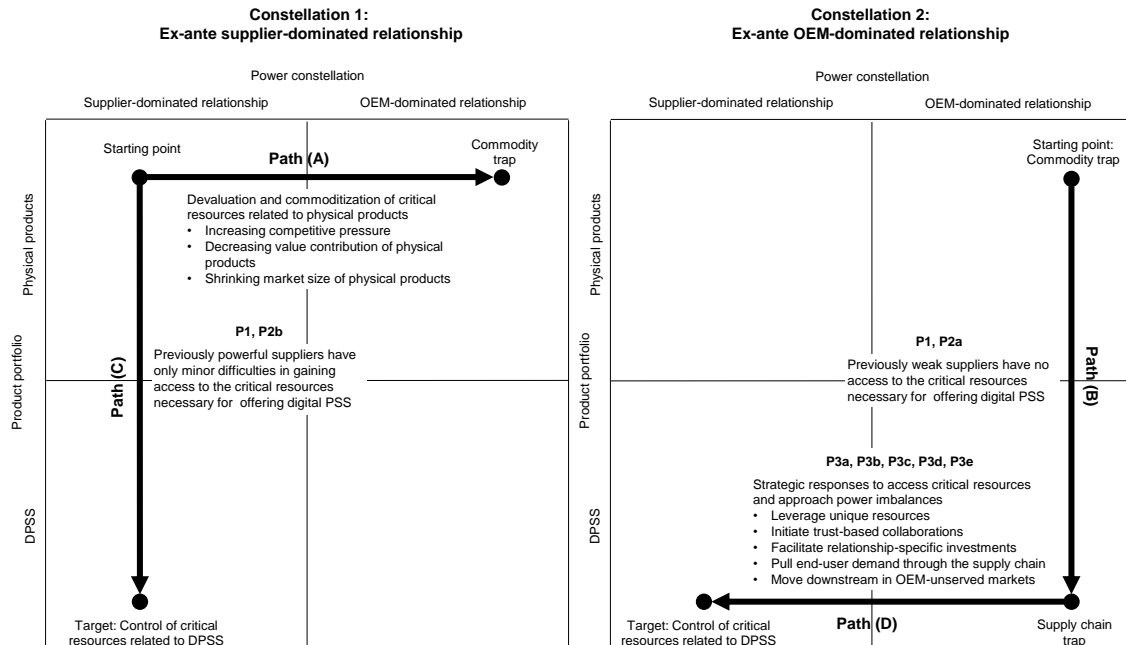
“First of all, we try to secure the core business. The second is to open a separate channel, where you take care of exactly these issue [OEM dependence], which are not necessarily related to the primary product, so you don't build a solution around a powertrain component, but you create a new market for yourself.” (Expert 4)

6. Discussion

Digital servitization is emerging as an increasingly prevalent phenomenon in both practice and academic research. Yet, insights about the disruptive potential of digital servitization on power structures are still elusive (Kohtamäki et al. 2019), especially regarding actors far upstream the supply chain. Addressing this research need and extending the literature on power structures in digital servitization settings (Vendrell-Herrero et al. 2017; Huikkola et al. 2020), our case study uses RDT to investigate (1) effects of digital servitization on the power constellations between an industrial supplier and its OEM customers, and (2) strategic responses of an industrial supplier to extend or re-gain power. Building on our case results, we derive eight propositions based on two scenarios of an ex ante supplier-dominated or OEM-dominated relationship, which are illustrated in Figure 2 and will be elaborated in the following sections. We start by describing how the industrial supplier has already moved into the commodity trap in some markets. Thereafter, we discuss how the power relations between OEM customers and industrial suppliers caught in the commodity trap are affected by digital servitization. We also show how this differs in cases where the

industrial supplier is more dominant than OEM customers (Constellation 1). Lastly, we outline strategic responses for weak industrial suppliers in order to shift towards a more supplier-dominated power relation with OEM customers (Constellation 2).

Figure 2. Overview of power constellations and propositions.



6.1 Understanding digital servitization efforts

PowerTrain SE is considered a premium supplier of industrial technology with advanced knowledge in the production and development of complex powertrain components, which enabled it to achieve a dominant position towards OEM customers in some markets. However, PowerTrain SE is increasingly operating in mature markets, where the innovation potential for physical components is limited due to their advanced stage of development and specifications given by OEM customers. This has already led to a commoditization of product technology and its applications. Yet, obligatory product-related services in form of maintenance and repair does not appear to be a sustainable measure to differentiate from competitors (Matthyssens and Vandenbempt 2008), as traditional service offerings have – at least in our case – also become commoditized. As a result, it becomes increasingly difficult

for our case firm to differentiate from low-cost competitors and in some instances, it has already lost its once dominant market position. In addition, emerging trends such as the transition to big data analytics and artificial intelligence affect the revenue potential of physical product suppliers in the industrial sector. In particular, these trends tend to reduce the spare parts required, as, for instance, DPSS like monitoring or predictive maintenance solutions prolong the product lifetime.

Thus, the viability of PowerTrain SE is threatened, since the relevance of once critical resources in form of knowledge regarding the production of high-quality physical components diminishes, deteriorating its standing in the supply chain and shifting power towards OEM customers (Cox et al. 2002; Pfeffer and Salancik 1978) (see Fig 2: Constellation 1, path (A)). Since the pursuit of cost leadership to withstand competition is not viable for a European supplier of premium powertrain technology due to its cost structure, PowerTrain SE has decided to pursue a digital servitization strategy to compensate for the decreasing value contribution of once critical resources related to physical products and avoid moving further into the commodity trap.

6.2 Digital servitization and power disruptions

While studies have so far primarily focused on the development of digital capabilities as a key prerequisite for the successful transformation from a manufacturer of physical products to a provider of DPSS (Ardolino et al. 2018; Ritter and Pedersen 2020), we identify three additional emerging resources that are critical to the provision of DPSS for the case firm: frequent end-user access, continuous access to product usage data, and inter-organizational trust with OEM customers.

The importance of close end-user ties has substantially increased as DPSS like predictive maintenance solutions require knowledge of the conditions at the point of use (Porter and Heppelmann 2014). Specifically, frequent end-user interaction enables the industrial supplier to understand end-users' pain points and integrate them into iterative development processes to create value for end-users. Once the DPSS is in use, continuous access to product usage data is required to understand end-user behavior and to be able to continuously improve, adjust, and derive additional DPSS offerings, aiming to support the end-users' success (Rymaszewska et al. 2017;

Loebbecke and Picot 2015). Consequently, continuous access to product usage data allows more proactive DPSS offerings, creating additional revenue potential (Baines et al. 2009). However, the industrial supplier typically delivers only a limited number of components for a complete solution to OEMs, while OEMs combine the different components in the end-product (e.g. a smart tractor) and integrate telematic solutions to permit a continuous data transfer. This forces PowerTrain SE to collaborate with OEMs in order to offer a DPSS, as it relies on them to gain data access. For the industrial supplier it is therefore critical to establish inter-organizational trust with OEMs in order to initiate data exchange agreements (Lee and Whang 2004; Tronvoll et al. 2020) and offer DPSS in the first place. Accordingly, a lack of control over any of the three identified critical resources will reduce the revenue potential of DPSS or completely prevents its development. For instance, if frequent interaction with the end-user is not possible, then there is no way to develop a DPSS that matches the actual end-user needs and creates value, as the sole access to product usage data and trustful relationship with the OEM cannot completely compensate for this. Therefore, the three identified novel critical resources form an interdependent construct, leading us to our first proposition:

Proposition 1: *In order to successfully offer digitalized product-service systems, industrial suppliers need to gain access to emerging critical resources in the form of frequent end-user interaction, continuous access to product usage data, and inter-organizational trust with OEM customers.*

As a consequence of this shift in critical resource needs, novel interdependencies within a supply chain are potentially emerging and disrupting existing power structures (Cox et al. 2002). While Vendrell-Herrero et al. (2017) argue that digital servitization increases the relative dependence of upstream on downstream firms, we find that a more nuanced perspective is required to better understand the impact of digital servitization on the power balance within a supply chain. According to our results, the impact of digital servitization on the power balance between OEMs and suppliers depends rather on the power structure between both prior to the advent of digital servitization as it determines the influence one can exert to gain control over novel critical resources. Consequently, the ex-ante distribution of power is central to explain the impact of digital servitization on power structures.

In markets where the industrial supplier is already caught in the commodity trap and hence in a weaker position vis-à-vis OEMs prior to the introduction of DPSS (see Constellation 2 in Figure 2), the given power structure seems to be further reinforced. Powerful OEMs are generally able to develop DPSS on their own, as they are often large corporations with sufficient financial means to develop digital capabilities and digitalize their PSS offerings. Moreover, OEMs typically act as direct point of contact for end-users. They are therefore centrally located in the supply chain network and are able to control the strategically important relationship with end-users. Hence, the central network position is an important power source in a digitally servitized supply chain (Kähkönen and Virolainen 2011), as it enables easy access to emerging critical resources in form of frequent end-user interaction and continuous access to product usage data.

As a result, it is extremely challenging for firms far upstream the supply chain such as PowerTrain SE to gain access to emerging critical resources. If PowerTrain SE attempts to approach end-users in order to develop DPSS, OEM customers generally exploit their dominant position in the network to prevent the industrial supplier from interacting with end-users by using coercive power (i.e. threatening to cancel their sales orders). Therefore, the OEM's control of organization-specific (digital capabilities) and in particular network-specific power sources (end-user interface and data access) restricts the industrial suppliers' alternatives to develop DPSS on its own and further increases its dependence on already dominant OEMs.

Thus, in the case of more powerful OEMs prior to digital servitization, power asymmetry seems to further shift towards OEMs with the onset of digital servitization efforts, as it leaves industrial suppliers trapped in the supply chain behind OEMs (see Figure 2: Constellation 2, path (B)).

Proposition 2a: *When industrial suppliers hold less power than their OEM customers before the advent of digitalized product-service systems, the inability to gain control over critical resources related to digital servitization will reinforce given power structures.*

However, in markets where the industrial supplier is still in a more powerful position before the implementation of DPSS (Constellation 1 in Figure 2), weaker OEMs are generally inclined to provide the supplier with access to end-users and product usage

data. This is the case when OEMs either do not possess the financial means and digital capabilities to develop DPSS by themselves or have strategically decided to outsource DPSS development projects to suppliers. Hence, weak OEMs become more dependent on PowerTrain SE as they need a capable business partner to provide them with telematics solutions and data analytics capabilities to enable the provision of DPSS solutions. Thereby, PowerTrain SE is able to improve its power position and exert more influence over the supply chain, as it gains control over end-user interaction and product usage data. But unlike a powerful OEM, the industrial supplier does not utilize coercive power forcing the weaker OEM to take a smaller share of the DPSS sales, as the industrial supplier is still interested in maintaining a trustful relationship in order to share risks while gaining knowledge of end-user markets. Nonetheless, as the successful deployment of new services is generally related to the degree of control a manufacturer can exert over a service value chain (Raynor and Christensen 2002), this enables the industrial supplier to succeed in its digital servitization efforts and increase its dominance (see Figure 2: Constellation 1, path (C)).

***Proposition 2b:** When industrial suppliers hold more power than their OEM customers before the advent of digitalized product-service systems, the ability to gain control over critical resources related to digital servitization will reinforce given power structures.*

6.3 Strategic responses to power imbalances

For industrial suppliers that are positioned in the quadrant of OEM-dominated DPSS, the objective should be to shift power relations toward or, ideally, into the supplier-dominated DPSS quadrant. (see Figure 2: Constellation 2, path (D)). To achieve this, industrial suppliers can either increase the dependence of OEMs on them or reduce their own dependence on OEMs (Cox et al. 2002). In addition, suppliers may also utilize trust-based strategies to compensate for a lack of power and maintain access to vital resources (Ireland and Webb 2007). Related to these mechanisms, we have identified five specific strategies that PowerTrain SE utilizes to exploit novel opportunities in a digitally servitized supply chain and improve its power position (see Table 2).

Table 2. Strategic responses of industrial supplier to address power imbalances in digitally servitized supply chains.

Focus point	Strategic response	Specific action to realize strategic response	Mechanism
OEM	a. Leverage DPSS-critical component knowledge	Utilize tacit knowledge about the load profiles and fatigue patterns of complex components to add value to the DPSS of OEMs.	Increase relative dependence of OEMs
	b. Facilitate data-exchange specific investments	Develop a joint data sharing infrastructure with OEMs by offering digital services free of charge to build-up switching costs.	Increase relative dependence of OEMs
	c. Signal relationship commitment in traditional service offerings	Commit to exclusive contracts with specific OEMs in traditional service markets to signal relationship commitment and jointly transform these services into DPSS.	Build inter-organizational trust to compensate lack of power
End-user	d. Exploit empowered end-users to pull demand through the supply chain	Directly engaging with end-users to create a demand for an industrial supplier's DPSS, in order to force OEM customers to implement the DPSS into their offerings.	Decrease relative dependence on OEMs
	e. Move downstream in OEM-unserved markets	Go downstream in OEM-unserved markets to create new revenue streams by selling DPSS to end-users and avoid competition with current OEM customers.	Decrease relative dependence on OEMs

To re-balance power relations, the industrial supplier tries to leverage its unique knowledge about components that are critical to the accurate and reliable provision of DPSS (Ulaga and Reinartz 2011; Finne et al. 2015). When providing a predictive maintenance solution, it is essential to have adequate knowledge to predict when a certain component is going to fail. However, OEMs often lack high-end component knowledge, as they have outsourced large parts of the component production, causing a lack of necessary engineering capabilities (Takeishi 2001). Likewise, while Power Train SE has disadvantages in the development of new software solutions compared to novel market participants from the information technology sector such as Google, these new participants lack sufficient knowledge about the load profiles, fatigue patterns, and permissible thresholds of physical components. Particularly, for complex components such as gearboxes or engines, this domain knowledge enables the industrial supplier to more accurately predict component failures. Hence, while the relevance of physical materiality likely decreases in a digitally servitized supply

chain (Porter and Heppelmann 2014), the knowledge about the operability of physical components remains critical when combined with sufficient analytics capabilities to enable accurate and reliable predictive maintenance solutions. Consequently, in cases where the case firm delivers a sufficiently complex component that constitutes a critical part of the overall system, OEMs depend on the tacit component knowledge of PowerTrain SE to provide a DPSS offering covering the entire end-product.

Proposition 3a: *By leveraging the implicit knowledge of complex physical components integrated in digitalized product-service systems, industrial suppliers can increase the relative dependence of their OEM customers.*

The joint development and provision of DPSS requires the development of a common data sharing infrastructure (Porter and Heppelmann 2014), which entails considerable investments for the involved actors. Given that there are still hardly any uniform data formats, structures, and interfaces in most manufacturing industries, these investments are often tied to the relationship with a certain OEM, thereby creating relation-specific digital assets (Kamalaldin et al. 2020). In this respect, digital services underlying DPSS differ significantly from traditional services, as close cooperation between the industrial supplier and its OEM customers is usually not essential for the provision of traditional services (e.g. repairs). Hence, the close cooperation required to develop joint DPPS offers the opportunity (or threat) to build-up switching costs and lock the involved parties into the relationship (Cox et al. 2002). Tian et al. (2021) support this by outlining a more sequential approach for upstream actors in their digital servitization transformation journey, focusing first on improving the collaboration to supply chain partners and then shifting to lock-in measures in the downstream part of the supply chain. PowerTrain SE tries to exploit this circumstance by offering its OEM customers certain digital service solutions free of charge in order to persuade them into setting up a joint data infrastructure and engage in regular interactions regarding DPSS projects. While this entails substantial investments on the industrial supplier-side with no immediate returns, the aim is to build up enough switching costs over time to establish mutual dependencies.

Proposition 3b: *By encouraging OEM customers to undertake data-exchange specific investments for the joint development of digitalized product-service systems, industrial suppliers can increase the relative dependence of their OEM customers.*

Since PowerTrain SE already has long-standing and trusting business relationships with its OEM customers in physical markets, it tries to exploit them (Obal 2013). However, this trust does not necessarily extend to DPSS, as a change of the underlying objective of a relationship can alter trust between partners (Otto and Obermaier 2009). Particularly, the uncertainty about the value of data and its applications seems to raise concerns that one party might betray the other, e.g. by using the data to compete with the other party. To address this issue, our case company tries to demonstrate its trustworthiness by making concessions in traditional service offerings and signal commitment to the business relationship. Hart and Saunders (1997, p. 33) state that “as one partner demonstrates confidence-inspiring behavior, we would expect that the other partner would reciprocate and practice similar behaviors.” Accordingly, PowerTrain SE guarantees exclusivity regarding traditional services like repair and maintenance to a particular OEM to signal relationship commitment and reaffirm OEM customer’s trust to potentially transform these traditional reactive services into joint DPSS such as remote monitoring or predictive maintenance solutions.

Proposition 3c: *By embracing a stronger commitment to a close partnership in traditional service offerings, industrial suppliers can reaffirm trust with their OEM customers regarding the joint development of digitalized product-service systems, thereby compensating power imbalances.*

In our case, however, some OEM customers were simply refusing to cooperate with the industrial supplier to maintain their position of power (Kähkönen 2014). Nevertheless, the increasing relevance of product usage and customer-related data may not only have strengthened the position of actors in control of end-user interfaces, but also empower the standing of end-users such as operators and consumers in the supply chain (Bustinza et al. 2013). This offers end-users the opportunity to exert more control over the supply chain. To exploit this, the industrial supplier applied a so-called pull strategy (Kotler et al. 1999). This means that our case

firm is engaging with end-users to convince them of the benefits of its DPSS, but is not selling them directly to end-users. Instead, if the industrial supplier is successful and end-users demand its DPSS (e.g. a monitoring solution for a component), they will pass the demand onto OEMs and force them to integrate the industrial supplier's DPSS into their offerings (e.g. a smart tractor). Thus, the demand of end-users "pulls through" the supply chain to the industrial supplier. Thereby, our case firm is able to sell its DPSS without moving downstream and bypassing the OEM as an intermediary, but rather indirectly forces OEMs to integrate its solution into the end-product. This approach offers the advantage that the industrial supplier does not necessarily circumvent OEMs and thus has to fear countermeasures from them, but remains in its upstream supply chain position and continues to leave the customer interface to OEMs. Since OEMs are typically less concerned about the sourcing of a certain component, as long as they get the sales order, PowerTrain SE can interact with end-users within the same supply chain without losing the trust of its OEM customers. However, this strategy is only meaningful in specific markets with large end-users (e.g. government entities) or end-user associations (e.g. machinery cooperatives), as the effort to approach a high number of individual end-users is impractical for the industrial supplier due to the missing sales network. In this regard, our case firm leverages conferences or fairs, association meetings, or contacts to governmental agencies in order to generate interest from large end-users for its DPSS.

***Proposition 3d:** By convincing powerful end-users or large end-user associations of their digitalized product-service system, industrial suppliers can force OEMs to incorporate it into the final system, reducing the dependence on OEM customers.*

Lastly, our case firm has chosen to move downstream, but only in markets outside of its current supply chain. While vertical repositioning is a common strategic response to (digital) servitization efforts (Huikkola et al. 2020; Rymaszewska et al. 2017; Wise and Baumgartner 1999), the role of power structures in strategic re-position moves is often neglected (Rabetino and Kohtamäki 2018). Yet, vertical repositioning usually involves contesting the position of other actors in the supply chain, potentially causing serious conflicts between them (Paiola and Gebauer 2020; Wise and Baumgartner 1999). Accordingly, PowerTrain SE fears that powerful OEMs may exert coercive power and cut or cancel their orders if the industrial supplier decides to

move downstream within its current supply chain. Thus, PowerTrain SE has decided to move downstream only in markets unattended by its OEM customers to avoid adverse effects on the physical product business and not undermine efforts to establish trust with OEM customers. As the sales of physical products to OEMs still constitutes its primary business model, the risk of losing this business for the - at least at first - relatively small sales from DPSS is not a valid option for the industrial supplier. Particularly, as the market for single component solutions is mostly limited to specific high-value components (e.g. engines), as end-users generally desire a solution for the complete product. Hence, the industrial supplier pursues such a re-positioning strategy only in markets currently unserved by OEM customers and even tries to develop digital services unrelated to its physical product portfolio in order to join different supply chain networks, thereby creating outside options (Malhotra and Gino 2011). To achieve this aim, the industrial supplier is working to establish close collaborations with new types of end-users to jointly develop DPSS that are niche applications now but have the potential to evolve into significant revenue contributors in the future.

***Proposition 3e:** By moving downstream into markets outside of the current supply chain, industrial suppliers can reduce the dependence on OEM customers without incurring negative repercussions.*

7. Conclusion

While the research focus in the literature on digital servitization has so far been on OEMs or commercial end-users (Paiola and Gebauer, 2020), we explicitly adopt the perspective of an industrial supplier of powertrain technology and investigate through the lens of resource dependence theory how digital servitization disrupts the power structures between an industrial supplier and its OEM customers as well as outline specific response strategies. Thereby, we especially react to the research needs expressed by Kohtamäki et al. (2019) urging to better understand how digital servitization alters power constellations in different sections of the supply chain, and Li et al. (2020) demanding more theory grounded research in digital servitization literature.

7.1 Theoretical implications

Our first contribution is that we highlight three emerging novel critical resources for industrial suppliers in the form of frequent end-user interaction, continuous access to product usage data, and inter-organizational trust with OEM customers, which are critical to succeed in digital servitization efforts. By linking these critical resources to different levels of power sources, we enrich existing digital servitization literature with findings from conceptual power regime works and outline that digital servitization does particularly increase the relevance of network-level power sources such as the control over strategic relationships. Second, we refine and specify the notion of Vendrell-Herrero et al. (2017) that digital servitization favors per se downstream actors, as we show that digital servitization shifts power to supply chain actors that are more dominant prior to the advent of digital servitization. Specifically, dominant actors are able to exert influence over the digital service value chain, as they gain control over emerging network-level resources and thereby can exclude other actors from accessing them to further reinforce their supply chain standing. Therefore, we conclude that digital servitization is at least initially reinforcing rather than dissolving (Holmström et al. 2019) given power structures between industrial suppliers and its OEM customers. Third, we contribute to the literature on strategic responses to power disruptions of digital servitization (Vendrell-Herrero et al. 2017; Huikkola et al. 2020; Finne et al. 2015) by identifying five specific strategies related to established mechanisms in power regimes that non-dominant industrial suppliers can pursue to combat power imbalances without fearing adverse effects on the business relationship with OEMs. In this way, we complement the literature by outlining alternative strategies to the often-cited moving downstream narrative that do not require a re-positioning in the focal supply chain and still provide access to critical resources related to digital servitization.

7.2 Managerial implications

Turning digital servitization into a success story poses a number of challenges for managers, particularly in product-centric firms upstream in the supply chain. Our study offers a guide by providing a comprehensive picture of the digital servitization

journey of an industrial supplier. In particular, our four-field framework illustrates paths for diverse constellations, demonstrating how industrial suppliers can succeed in a digitally servitized environment. Executives might consider it notably useful to get an idea which critical resources should be under control in order to acquire relationship- and network-specific power sources. Moreover, the concrete application examples underlying the various strategic responses enable managers to act appropriately in constellations where the supplier is the less powerful actor. In essence, the acknowledgement of the importance to position oneself within the supply chain in correspondence to changing critical resources and its implications on power balances constitutes ultimately a key element for managers to actively and successfully handle digital servitization efforts.

7.3 Limitations and avenues for further research

Although we are deeply convinced that our in-depth single case study reveals some profound insights, of course, our study is not without limitations. As with any single case study, the generalizability of our findings is limited. For instance, the case company is large compared to the industry average and ranks among the leaders in certain markets for industrial drive technology. Having said this, we are convinced that due to the extensive product portfolio and diverse customer base of our case firm, it is still at least revelatory for industrial suppliers. Additionally, the risk of over-interpretation influencing the results and conclusion constitutes a limitation in case study research (Yin 2018). We tried to address this limitation by continuously exchanging our interpretations with employees of the case firm, involving independent researchers to validate our data structure, and applying rigorous data structure development.

Our recommendations for future research are tripartite: First, we strongly recommend to study the phenomenon of power disruptions by digital servitization through a multi-actor lens along the supply chain or through a network perspective. The simultaneous investigation of suppliers, OEMs, end-users, and other actors might offer a valuable and encompassing picture of inter-actor dependencies. Second, we invite researchers to empirically test or extend our stated propositions in order to offer

a better generalization among different industries and to further deepen the understanding of digital servitization. Third, we encourage research to complement our identified strategic responses, for instance with a more explicit ecosystem perspective including actors outside the traditional supply chain (e.g. alliances among suppliers or the integration of third-party developer communities), or to evaluate ex-post under which conditions our identified strategies are particularly effective.

References

- Ardolino, Marco; Rapaccini, Mario; Saccani, Nicola; Gaiardelli, Paolo; Crespi, Giovanni; Ruggeri, Carlo (2018): The role of digital technologies for the service transformation of industrial companies. In *International Journal of Production Research* 56 (6), pp. 2116–2132.
- Arnold, Christian; Kiel, Daniel; Voigt, Kai-Ingo (2016): How the industrial internet of things changes business models in different manufacturing industries. In *International Journal of Innovation Management* 20 (8), pp. 1–25.
- Baines, Tim; Bigdeli, Ali Ziaee; Sousa, Rui; Schroeder, Andreas (2020): Framing the servitization transformation process: A model to understand and facilitate the servitization journey. In *International Journal of Production Economics* 221, in press.
- Baines, Tim; Lightfoot, Howard; Smart, Palie (2011): Servitization within manufacturing. In *Journal of Manufacturing Technology Management* 22 (7), pp. 947–954.
- Baines, Tim S.; Lightfoot, Howard W.; Benedettini, Ornella; Kay, John M. (2009): The servitization of manufacturing: A review of literature and reflection on future challenges. In *Journal of Manufacturing Technology Management* 20 (5), pp. 547–567.
- Baines, Tim S.; Lightfoot, Howard W.; Evans, Steve; Neely, Andy; Greenough, Richard; Peppard, Joe et al. (2007): State-of-the-art in product-service systems. In *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture* 221 (10), pp. 1543–1552.
- Benitez, Guilherme Brittes; Ayala, Néstor Fabián; Frank, Alejandro Germán (2020): Industry 4.0 innovation ecosystems: an evolutionary perspective on value cocreation. In *International Journal of Production Economics* 228, in press.
- Benton, W. C.; Maloni, Michael (2005): The influence of power driven buyer/seller relationships on supply chain satisfaction. In *Journal of Operations Management* 23 (1), pp. 1–22.
- Bigdeli, Ali Z.; Bustinza, Oscar F.; Vendrell-Herrero, Ferran; Baines, Tim (2018): Network positioning and risk perception in servitization: evidence from the UK road transport industry. In *International Journal of Production Research* 56 (6), pp. 2169–2183.
- Boehmer, Julius H.; Shukla, Manish; Kapletia, Dharm; Tiwari, Manoj Kumar (2020): The impact of the Internet of Things (IoT) on servitization: an exploration of changing supply relationships. In *Production Planning & Control* 31 (2-3), pp. 203–219.
- Bustinza, Oscar F.; Parry, Glenn C.; Vendrell-Herrero, Ferran (2013): Supply and demand chain management: The effect of adding services to product offerings. In *Supply Chain Management: An International Journal* 18 (6), pp. 618–629.

- Caniëls, Marjolein C. J.; Gelderman, Cees J. (2007): Power and interdependence in buyer supplier relationships: A purchasing portfolio approach. In *Industrial Marketing Management* 36 (2), pp. 219–229.
- Carter, Craig R.; Rogers, Dale S.; Choi, Thomas Y. (2015): Toward the theory of the supply chain. In *Journal of Supply Chain Management* 51 (2), pp. 89–97.
- Casciaro, Tiziana; Piskorski, Mikolaj Jan (2005): Power imbalance, mutual dependence, and constraint absorption: A closer look at resource dependence theory. In *Administrative Science Quarterly* 50 (2), pp. 167–199.
- Cenamor, Javier; Sjödin, D. Rönnberg; Parida, Vinit (2017): Adopting a platform approach in servitization: Leveraging the value of digitalization. In *International Journal of Production Economics* 192, pp. 54–65.
- Chesbrough, Henry (2011): The case for open services innovation: the commodity trap. In *California Management Review* 53 (3), pp. 5–20.
- Corbin, Juliet; Strauss, Anselm (2008): Strategies for qualitative data analysis. In Juliet Corbin, Anselm Strauss (Eds.): *Techniques and Procedures for Developing Grounded Theory. Basics of Qualitative Research*, Thousand Oaks: Sage, pp. 65–86.
- Coreynen, Wim; Matthyssens, Paul; van Bockhaven, Wouter (2017): Boosting servitization through digitization: Pathways and dynamic resource configurations for manufacturers. In *Industrial Marketing Management* 60, pp. 42–53.
- Coreynen, Wim; Matthyssens, Paul; Vanderstraeten, Johanna; van Witteloostuijn, Arjen (2020): Unravelling the internal and external drivers of digital servitization: A dynamic capabilities and contingency perspective on firm strategy. In *Industrial Marketing Management* 89, pp. 265–277.
- Corley, Kevin G.; Gioia, Dennis A. (2004): Identity ambiguity and change in the wake of a corporate spin-off. In *Administrative Science Quarterly* 49 (2), pp. 173–208.
- Cox, A.; Ireland, P.; Lonsdale, C.; Sanderson, J.; Watson, G. (2002): *Supply Chains, Markets and Power: Mapping Buyer and Supplier Power Regimes*. London: Routledge.
- Cox, Andrew (1999): Power, value and supply chain management. In *Supply Chain Management: An International Journal* 4 (4), pp. 167–175.
- Cox, Andrew (2001): Understanding buyer and supplier power: a framework for procurement and supply competence. In *Journal of Supply Chain Management* 37 (2), pp. 8–15.
- Crook, T. Russell; Combs, James G. (2007): Sources and consequences of bargaining power in supply chains. In *Journal of Operations Management* 25 (2), pp. 546–555.
- Drees, Johannes M.; Heugens, Pursey PMAR (2013): Synthesizing and extending resource dependence theory: A meta-analysis. In *Journal of Management* 39 (6), pp. 1666–1698.

- Dyer Jr, W. Gibb; Wilkins, Alan L. (1991): Better stories, not better constructs, to generate better theory: A rejoinder to Eisenhardt. In *Academy of Management Review* 16 (3), pp. 613–619.
- Eisenhardt, Kathleen M. (1989): Building theories from case study research. In *Academy of Management Review* 14 (4), pp. 532–550.
- Eloranta, Ville; Turunen, Taija (2016): Platforms in service-driven manufacturing: Leveraging complexity by connecting, sharing, and integrating. In *Industrial Marketing Management* 55, pp. 178–186.
- Emerson, Richard M. (1962): Power-dependence relations. In *American Sociological Review* 27 (1), pp. 31–41.
- Falkowski, J. (2015): Resilience of farmer-processor relationships to adverse shocks: the case of dairy sector in Poland. In *British Food Journal* 117 (10), pp. 2465–2483.
- Finne, Max; Turunen, Taija; Eloranta, Ville (2015): Striving for network power: The perspective of solution integrators and suppliers. In *Journal of Purchasing and Supply Management* 21 (1), pp. 9–24.
- Gebauer, Heiko; Paiola, Marco; Saccani, Nicola; Rapaccini, Mario (2020): Digital servitization: Crossing the perspectives of digitization and servitization. In *Industrial Marketing Management* 93, pp. 382–388.
- Gerring, John (2004): What is a case study and what is it good for? In *American Political Science Review* 98 (2), pp. 341–354.
- Gibbert, Michael; Ruigrok, Winfried; Wicki, Barbara (2008): What passes as a rigorous case study? In *Strategic Management Journal* 29 (13), pp. 1465–1474.
- Gioia, Dennis A.; Corley, Kevin G.; Hamilton, Aimee L. (2013): Seeking qualitative rigor in inductive research: Notes on the Gioia methodology. In *Organizational Research Methods* 16 (1), pp. 15–31.
- Glaser, Barney G.; Strauss, Anselm L. (1967): *The Discovery of Grounded Theory: Strategies for Qualitative Research*. London: Wiedenfeld and Nicholson.
- Hart, Paul; Saunders, Carol (1997): Power and trust: Critical factors in the adoption and use of electronic data interchange. In *Organization Science* 8 (1), pp. 23–42.
- He, Qile; Ghobadian, Abby; Gallear, David (2013): Knowledge acquisition in supply chain partnerships: The role of power. In *International Journal of Production Economics* 141 (2), pp. 605–618.
- Hillman, Amy J.; Withers, Michael C.; Collins, Brian J. (2009): Resource dependence theory: A review. In *Journal of Management* 35 (6), pp. 1404–1427.
- Hingley, Martin; Angell, Rob; Lindgreen, Adam (2015): The current situation and future conceptualization of power in industrial markets. In *Industrial Marketing Management* 48, pp. 226–230.

- Holmström, Jan; Holweg, Matthias; Lawson, Benn; Pil, Frits K.; Wagner, Stephan M. (2019): The digitalization of operations and supply chain management: Theoretical and methodological implications. In *Journal of Operations Management* 65 (8), pp. 728–734.
- Huikkola, Tuomas; Rabetino, Rodrigo; Kohtamäki, Marko; Gebauer, Heiko (2020): Firm boundaries in servitization: Interplay and repositioning practices. In *Industrial Marketing Management* 90, pp. 90–105.
- Ireland, R. Duane; Webb, Justin W. (2007): A multi-theoretic perspective on trust and power in strategic supply chains. In *Journal of Operations Management* 25 (2), pp. 482–497.
- Jones, Stephen L.; Fawcett, Stanley E.; Wallin, Cynthia; Fawcett, Amydee M.; Brewer, Barry L. (2014): Can small firms gain relational advantage? Exploring strategic choice and trustworthiness signals in supply chain relationships. In *International Journal of Production Research* 52 (18), pp. 5451–5466.
- Kähkönen, Anni-Kaisa (2014): The influence of power position on the depth of collaboration. In *Supply Chain Management: An International Journal* 19 (1), pp. 17–30.
- Kähkönen, Anni-Kaisa; Virolainen, Veli Matti (2011): Sources of structural power in the context of value nets. In *Journal of Purchasing and Supply Management* 17 (2), pp. 109–120.
- Kamalaldin, Anmar; Linde, Lina; Sjödin, David; Parida, Vinit (2020): Transforming provider-customer relationships in digital servitization: A relational view on digitalization. In *Industrial Marketing Management* 89, pp. 306-325.
- Kamp, Bart; Ochoa, Ainhoa; Diaz, Javier (2017): Smart servitization within the context of industrial user–supplier relationships: contingencies according to a machine tool manufacturer. In *International Journal on Interactive Design and Manufacturing* 11 (3), pp. 651–663.
- Kohtamäki, Marko; Parida, Vinit; Oghazi, Pejvak; Gebauer, Heiko; Baines, Tim (2019): Digital servitization business models in ecosystems: A theory of the firm. In *Journal of Business Research* 104, pp. 380–392.
- Kohtamäki, Marko; Parida, Vinit; Patel, Pankaj C.; Gebauer, Heiko (2020): The relationship between digitalization and servitization: The role of servitization in capturing the financial potential of digitalization. In *Technological Forecasting and Social Change* 151, in press.
- Kotler, Philip; Ang, Swee Hoon; Leong, Siew Meng; Tan, Chin Tiong (1999): *Marketing management: An Asian perspective*. Singapore: Prentice Hall.
- Kumar, Nirmalya (2005): The power of power in supplier-retailer relationships. In *Industrial Marketing Management* 34 (8), pp. 863–866.
- Kumar, Nirmalya; Scheer, Lisa K.; Steenkamp, Jan-Benedict E. M. (1995): The effects of perceived interdependence on dealer attitudes. In *Journal of Marketing Research* 32 (3), pp. 348–356.

- Lee, Hau L.; Whang, Seungjin (2004): E-business and supply chain integration. In Terry P. Harrison, Hau L. Lee, John J. Neale (Eds.): *The Practice of Supply Chain Management: Where Theory and Application Converge*. Boston: Springer, pp. 123–138.
- Lee, Jaegul; Berente, Nicholas (2012): Digital innovation and the division of innovative labor: Digital controls in the automotive industry. In *Organization Science* 23 (5), pp. 1428–1447.
- Lerch, Christian; Gotsch, Matthias (2015): Digitalized product-service systems in manufacturing firms: A case study analysis. In *Research-Technology Management* 58 (5), pp. 45–52.
- Li, Ai Qiang; Kumar, Maneesh; Claes, Björn; Found, Pauline (2020): The state-of-the-art of the theory on Product-Service Systems. In *International Journal of Production Economics* 222, in press.
- Lincoln, Yvonna S.; Guba, Egon (1985): *Naturalistic inquiry*. Beverly Hills: Sage.
- Loebbecke, Claudia; Picot, Arnold (2015): Reflections on societal and business model transformation arising from digitization and big data analytics: A research agenda. In *The Journal of Strategic Information Systems* 24 (3), pp. 149–157.
- Malhotra, Deepak; Gino, Francesca (2011): The pursuit of power corrupts: How investing in outside options motivates opportunism in relationships. In *Administrative Science Quarterly* 56 (4), pp. 559–592.
- Maloni, Michael; Benton, Wilhelm C. (2000): Power influences in the supply chain. In *Journal of Business Logistics* 21 (1), pp. 49–74.
- Matthyssens, Paul; Vandenbempt, Koen (2008): Moving from basic offerings to value-added solutions: Strategies, barriers and alignment. In *Industrial Marketing Management* 37 (3), pp. 316–328.
- Naik, Parikshit; Schroeder, Andreas; Kapoor, Kawaljeet Kaur; Bigdeli, Ali Ziaee; Baines, Tim (2020): Behind the scenes of digital servitization: Actualising IoT-enabled affordances. In *Industrial Marketing Management* 89, pp. 232–244.
- Neely, Andy (2008): Exploring the financial consequences of the servitization of manufacturing. In *Operations Management Research* 1 (2), pp. 103–118.
- Nienhüser, Werner (2008): Resource dependence theory: How well does it explain behavior of organizations? In *Management Revue* 19 (1/2), pp. 9–32.
- Obal, Michael (2013): Why do incumbents sometimes succeed? Investigating the role of interorganizational trust on the adoption of disruptive technology. In *Industrial Marketing Management* 42 (6), pp. 900–908.
- Obermaier, Robert (2019): Industrie 4.0 and Digitale Transformation als unternehmerische Gestaltungsaufgabe. In Robert Obermaier (Ed.): *Handbuch Industrie 4.0 and Digitale Transformation. Betriebswirtschaftliche, technische and rechtliche Herausforderungen*. Wiesbaden: Springer Gabler, pp. 3–46.

- Oliva, Rogelio; Kallenberg, Robert (2003): Managing the transition from products to services. In *International Journal of Service Industry Management* 14 (2), pp. 160–172.
- Opresnik, David; Taisch, Marco (2015): The value of big data in servitization. In *International Journal of Production Economics* 165, pp. 174–184.
- Otto, Andreas; Obermaier, Robert (2009): How can supply networks increase firm value? A causal framework to structure the answer. In *Logistics Research* 1 (3-4), pp. 131–148.
- Pagani, Margherita; Pardo, Catherine (2017): The impact of digital technology on relationships in a business network. In *Industrial Marketing Management* 67, pp. 185–192.
- Paiola, Marco; Gebauer, Heiko (2020): Internet of things technologies, digital servitization and business model innovation in BtoB manufacturing firms. In *Industrial Marketing Management* 89, pp. 245–264.
- Paschou, T.; Rapaccini, M.; Adrodegari, F.; Saccani, N. (2020): Digital servitization in manufacturing: A systematic literature review and research agenda. In *Industrial Marketing Management* 89, pp. 278-292.
- Paulraj, Antony; Chen, Injazz J. (2007): Strategic buyer–supplier relationships, information technology and external logistics integration. In *Journal of Supply Chain Management* 43 (2), pp. 2–14.
- Perlman, Cassie (2017): *From product to platform: John Deere revolutionizes farming*. Available online at <https://digital.hbs.edu/data-and-analysis/product-platform-john-deere-revolutionizes-farming/>.
- Perreault Jr, William D.; Leigh, Laurence E. (1989): Reliability of nominal data based on qualitative judgments. In *Journal of Marketing Research* 26 (2), pp. 135–148.
- Pfeffer, Jeffrey (1981): *Power in organizations*. Marshfield: Pitman.
- Pfeffer, Jeffrey; Salancik, Gerald R. (1978): *The external control of organizations: A resource dependence perspective*. Stanford: Stanford University Press.
- Pham, Xuan; Stack, Martin (2018): How data analytics is transforming agriculture. In *Business Horizons* 61 (1), pp. 125–133.
- Piekkari, Rebecca; Welch, Catherine; Paavilainen, Eriikka (2009): The case study as disciplinary convention: Evidence from international business journals. In *Organizational Research Methods* 12 (3), pp. 567–589.
- Porter, Michael E.; Heppelmann, James E. (2014): How smart, connected products are transforming competition. In *Harvard Business Review* 92 (11), pp. 64–88.
- Porter, Michael E.; Heppelmann, James E. (2015): How smart, connected products are transformation companies. In *Harvard Business Review* 93 (10), pp. 96-114.
- Porter, P. (1985): *Competitive Advantage*. New York: Free Press.

- Rabetino, Rodrigo; Harmsen, Willem; Kohtamäki, Marko; Sihvonen, Jukka (2018): Structuring servitization-related research. In *International Journal of Operations & Production Management* 38 (2), pp. 350–371.
- Rabetino, Rodrigo; Kohtamäki, Marko (2018): To Servitize Is to (Re) position: Utilizing a Porterian View to Understand Servitization and Value Systems. In Marko Kohtamäki, Tim Baines, Rodrigo Rabetino, Ali Z. Bigdeli (Eds.): *Practices and Tools for Servitization*. Cham: Springer International Publishing, pp. 325–341.
- Rabetino, Rodrigo; Kohtamäki, Marko; Gebauer, Heiko (2017): Strategy map of servitization. In *International Journal of Production Economics* 192, pp. 144–156.
- Raynor, Michael; Christensen, Clayton M. (2002): *Integrate to innovate: The determinants of success in developing and deploying new services in the communications industry*. New York: Deloitte Research Publication.
- Rifkin, Jeremy (2014): *The zero marginal cost society: The internet of things, the collaborative commons, and the eclipse of capitalism*. New York: Palgrave Macmillan.
- Ritter, Thomas; Pedersen, Carsten Lund (2020): Digitization capability and the digitalization of business models in business-to-business firms: Past, present, and future. In *Industrial Marketing Management* 86, pp. 180–190.
- Rymaszewska, Anna; Helo, Petri; Gunasekaran, Angappa (2017): IoT powered servitization of manufacturing—an exploratory case study. In *International Journal of Production Economics* 192, pp. 92–105.
- Seuring, Stefan A. (2008): Assessing the rigor of case study research in supply chain management. In *Supply Chain Management* 13 (2), pp. 128–137.
- Siggelkow, Nicolaj (2007): Persuasion with case studies. In *Academy of Management Journal* 50 (1), pp. 20–24.
- Sjödin, David; Parida, Vinit; Kohtamäki, Marko; Wincent, Joakim (2020): An agile co-creation process for digital servitization: A micro-service innovation approach. In *Journal of Business Research* 112, pp. 478–491.
- Sklyar, Alexey; Kowalkowski, Christian; Tronvoll, Bård; Sörhammar, David (2019): Organizing for digital servitization: A service ecosystem perspective. In *Journal of Business Research* 104, pp. 450–460.
- Smith, J. A.; Harre, R.; van Langenhove, L. (Eds.) (1996): *Rethinking methods in psychology*. London: Sage.
- Stabell, Charles B.; Fjeldstad, Øystein D. (1998): Configuring value for competitive advantage: on chains, shops, and networks. In *Strategic Management Journal* 19 (5), pp. 413–437.
- Strauss, Anselm; Corbin, Juliet (1998): *Basics of qualitative research techniques*. Thousand Oaks: Sage.

- Suppatvech, Chutikarn; Godsell, Janet; Day, Steven (2019): The roles of internet of things technology in enabling servitized business models: A systematic literature review. In *Industrial Marketing Management* 82, pp. 70–86.
- Takeishi, Akira (2001): Bridging inter-and intra-firm boundaries: management of supplier involvement in automobile product development. In *Strategic Management Journal* 22 (5), pp. 403–433.
- Tian, Jiamian; Coreynen, Wim; Matthyssens, Paul; Shen, Lei (2021): Platform-based servitization and business model adaptation by established manufacturers. In *Technovation*, in press.
- Touboulic, Anne; Chicksand, Daniel; Walker, Helen (2014): Managing imbalanced supply chain relationships for sustainability: A power perspective. In *Decision Sciences* 45 (4), pp. 577–619.
- Tronvoll, Bård; Sklyar, Alexey; Sörhammar, David; Kowalkowski, Christian (2020): Transformational shifts through digital servitization. In *Industrial Marketing Management* 89, pp. 293-305.
- Tukker, Arnold; Tischner, Ursula (2006): *New business for old Europe: product-service development, competitiveness and sustainability*. Sheffield: Greenleaf Publishing.
- Uлага, Wolfgang; Reinartz, Werner J. (2011): Hybrid offerings: how manufacturing firms combine goods and services successfully. In *Journal of Marketing* 75 (6), pp. 5–23.
- Ulrich, David; Barney, Jay B. (1984): Perspectives in organizations: resource dependence, efficiency, and population. In *Academy of Management Review* 9 (3), pp. 471–481.
- Vandermerwe, Sandra; Rada, Juan (1988): Servitization of business: adding value by adding services. In *European Management Journal* 6 (4), pp. 314–324.
- Vendrell-Herrero, Ferran; Bustinza, Oscar F.; Parry, Glenn; Georgantzis, Nikos (2017): Servitization, digitization and supply chain interdependency. In *Industrial Marketing Management* 60, pp. 69–81.
- Vendrell-Herrero, Ferran; Wilson, James R. (2017): Servitization for territorial competitiveness: Taxonomy and research agenda. In *Competitiveness Review: An International Business Journal* 27 (1), pp. 2–11.
- Weber, Max (1922): *Wirtschaft and Gesellschaft. Grundriss der verstehenden Soziologie*. Tübingen: Mohr.
- Welch, Catherine; Piekkari, Rebecca; Plakoyiannaki, Emmanuella; Paavilainen-Mäntymäki, Eriikka (2011): Theorising from case studies: Towards a pluralist future for international business research. In *Journal of International Business Studies* 42 (5), pp. 740–762.
- Wise, Richard; Baumgartner, Peter (1999): Go downstream. In *Harvard Business Review* 77 (5), pp. 133–141.

- Yin, Robert K. (2018): *Case study research and applications. Design and methods*. Los Angeles: Sage.
- Yoo, Youngjin; Henfridsson, Ola; Lyytinen, Kalle (2010): Research Commentary — The New Organizing Logic of Digital Innovation: An Agenda for Information Systems Research. In *Information Systems Research* 21 (4), pp. 724–735.

How New Kids on the Block Shape Competition on the Battleground

– Classification and Reversing Value Creation Strategies of

Industrial Internet-of-Things Platforms

Philipp Mosch (philipp.mosch@uni-passau.de)
Chair for Business Economics, Accounting and Control
DE-94032 Passau, Germany

Robert Obermaier
Chair for Business Economics, Accounting and Control
DE-94032 Passau, Germany

Abstract

Previous research has drawn attention primarily to digital consumer platforms, yet ignoring the specificities of industrial settings. Hence, existing research findings may fall short regarding Industrial Internet-of-Things Platforms (IIoTP), leading to an incomplete understanding of digital platforms. This study addresses this research need by carefully reviewing existing literature on digital platforms and applying explorative multiple case study research to three IIoTPs. The authors examine deductively (1) which IIoTP types can be distinguished and (2) how value creation logics derived from digital consumer platforms are applied on IIoTPs as well as how different IIoTP types can be classified. Based on this, the study draws special attention to IIoTPs from Internet technology firms and incumbent industrial firms as new kids on the block that exhibit complex cooperative relationships at different vertical platform levels. Thereby, the study inductively derives (3) which strategic measures are needed for a successful evolution, and (4) which dynamic strategic trajectories occur. The study identifies four IIoTP types, namely Digital Marketplace, Connectivity Platform, Hyperscaler, and Integrated IIoTP. In addition, the authors enrich literature by showing that specific value creation logics are executed differently on specific IIoTP types. Moreover, through the linkage of five strategic measures to the dominant value creation logics, the authors provide important contextualization on different vertical platform layers. Finally, the study offers IIoTP managers insights by identifying dynamic strategic trajectories that reveal Hyperscalers are in the best position to profit from innovation in the IIoTP market, thereby reversing the common notion that downstream positioning is prerequisite to succeed.

Keywords: Digital Platform; Industrial Internet-of-Thing; B2B; Value Creation Logic; Multiple Case Study; Strategic trajectories

1. Introduction

Over the past two decades, Internet companies like Google, Amazon, and Facebook have successfully demonstrated that digital platforms based on business-to-consumer (B2C) or consumer-to-consumer (C2C) interactions are able to significantly create new businesses (Gebauer et al. 2021) while fundamentally transforming existing ones (Gawer 2021). Leveraging digital technologies such as cloud computing and big data analytics, these so-called digital consumer platforms connect two or more distinct actor groups on a two- or multi-sided market (Hagiu and Wright 2015; Rochet and Tirole 2003). Thereby, they act as central intermediaries that provide the necessary infrastructure and enable value-creating interactions between the actor groups under predefined rules (Gassmann et al. 2017; Täuscher and Laudien 2018; Parker et al. 2016).

More recently, and somewhat parallel, “Industrie 4.0” and other comparable initiatives worldwide have driven digital transformation in the industrial sphere, leading to the development of digital industrial platforms, also referred to as *Industrial Internet-of-Things Platforms (IIoTP)* (Obermaier 2019; Hein et al. 2019). Generally, IIoTPs are characterized by two key aspects: (1) they provide the basis for transactions between different B2B actors and/or (2) enable innovation for B2B actors involving third-party complementors (Cusumano et al. 2020; Gawer 2021). Unlike digital platform markets in B2C sectors, which are often consolidated and dominated by a single or few companies, IIoTP markets are still in their nascent phase, leaving the current market structure heterogenous and the race for market leadership largely unclear.

Surprisingly, studies specifically investigating IIoTPs are still scarce (Foerderer et al. 2019; Hein et al. 2019), given that previous research has primarily focused on examining digital consumer platforms (Pagani and Pardo 2017; Leminen et al. 2020). In particular, there is a lack of research on different types of IIoTPs to provide a better understanding of IIoTP ecosystems and their underlying functionalities (Gebauer et al. 2021). Previous research (1) fails to adequately describe IIoTPs, as their taxonomies blend B2C and B2B sectors (Cusumano et al. 2019; Riasanow et al. 2020), (2) focuses mainly on specific technical elements or industries (Arnold et al.

2021; Jovanovic et al. 2021) or (3) lacks a consistent and consolidated picture of the IIoTP market (Falck and Koenen 2020; Brodtmann et al. 2020; Foerderer et al. 2019). Therefore, a deeper and differentiated understanding of IIoTP types regarding the different actors and elements is required to specify them as an object of research (de Reuver et al. 2018). Addressing this research need, we postulate our first research question:

(1) Which different types, actors and elements of IIoTPs can be described?

Rich literature has investigated the emergence and design of digital consumer platforms, particularly in comparison to traditional, non-digital platform settings (e.g., Eisenmann et al. 2009; Parker et al. 2016; Parker & van Alstyne, 2018). The extensive elimination of physical infrastructure made possible by information technology affects value creation, delivery and capture in three ways (Yoo et al. 2010; Parker et al. 2016; van Alstyne et al. 2016; de Reuver et al. 2018): First, growth through network effects can be achieved significantly faster and more cost-effectively than in non-digital platform settings. Second, transaction costs are nearly eliminated through data-driven, efficient matching between various platform actors. Third, innovative business and revenue models, such as sharing of goods, can be developed on a large scale.

However, IIoTPs may differ in their value creation logics compared to digital consumer platforms as they vary in a number of characteristics (Hein et al. 2019; Pauli et al. 2021): First, due to the greater variety, number and weight of different stakeholders (e.g., sensor or machine manufacturers, system integrators, software developers), the complexity of value creation and community governance on IIoTPs is significantly higher. Second, the data transferred on IIoTPs is considered more critical for the individual actor and its competitive advantage (e.g., production data for a manufacturer). Third, digital services offered on IIoTPs are more sophisticated and require a deeper understanding of the underlying processes. However, there is a lack of studies that specifically investigate how known value creation logics of digital consumer platforms are applied on IIoTPs (de Reuver et al. 2018; Hein et al. 2020) In particular, we intend to leverage the assigned value creation logics to develop a

delineated and comprehensive classification of the identified IIoTP types. Hence, we pose our second research question:

(2) Which value creation logics derived from digital consumer platforms are applied to different IIoTP types and how can the different IIoTP types be classified?

Over the last few years, we observe the entrance of incumbent industrial firms and Internet technology firms into IIoTP markets, triggering novel competition dynamics and generating additional opportunities for competitive advantage through the involvement of third-party complementors. These are the new kids on the block that this paper addresses in more detail. Both actor groups increasingly compete with their development environments, leading to a tense competition situation in this new battleground, where cooperation and competition take place at the same time (Bengtsson and Kock 2014; Pauli et al. 2021). However, in order to generate competitive advantage, both actor groups need to overcome significant hurdles, since the aforementioned potential differences in the application of value creation logics such as increased complexity of ecosystems may complicate the initiation of network effects and require novel strategies to make them succeed (Pauli et al. 2021; Hein et al. 2019). A prominent example for the complexity of this issue is the incumbent industrial firm General Electric, which drastically reduced investments into its own technologically advanced IIoTP Predix due to severe divergences between realized and expected return on investment (McGrath 2020). Despite the increasing importance of incumbent industrial and Internet technology firms in IIoTP markets, prior literature has been largely silent on the relationships between them (Pauli et al. 2021). Specifically, it remains unclear what strategic measures need to be considered for the success of the value creation logics of both actor groups and their IIoTP types, given their different industrial starting points, their position in the interorganizational supply chain, and their competitive relationships, thus preventing a deeper understanding of the underlying phenomenon of IIoTPs (de Reuver et al. 2018). Therefore, we state the third research questions along the following lines:

(3) Which strategic measures are crucial for the successful evolvement of value creation logics on IIoTPs by incumbent industrial firms and Internet technology firms?

As already emphasized, the entire IIoTP market is still in an emerging phase, which leads to a heterogeneous and dynamic field of players trying to gain a foothold in the market with different approaches (Rauen et al. 2018; Falck and Koenen 2020; Brodtmann et al. 2020). However, previous research on digital platforms has been rather static, making the study of development dynamics a blind spot (de Reuver et al. 2018; Gawer 2021). Specifically, the dynamic evolution of IIoTPs from incumbent industrial companies and Internet technology firms, as novel and key competing actors and its impact on the competitive situation in IIoTP markets holds potential for valuable insights for both academia and practitioners (Pauli et al. 2021; Gebauer et al. 2021). Therefore, examining not only the strategic measures, but also how IIoTPs of incumbent industrial firms and Internet technology firms evolve and change, provides a deeper understanding of the underlying strategic implications and competitive dynamics for the different actors (Gebauer et al. 2021). This leads to our fourth research question:

(4) Which dynamic strategic trajectories of IIoTPs by incumbent industrial firms and Internet technology companies can be identified and how do they affect the competitive situation between these two actor groups?

Addressing our four research questions, we carefully review academic and market studies to deductively identify the different IIoTP types, which value creation logics are applied on them, and how a classification framework can be derived. Based on this, we conduct explorative multiple case study research on three IIoTPs from the two new kids in IIoTP markets: incumbent industrial companies and Internet technology firms. Thereby, we inductively derive which strategic measures they need to consider to succeed in IIoTP markets and which dynamic strategic trajectories they follow.

Overall, we extend previous studies and make the following contributions to Information Systems (IS) (Pauli et al. 2021; de Reuver et al. 2018) and market-based platform literature (Eisenmann et al. 2006; Parker et al. 2016; Gawer 2021). (1) We identify, describe, and classify four different IIoTP types, namely *Digital Marketplace*, *Connectivity Platform*, *Hyperscaler*, and *Integrated IIoTP*, providing a comprehensive drawing of the IIoTPs' boundaries and the entire IIoTP market. (2)

We show that value creation logics of digital consumer platforms are partially different from their application in IIoT markets, leading to the implication that IIoTPs need to be examined not only with a clear distinction from digital consumer platforms, but also between different IIoT types. (3) By identifying five distinct strategic measures relevant to the success of value creation logics on *Integrated IIoTPs* from incumbent industrial firms and *Hyperscalers* developed by Internet technology companies, we provide important contextualization on different vertical platform layers within the same IIoT ecosystem. (4) We present dynamic strategic trajectories of *Integrated IIoTPs* and *Hyperscalers* that show upstream positioned *Hyperscalers* are in the best position to profit from exploiting value creation logics in IIoT markets, as they are able to change their role in the cooperative market situation to a more competitive and hierarchical direction. Thereby, we reverse the common logic that value creation in digital markets is best achieved at the downstream interface with the end-user, providing valuable implications for managers in IIoT companies.

We structure the study in the following manner: in section 2, we present the theoretical foundation. In section 3, we outline the methodology. The results are presented in section 4. In the final section, we discuss the findings and specify theoretical and managerial contributions.

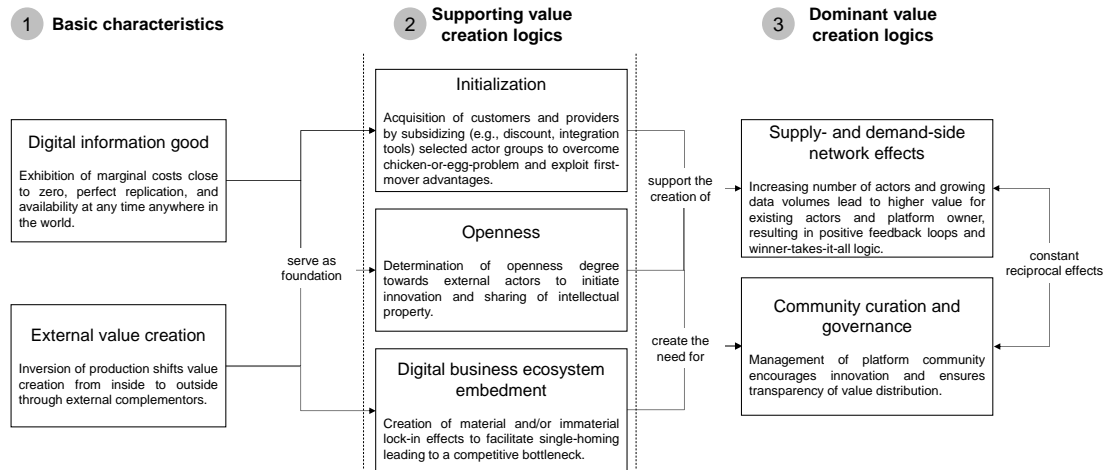
2. Theoretical foundation

In order to grasp the mechanisms of IIoTPs, it is necessary to understand how and which value creation logics are applied. We understand value creation logics as the operating principles, which are decisive to profit from innovation as a platform operator (Teece 2018; Helfat and Raubitschek 2018). However, in previous research (Parker et al. 2016; Eisenmann et al. 2011; Cusumano et al. 2019), which predominantly takes the market-based perspective (Hein et al. 2020), value creation logics are often derived from B2C settings (Gebauer et al. 2021). Therefore, we summarize the value creation logics identified from market-based literature on digital consumer platforms to provide a solid theoretical basis for application to IIoTPs.

Based on this, we identify two basic characteristics (digital information good, external value creation), three supporting value creation logics (initialization,

openness, digital business ecosystem embedment), and two dominant value creation logics (supply- and demand-side network effects, community curation and governance) that are relevant for operating in digital platform markets and build on each other to map a consecutive construct (see Figure 1).

Figure 1. Value creation architecture of digital consumer platforms.



2.1 Basic characteristics

Digital consumer platforms are generally characterized by the fact that the constant exchange between the different actors is primarily carried out by *digital information goods* based on data. Digital information goods have three essential characteristics: they exhibit (1) marginal costs close to zero, (2) are perfectly replicable and (3) available at any time. Once information is available in digital form, a digital copy can be produced with costs close to zero. Perfection refers to the perfect copy, which can be created digitally and usually corresponds completely to the digital original. The immediate availability almost anywhere in the world is ensured by the Internet. Broadly speaking, digital information goods can therefore be consumed virtually free of charge and perfectly replicable (McAfee and Brynjolfsson 2017; Rifkin 2014). The extensive detachment from the physical world makes the exchange between the different platform actors easier, thereby enabling a significantly faster and cheaper scaling than in non-digital settings (van Alstyne et al. 2016).

Generally, digital consumer platforms do not create their own content. Instead, they merely provide the infrastructure for efficient mediation between the various actors, thereby relying on *external value creation*. In physical product markets, value creation mainly takes place internally in a so-called pipeline business model through different stages (e.g., procurement, production, distribution) (Porter 1985). In platform markets, however, there are no clear value stream directions. Providers, customers and the platform operator itself are in a complex relationship with each other. The exchange of different values and resources takes place on a permanent basis and without a pre-defined order (Parker et al. 2016). In particular between providers and customers, new innovations and thus value are created. Therefore, digital consumer platforms rely on boundary resources, such as application programming interfaces (API), enabling external value creation in the form of innovations or transactions between various actors that complement the platform's offering (Karhu and Ritala 2020; Teece 2018).

The two basic characteristics serve as important input variables for the following supporting value creation logics, and thus overall provide the foundation for the value creation on digital consumer platforms.

2.2 Supporting value creation logics

Before network effects can be built, the question of timely entry into platform markets arises (Clement and Schreiber 2016; Shapiro and Varian 1999). After reaching a certain threshold (critical mass), first-mover companies can often build up a competitive advantage that is difficult for competitors to compensate. Therefore, the *initialization* is critical, as it describes the process to get first customers on a platform, if no providers are available yet, or to acquire first providers if no customers are registered yet. This dilemma is also called chicken-or-egg problem (Evans and Schmalensee 2010; Caillaud and Jullien 2003). One solution is to subsidize one of the two actor sides (Stummer et al. 2018). Many companies offer the service to selected actors at a significant discount or even free of charge and thus try to acquire new customers or customers from competing platforms. In addition, certain integration tools (e.g., modular interfaces, interactive development environments) are provided to

third-party complementors, such as app developers, to enable ease of participation (Tan et al. 2020). Basically, the following rule can be established: the actor group (provider or customer), which profits more from the presence of the other actor group, is charged with higher price premiums. The value of the one actor group for the other actor group thus determines the price (Armstrong 2006).

A closely related supporting value creation logic is defining the degree of *openness* on the platform (Parker and van Alstyne 2018; Jacobides et al. 2018). It is determined by how open the platform is designed to be to third-party developers or other partners and competitors. However, deciding on the degree of openness is often very complex. If the degree of openness is restricted too much by intensive control, third-party developers may be forced off the platform or may not be brought onto the platform at all. The ability to innovate and scale would be significantly restricted. If, on the contrary, the platform is open to all potential actors without any kind of control, this could lead to a high degree of fragmentation and heterogeneity, from which neither the developer or provider nor the customer side would benefit in the end. Additionally, new entrants may exploit resources disadvantageously to the platform operator, if the resources are too openly accessible (Karhu and Ritala 2020). Hence, on the one hand, opening up the platform can support the generation of network effects and innovation of third parties through better access for the different actors, further greatly reducing the risk of lock-in. On the other hand, however, a high degree of openness also increases competitive pressure through lower switching costs and thus reduces profitability (Eisenmann et al. 2009).

In order to build a stable, open and sustainable community, platform companies try to embed their actors in a so-called *digital business ecosystem*, which encompasses a multilateral set of partners (Adner 2017) and the development of various platform products, often developed through product sequencing (Helfat and Raubitschek 2018). It aims at keeping the switching costs as high as possible to generate a lock-in effect and prevent migration to competitors. The lock-in effect of ecosystems can be described in terms of a path dependency of the user. In early competitive stages of platform markets, the user usually can use different systems at the same time, also called multi-homing. After a certain period of time, the user may no longer perceive the use of several platforms as efficiently or advantageously and

prefer one platform; the other alternatives fade into the background (Evans 2003). As soon as the user has decided on an option, it finds itself in a so-called lock-in situation, which only allows a change with high costs in material (e.g., monetary) or immaterial (e.g., loyalty, learning) form and ultimately results in a single-homing situation, i.e. the exclusive use of one platform (Täuscher and Laudien 2018; Shapiro and Varian 1999).

The three supporting value creation logics identified and their success and stringency of implementation will largely determine how thriving the dominant value creation logics become. After all, the goal of digital consumer platforms is to (1) scale as fast as possible through supply- and demand-side network effects and (2) attract as many different complementors as possible using community curation and governance.

2.3 Dominant value creation logics

In order to attract sufficient actors for external value creation and to achieve the necessary dominant market position, so called *supply- and demand-side network effects* must be created. The platform actors, who are in complex and multiple relationships, generate them through the constant exchange of information goods (Shapiro and Varian 1999). One reason for the emergence of big digital consumer platforms are supply-side network effects, also called economies of scale (Bohr 1996): An increase in the output quantity per unit of time causes a decrease of the production costs per unit. The widespread absence of physical goods strengthens the supply-side network effects, since capacity limits in the production of digital goods can only arise when very high user numbers are involved. High initial fixed costs for developing and setting up and low variable costs mean that the average costs per user fall significantly as the number of users increases, leading to marginal costs close to zero (Evans and Schmalensee 2010; McAfee and Brynjolfsson 2017). Besides supply-side network effects, the main driver for network effects and the achievement of a dominant market position are direct and indirect demand-side network effects. In the case of direct demand-side network effects, the value for each individual actor on a platform network depends on the number of existing users (Shapiro and Varian 1999); they only refer to one side (e.g., providers or customers). For example, the

more users Facebook has, the more value it generates for each individual participant, since the latter can exchange information with more and more acquaintances. The number of connections between n network nodes, i.e. users, increases in quadratic form: $n(n - 1) = n^2 - n$, which is also called Metcalfe's Law (Gilder 1993). Indirect demand-side network effects affect at least two sides, e.g., providers and customers. The more providers, for example, offer their own homes as overnight accommodation on the Airbnb platform, the more potential guests are attracted and the more value is generated for all platform actors. The combination of supply- and demand-side network effects in a digital environment is the key to a rapid growth potential. The more users act on the demand side of the platform, the lower the marginal costs on the supply side and the more providers are attracted. This in turn makes the platform more competitive, which again attracts more customers and providers. This logic is also called positive feedback and inevitably leads to the dominance of individual digital consumer platforms in so-called winner-takes-it-all markets (Shapiro and Varian 1999). This effect is further supported by the introduction of AI-enabled services (e.g., individualized recommendation or dynamic pricing). These services lead to data network effects, which describe the effect that the more the platform provider learns from the data collected from users, the more valuable it becomes for each user, as the AI-enabled services can be improved through more and more data in self-reinforcing feedback loops (Gregory et al. 2020). However, the positive network effect can also quickly be reversed if the platform loses its attractiveness due to a new competitor or declining reputation due to management errors.

In order to avoid negative network effects, the focus of the platform lies in the continuous management of the actors. This so called *community curation and governance* intends to foster and diversify the innovation taking place on the platform (Boudreau 2012) and increase social and economic value (Dann et al. 2020). Innovations are usually created by third-party complementors outside the direct control of the focal platform. Therefore, the platform aims to understand how interdependent actors interact, develop and commercialize innovations to provide the basis on which complementary innovation can emerge (Jacobides et al. 2018). Often this is associated with breaking down barriers between different actors and making interactions as efficient as possible (Cusumano et al. 2019). Once again, the rule

applies: the more users or data, the better. The algorithms of curation become more and more precise with more data and can create individually tailored offers (Parker et al. 2016). Many digital consumer platforms therefore check the preferences of their own users at the time of registration to achieve the most precise match between supply and demand, thereby bringing the right complementary innovation to the right customer. In contrast: the worse the curating the greater the "noise", i.e. the proportion of content that does not fit. Curating is often also supported by a rating system for the content on the platform. For example, Teubner et al. (2017) show that a better rating score on the accommodation platform Airbnb allows the host to charge higher prices, which may also have a positive impact on the percentage fees charged by Airbnb. Yet the feedback also serves the need for third-party developers to get immediate feedback from the community so they can improve their applications (Pagano and Maalej 2013). In addition to community curation, the innovation taking place on the platform must be governed, regulated and controlled. This means determining transparently how value is created, how it is distributed fairly among all involved actors, and how any conflicts that may arise can be resolved quickly. If one side is overcharged with fees or feels disadvantaged, this has a direct and pervasive effect on the number of users and providers and thus also on the generation of network effects (Parker et al. 2016).

Both dominant value creation logics form an interdependent and reciprocal relationship. On the one hand, network effects are more difficult to achieve without effective community curation and governance. On the other hand, the lack of network effects may render community curation and governance obsolete.

3. Methodology

3.1 Research design

In this study, we employed a four-step approach that follows the research questions and is both conceptual and empirical in nature, incorporating different theoretical perspectives (Hein et al. 2020). First, we carefully reviewed literature that adopts the socio-technical perspective on IIoTPs in academic and market studies to identify different IIoTP types, actors, and elements (Arnold et al. 2021; Falck and Koenen

2020). Second, we conceptually combined the market-based perspective investigating the value creation logics of digital consumer platforms (Eisenmann et al. 2006; Parker et al. 2016) and the socio-technical view (de Reuver et al. 2018) to describe the identified IIoT types and construct an IIoT classification. Third, we empirically identified the strategic measures to bring the value creation logics to success by conducting explorative multiple case study research based on 10 expert interviews and publicly available data from the two most relevant actor groups that offer IIOs in the market, i.e., incumbent industrial companies and Internet technology firms. Fourth, using the same data set, we applied the conceptually elaborated classification framework to draw different strategic trajectories of the two actor groups.

In this study, explorative case study research is particularly suitable, as it has emerged as the preferred approach to understand and describe a contemporary phenomenon (in our case digital platforms) in-depth in its contextual conditions (in our case industrial sector) (Yin 2018; Stake 1995). Moreover, we chose case study research with multiple cases as it allows better theory building and generalizability compared to the investigation of a single case (Eisenhardt and Graebner 2007), especially in markets with a heterogeneous actor structure, as is the case in IIoT ecosystems.

3.2 Case selection and description

We selected the three case firms from the two most relevant actor groups (incumbent industrial firms and Internet technology companies) by theoretical sampling (Bell et al. 2018) using the following criteria. First, we chose firms that offer an IIoT as one of its core products and act as leaders in their respective markets. Second, we focused on firms that provide access to key informants while having sufficient publicly available secondary data. Third, similar to Sklyar et al. (2019), we took firms that operate in the same ecosystem and represent the different platform layers and actors, minimizing extraneous variation and ensuring comparative data for theory building.

Case firms A and B are two U.S.-based Internet technology companies that are market leaders in the field of digital infrastructure and analytics services and thus operate mainly in the infrastructure layer. They portray the Internet technology firms

in the IIoTP market, offering *Hyperscalers* that serve simultaneously customers in the B2C and B2B sectors. However, we focus on the IIoTP solutions relevant for B2B offerings. In general, both firms are software companies that have invested a significant amount of capital in the development and establishment of their IIoTP in recent years. They aim to leverage their existing software knowledge to act as base layer for a variety of digital business models.

Case firm C constitutes a multinational European incumbent industrial firm that operates in several sectors, providing mainly physical industrial components and solutions, but also an *Integrated IIoTP* and corresponding software services to its customers in a B2B relationship. Since it constitutes one of the major market leaders, it is suitable to represent the group of incumbent industrial firms offering an Integrated IIoTP. Over the last decade, case firm C decided to strategically invest in offering an Integrated IIoTP as critical part of its digital transformation efforts to enrich its existing physical product portfolio, maintain its competitive advantage and increase both revenues and profitability. Using the infrastructure services of Hyperscalers, case firm C offers solutions that are based on them.

3.3 Data collection

Since we aim to paint a picture of the entire IIoTP market, we chose to follow a collection process that consists of two main steps. First, we carried out extensive market research to grasp all relevant actors and IIoTP types. For this purpose, we drew on several very recent practice studies analyzing the IIoTP market (e.g., Brodtmann et al. 2020; Falck and Koenen 2020) to gain an initial understanding of the IIoTP market and key players. Moreover, we searched the Nexis database and other newspaper databases (e.g., FAZ, Manager Magazin) for additional IIoTP examples and use case descriptions to obtain a comprehensive picture of the IIoTP market. One author also attended two relevant fairs to conduct informal interviews and gather further information about the different actors in IIoTP markets. Finally, we explicitly asked two consultants with industry expertise of IIoTPs to share their understanding of the market to complement our knowledge of the IIoTP market.

Second, we conducted and transcribed verbatim 10 in-depth, semi-structured expert interviews (Stake 1995) between May and September 2020 with employees of Internet technology firms and incumbent industrial companies represented by the three case firms to identify and describe the strategic measures and potential strategic trajectories. The sample comprises interview partners working in different departments relevant to the establishment of IIoTPs and covering various hierarchical levels (see Table 1). The use of multiple data sources offers a stronger substantiation of constructs and hypotheses (Eisenhardt 1989). Therefore, we triangulated the interview data with extensive archival records (e.g., annual reports and press releases) and two interviews with consultants specified in the field of IIoTPs, to ensure reliability of the results. Except one interview (due to missing permission, however, intensive notes were conducted), all interviews were recorded and transcribed verbatim. The interviews lasted on average 56 minutes. All interviews were executed via videoconferencing applications. We stopped reaching out to further interview partners, when additional interviews led only to marginal added insights regarding new properties, dimensions, or relationships (Strauss and Corbin 1998).

Table 1. Overview of interview partners.

Expert	Case firm	Actor group (IIoTP type)	Position	Interview duration (hours and minutes)
1	A	Internet technology firm (Hyperscaler)	Regional Manager	00:30
2	A		Solution Architect	00:46
3	B		Vice President	00:32
4	B		Team Lead	01:00
5	B		Team Lead	01:00
6	C	Incumbent industrial firm (Integrated IIoTP)	Executive	01:14
7	C		Executive	01:04
8	C		Head of Product Management	01:05
9	C		Team Lead	01:00
10	C		Solution Architect	01:10
11	Consultancies for triangulation		Partner	00:45
12	Consultancies for triangulation		Consultant	01:07

3.4 Data analysis and validation

In order to derive the results from the interview data, we applied the procedure outlined by Gioia et al. (2013), whereby we rigorously structured 194 full text pages of interview with overall 678 codings using the software MAXQDA 2018. Thereby,

we applied comparative peer evaluation to ensure validity of the findings (Miles and Huberman 1994). In addition to the author, two experienced student researchers were involved in data collection and went through the coding process to perform independent parallel data analysis and investigator triangulation (Bell et al. 2018). The coding process itself involved three steps. First, all three coders read through the transcribed interviews without a prior coding scheme to identify statements that were considered relevant with respect to our research questions. This open and inductive in-vivo coding resulted in first-order concepts. Second, we looked for commonalities and variations among the first-order concepts to derive second-order themes that were the result of the researcher's own interpretations. Third, we summarized the elaborated second-order themes into dense dimensions. Throughout the whole coding process, we constantly compared and discussed the individual coding results until consensus was reached. Furthermore, we ensured reliability of our data analysis by including two independent researchers who are familiar with qualitative research methods, but were not involved in our study. First, they assigned randomly sorted first-order concepts to our derived second-order themes within our data analysis structure. Second, they coded all quotes relevant for this study by using the second-order themes. We computed the inter-judge agreement by applying the widely accepted proportional loss reduction method by Rust and Cooil (1994), resulting in a value of 0.97 for the data analysis structure and 0.88 for the coded quotes, both well above the threshold of 0.70 recommended for exploratory research (Nunnally 1978). Additionally, the consultants from the dataset acted as counterparts to discuss the results, further increasing the validity of our findings. Finally, we shared our overall results with the interview participants from the case firms to solicit feedback and thereby continue to increase objectivity regarding the interpretation of our analysis.

4. Results

4.1 Identification and description of IIoTP types

In the first step of our four-part research design, we use existing classification approaches in scientific and market studies to identify the most common IIoTP types in a deductive manner. Taking the socio-technical perspective, we subsequently

describe the different IIoTP types in terms of their socio-technical elements, i.e. their different actors and platform layers.

Since the literature regarding IIoTPs is still in its infancy, there are only few scientific studies that classify and describe different types of IIoTPs. However, these studies lack an encompassing view of the IIoTP market, since they also include digital consumer platforms (Cusumano et al. 2019; Evans and Gawer 2016; Täuscher and Laudien 2018; Riasanow et al. 2020), take a very narrow industry perspective (Jovanovic et al. 2021) or focus mainly on technical architectural features (Arnold et al. 2021). Based on these studies, we therefore broaden our perspective by integrating market studies, such as the latest practitioner reports, to identify the most relevant IIoTP types. Although there is no general consensus among these studies on the number and types of IIoTPs, the following four were commonly found by different authors and therefore considered the most relevant: *Digital Marketplace*, *Connectivity Platform*, *Hyperscaler*, and *Integrated Industrial Internet-of-Things Platform* (see Table 2).

Table 2. Synthesis of different scientific and market studies regarding their IIoTP types.

Scope	Authors	IIoTP types			
		Digital Marketplace	Connectivity Platform	Hyperscaler	Integrated IIoTP
Scientific studies	Evans and Gawer (2016)	X		X	
	Täuscher and Laudien (2018)	X			
	Cusumano et al. (2019)	X		X	
	Riasanow et al. (2020)			X	X
	Jovanovic et al. (2021)		X		X
	Arnold et al. (2021)		X	X	X
Market studies	Rauen et al. (2018)	X		X	X
	Graff et al. (2018)	X		X	X
	Lerch et al. (2019)	X			X
	Brodthmann et al. (2020)	X	X		X
	Falck and Koenen (2020)	X			X
	Koenen and Heckler (2020)	X	X		X

Note: "X" means that the IIoTP type is included in the respective study.

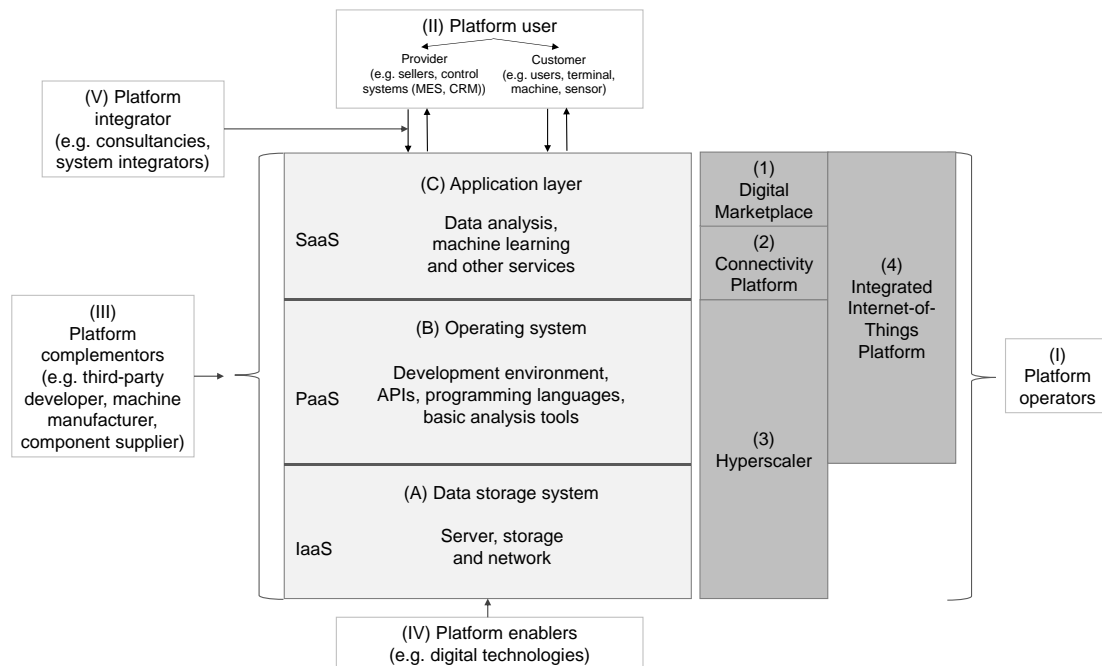
Following that, we describe the IIoTP types with regard to their socio-technical elements (see Figure 2). First, we use three common platform layers that are usually build upon each other to describe the underlying architecture (Villegas et al. 2012): Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), and Software-as-a-Service (SaaS). The IaaS layer (A) provides the data storage system, i.e., the

technological basis to deploy storage, network and server capacities that are adjustable in terms of scalability and customization. PaaS solutions (B) offer the operating system on which actors are able to build applications and generic analysis tools via open application programming interfaces (API). SaaS (C) represents the application layer, which includes specialized, single-purpose software applications that are delivered to the customer.

Second, we assign a diverse set of various actor groups to the different IIoT types: Platform operators (I; host of the platform), platform users (II; providers and customers), platform complementors (III; e.g., third-party developers, machine manufacturers), platform enablers (IV; e.g., digital technologies, Internet, connectivity devices), and platform integrators (V; e.g., consultancies, system integrators) (Obermaier and Mosch 2019; Pauli et al. 2021).

In Figure 2, we portray the relevant platform actors (I-V) and platform layers (A-C) interacting on the different IIoT types (1-4), ultimately forming the digital business ecosystem of IIoTPs. We specify the various IIoT types in the following and guide the reader by constantly referring to the different numbered actors and elements in Figure 2.

Figure 2. Actors, platform layers, and types of IIoTPs.



Digital Marketplaces (1) constitute two-sided markets for physical or digital products/services, aiming to efficiently connect providers and customers that interact in a dyadic relationship (Evans and Gawer 2016). Examples include company-owned online platforms (e.g., Klöckner & Co.), pure e-commerce marketplaces (e.g., Mercateo, Amazon Business), industrial data platforms (e.g., Telekom Data Intelligence Hub), or supply chain and logistics services between carriers and manufacturers (e.g., Cargo One) (Jones and Tonetti 2019; Koenen and Heckler 2020). *Digital Marketplaces* usually operate in the SaaS layer (C) and lack of third-party community involvement (III). They rather focus on the efficient connection of the platform users (II) and generally do not offer own products or data. Via Internet technology (IV) they ensure an efficient, in many parts automated process, thus reducing the complexity in B2B relationships. Platform integration (V) is often carried out by the platform operator itself.

Connectivity Platforms (2) are built as digital transaction platforms in the form of two-sided markets with dyadic relationships between different machines and/or humans (II) that enable data exchange, usually at the shop-floor level. Typical examples are incumbent industrial firms such as Maschinenfabrik Reinhausen and Trumpf that provide *Connectivity Platforms*, labelled as MR-CM or TruConnect, and offer them in conjunction with their own machines, often specialized in a certain industry. They aim to achieve efficiency gains in production through process innovation, ultimately leading to the establishment of a smart factory (Obermaier et al. 2019). Sensor technology and local networks (IV) on the machines are essential components to facilitate the conversion of analog information (e.g., temperature and vibrations) into digital form (Jovanovic et al. 2021). *Connectivity Platforms* usually constitute SaaS solutions (C) and are adapted to the requirements of the individual firm or even factory. Third-party developers (III) are usually not involved. Therefore, platform integration (V) is usually conducted by the platform operator itself or might be supported by system integrators.

Hyperscalers (3) provide IaaS (A) and open PaaS (B) offerings, thus representing a multi-sided market in which third-party developers (III) are able to create digital services for industrial customers (II). As *Hyperscalers* provide the basic infrastructure services on which other build their own services and are therefore

located upstream of the inter-organizational supply chain. They usually store and analyze end-user data of downstream firms without having a direct interface to the end-user. Amazon Web Services (AWS), Microsoft Azure and Google Cloud are by far the most important *Hyperscalers* (Gartner 2020), resulting in a consolidated market that is occupied by highly competitive companies (Brodtmann et al. 2020). *Hyperscalers* provide on-demand storage to other IIoT types and industrial customers via public cloud technology (IV), enabling scalability of the individual customer services while ensuring the operation and security of the platform. *Hyperscalers* offer not only storage capacity, but also the corresponding analysis tools and various digital services via a PaaS solution, usually involving a huge developer community that develops SaaS offerings based on open source technologies. This allows companies using *Hyperscalers* to either run existing applications developed by the community or to program their own custom applications. The platform integration (V) is often supported by consultancies.

Integrated IIoTPs (4) operate in a cloud or edge setting (IV) and enable the extraction, structuring and analysis of machine or product data (II) at the shop-floor level (process innovation) or the connection of machines at the customer level (product innovation). They offer tailored applications created by themselves or a third-party developer community (III), forming a multi-sided market. This IIoT type is called *Integrated IIoTP* as it is often provided by incumbent industrial companies embedded in their existing physical product and service portfolio (V). Prominent examples are Siemens Mindsphere and Bosch IoT Suite. These two platforms cover a broad spectrum of services and usually operate across similar industries (Arnold et al. 2021). Being dependent on *Hyperscalers* for cloud computing, *Integrated IIoTPs* are positioned at the downstream end of the inter-organizational supply chain, occupying the end-user interface by focusing on ready-to-use PaaS solutions (B) and customized digital services in the SaaS layer (C) for specific industries based on their domain knowledge.

4.2 Value creation logics and classification of IIoT types

In the second step of our research approach, we assign the value creation logics derived from digital consumer platforms to the different identified IIoT types (see Table 3) and develop a classification framework based on this (see Figure 3). We observe that *Digital Marketplaces*, *Hyperscalers*, and *Integrated IIoTPs* exhibit a number of value creation logics. However, the dominant value creation logic of community curation and governance, which comes along with the integration of the PaaS layer that is key for complementary innovation (Pauli et al. 2021), is only visible at *Hyperscalers* and *Integrated IIoTPs*.

Table 3. Value creation logics on IIoTPs.

IIoTP type	Basic characteristics		Supporting value creation logics			Dominant value creation logics	
	Digital good	External value creation	Initialization	Openness	Eco-system	Community	Network effects
Digital Marketplace	X	X	X		X		X
Connectivity Platform	X	X					
Hyperscaler	X	X	X	X	X	X	X
Integrated IIoT	X	X		X	X	X	

Digital Marketplaces show similar value creation logics as digital platforms in the B2C field, particularly intense demand-side network effects. Therefore, the successful acquisition of providers and customers to overcome the initialization problem determines how effectively network effects are created. The involvement of a third-party community (e.g., developers) and hence the management of openness are lacking here. Low access and transaction fees are intended to overcome the initialization problem and promote direct and indirect network effects. In order to mitigate the danger of being exchangeable, *Digital Marketplaces* often try to generate a lock-in effect in the form of a vertical integration, such as the integration into customer's procurement processes. In these cases, switching to a competitor is only associated with very high costs and is thus made almost impossible. Therefore, the digital business ecosystem embedment constitutes an important factor to maintain network effects and ultimately competitive advantage.

In contrast, *Connectivity Platforms* are not about inducing as many transactions of different actors as possible on the platform or providing the basis for innovation, but about organizing a simple and efficient connection via open interfaces between different systems to a functioning overall construct. Therefore, both dominant value creation logics play a rather subordinate role on *Connectivity Platforms* as they are usually customized to a certain manufacturing company. The goal of *Connectivity Platforms* is to establish an independently organized production that is able to produce very small batches up to batch size one. Frequently, the processing of the accumulated data takes place on premise or in a private cloud setting, since a public cloud connection is often either undesirable (e.g., for data protection reasons), simply unnecessary or (still) too slow. In this so-called edge computing, the processor is installed directly at the relevant machine and thus enables real-time processing of the data.

Yet the situation is different with *Hyperscalers*. Due to the focus on scalable solutions and large developer communities, both dominant value creation logics have a high relevance for them. Community curation and governance plays a crucial role, since third-party developers constitute an important source of complementary innovation on *Hyperscalers*. Supporting this, *Hyperscalers* often rely on open standards and open source tools. Additionally, supply-side network effects, i.e., economies of scale, play a major role. Economies of scale can be described as the mechanism that an increase in the output quantity per unit of time causes a decrease of the production costs per unit (Bohr 1996). Transferred to the case of *Hyperscalers*, this means that the more storage capacity that can be built up in the form of server parks, the lower the storage costs per gigabyte and the greater the competitive advantage. This kind of scaling is necessary to reduce the risk of massive investments and thus high fixed costs per output unit associated with the physical server infrastructure of *Hyperscalers* through so-called fixed cost depression, ultimately creating high revenue and profit potential (Obermaier 2021). Moreover, direct and indirect demand-side network effects represent an important value creation logic to reach market dominance. After all, the more third-party developers, the better the range of applications, and the better the range of applications, the more interesting the IIoTP is to potential customers. The close involvement of third-party developers

allows economies of scope (Teece 1980; Panzar and Willig 1981) to emerge in cases where the cost of joint production is less than the cost of producing each output individually (Gawer 2014; Bohr 1996). Overall, the greater the diversification of third-party complementors on the IIoT, the better the economies of scope. Economies of scale and scope are particularly important in the case of *Hyperscalers*, since they mainly follow a cost leadership strategy that targets a wide range of different industries. The initialization problem is addressed by the infrastructure-giving character of a *Hyperscaler* for other IIoT types and specific measures. For instance, AWS and Microsoft Azure subsidize the customer side with a free platform access and offer selected services free of charge for the first twelve months. After that, the billing is usage-based (pay-per-use) whereby the price per gigabyte decreases with higher usage and thus volume discounts are granted. Due to this billing model, platform users are able to convert their fixed development costs for digital services into variable costs, thereby flexibilizing their overall cost structure (Obermaier 2021). For the provider side, platform access is limited and only available for a fee. Through this barrier to entry and an appropriate curation, the quality of the developer community is ensured to ultimately achieve an embedding in a digital business ecosystem.

Integrated IIOTs provide SaaS and PaaS offerings that are often tailored to and integrated with specific manufacturing industries. The number of potential customers of each SaaS solution on the IIoT is naturally limited to the numbers of actors in a particular industry as they are usually not transferable to other industries. Therefore, network effects are typically low and not able to work as effective as with *Hyperscalers*. Even though *Integrated IIOTs* are platform users on *Hyperscalers* as they leverage their IaaS layer and thus have a more variable cost structure with regard to cloud computing, they still need to invest heavily in their PaaS and SaaS offerings to compete. In addition, *Integrated IIOTs* have a smaller number of their respective complementors for innovation due to their specialization. Therefore, owing to the lower economies of scale and scope as well as poor demand-side network effects, the revenue and profit potential through scaling and diversification is fundamentally lower than for *Hyperscalers*. However, because of their close interaction with end-users and considerable domain knowledge in specific industries, *Integrated IIOTs*

have the advantage of knowing where the single applications can provide the most value to the end-user. Building on this, *Integrated IIoTPs* mainly follow a focused differentiation strategy where they target only few sectors with their domain knowledge. In this regard, the initialization problem is not a major concern as the *Integrated IIoTP*, which is typically provided by incumbent industrial manufacturers, leverages existing provider and customer relationships to attract initial users to their platform. However, to increase the range of specific services for certain industries, *Integrated IIoTPs* try to establish open digital business ecosystems via their PaaS solutions containing different third-party development communities. As a result, community curation and governance play an important role in *Integrated IIoTPs*. However, since *Integrated IIoTPs* use *Hyperscalers* as IaaS platform layer, they depend on them to a considerable extent (Pauli et al. 2021). In addition, both IIoTP types increasingly compete with each other in the PaaS layer, which may lead to adjustments in their offerings and target groups.

Based on the previous arguments and condensed to the two dominant value creation logics network effects and community curation and governance, we develop the following classification matrix of the four IIoTP types. The matrix relates two variables, namely the relevance of community curation and governance (low/high) and the network effect potential of transaction good (low/high) (see Figure 3).

Figure 3. Classification of IIoTP types based on dominant value creation logics.

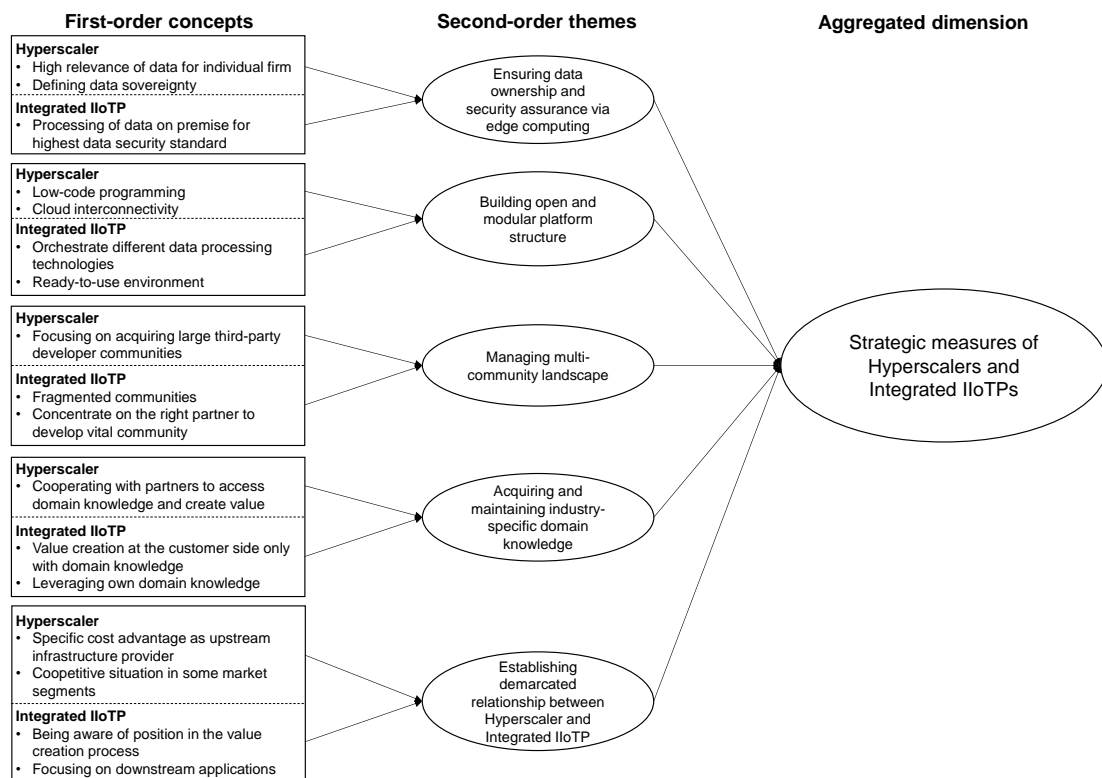
Relevance of community curation and governance	High	Integrated IIoT Platform	Hyperscaler
	Low	Connectivity Platform	Digital Marketplace
		Low	High
		Network effect potential of transaction good	

In doing so, we summarize that the two dominant value creation logics are not applicable to all four IIoT types, and thus they differ not only in their value creation logics compared to digital consumer platforms, but also among themselves in particular.

4.3 Strategic measures of Hyperscalers and Integrated IIoTPs

Addressing our third research question, we examine *Hyperscaler* and *Integrated IIoT* via multiple case study research, since both IIoT types exhibit closely interwoven relationships that include diverging positions in the value creation process and co-competition situations, calling for a more nuanced investigation. Thereby, we identify strategic measures that are relevant to bring success to the application of value creation logics in IIoT markets.

Figure 4. Data analysis of Hyperscalers and Integrated IIoTPs regarding strategic measures.



The analysis of our interview and secondary data reveals five strategic measures: (1) ensuring data ownership and security assurance via edge computing, (2) building open and modular platform structure, (3) managing multi-community landscape, (4) acquiring and maintaining industry-specific domain knowledge, and (5) establishing a demarcated relationship between *Hyperscaler* and *Integrated IIoTP* (see Figure 4).

The manufacturing industry is considered a conservative industry that is slowly changing existing processes and finds itself in a low level of maturity of IIoTP adoption. In particular, there are hesitations to process data on IIoTPs, often due to the preference to keep critical information internal and proprietary. However, this hinders IIoTPs to overcome the initialization problem and enhance network effects and growth. Therefore, data and its ownership are assigned a completely different priority compared to the B2C sector. The transfer of highly critical data, for example from R&D or production, to the cloud of IIoTPs represents a major obstacle for manufacturing companies to adopt IIoTP offerings that needs to be addressed.

“Which data do I want to keep within my system? [...] Do I want to give them out? Data security is an extremely important issue. [...] To put it bluntly: There is data in the industry that makes companies go bankrupt. And you have to protect it in a different way than in the consumer sector.” (Expert 10, Solution Architect, Firm C)

Therefore, companies demand high data security standards and still often choose to process the data on premise directly at the point of origin, e.g., the machine or connectivity device. As a result, case firms A and B as *Hyperscalers* as well as case firm C as *Integrated IIoTP* increasingly offer so-called edge computing devices with high processing power to increase trust and serve as a bridge technology towards a cloud solution.

“I think a driver is also a piece of security, that [companies] just try to not necessarily open the ports to the cloud, but preprocess relevant production data or KPIs in the field.” (Expert 12, Consultant, Consultancy)

Altogether, both IIoTP types need to develop their services with regard to an explicit definition of data ownership and data security via edge computing offerings to create trust and ultimately enable cloud computing. However, this creates challenges as the different technologies need to be orchestrated in a purposeful way. Besides cloud and edge computing technology, there is also fog computing, which uses cloud computing

only for certain processing steps or specific data analysis tasks. Therefore, it is crucial not only to determine what budget is allocated to which technologies, but also to clearly define how the various technologies interact. Since manufacturing companies often differ considerably in their characteristics and needs, it drives IIoTP providers to customize their offerings. Therefore, IIoTP providers face the challenge to balance between standardized and individual offerings. On the one hand, if the IIoTP is too specialized, the network effect potential is significantly reduced. On the other hand, if the IIoTP's offering is too generic, customer requirements will not be fulfilled and the competitive advantage of a customized manufacturing platform vanishes.

“The art of an [IIoTP] is to make the most flexible offering possible, that you can serve customers with special needs and that you can serve, let's say, the fast and innovative customers as well as the slow and conservative customers.” (Expert 2, Solution Architect, Firm A)

In this regard, *Hyperscalers* encounter specific hurdles. Their relatively broad and generic IIoTP solutions require programming know-how that manufacturing firms often lack. In order to address this issue, *Hyperscalers* increasingly provide low-code programming and ready-to-use development settings like *Integrated IIoTPs*. However, this limits the flexibility though so that individual specifications are more difficult to implement. As a result, both IIoTP types ought to have an open modular structure, often represented by a so-called multi-tenant architecture. This means, that various customers operate on a single architecture environment and can cost-effectively decide which modules to deploy on the platform, allowing them to adapt to their individual needs while also using pre-configured tools and applications. Increasingly, IIoTPs pursue open multi-cloud strategies in order to improve inter-connectivity.

“I believe that if you take it to heart [...] that you really build on these open modules and open standards, then you can be successful in any case.” (Expert 4, Team Lead, Firm B)

Adding to that, due to the heterogeneity within the manufacturing sector, separate IIoT communities in terms of developers, users and partners were formed in recent years. Hence, the IIoTP providers need to decide not only how, but also which communities should be targeted, curated and managed leading to a high complex

stakeholder management. Especially in the initial phase, case firm C aimed for rapid growth in its partner network, but failed to manage it adequately. This led to the fact that the own third-party community did not act in a coordinated and networked way and synergies were not created among different user groups.

“I would rather say today: Concentrate and bring in the right partners [...]. And then take care of them properly. If you on-board 200 partners in a year, it's clear that you can't manage everyone equally.” (Expert 7, Executive, Firm C)

Hence, a focused multi-community is rather essential for an IIoTTP to effectively govern developers, users, and further complementors (e.g., financial institutions) so that they can also create added value in cloud-to-cloud connection with other IIoTTPs on the horizontal level. In order to develop and offer analysis applications that fit the special characteristics of various manufacturing firms (e.g., chemical vs automotive production), domain knowledge constitutes a key resource to create added value at the customer side. For example, to offer a predictive maintenance service for a robot on an assembly line, it is essential to know which temperature peaks are allowed in different parts or at which threshold of a vibration is unusual. Case firm C as a large incumbent manufacturing company offering an Integrated IIoTTP and serving various industries is clearly at an advantage here.

“We have a tremendous advantage here, because we have been in the industry for many years [...]. We also manufacture products and of course we use this expertise to say: What standards do we need? What do we need for connectors?” (Expert 10, Solution Architect, Firm C)

Hence, *Hyperscalers* are dependent on the domain knowledge of individual firms using infrastructure services and developing specific applications or on collaboration partners like *Integrated IIoTTPs* in order to onboard potential customers and third-party complementors to generate network effects. However, *Integrated IIoTTPs* also rely on *Hyperscalers* to deliver cloud computing technologies, resulting in close interdependence. Additionally, *Hyperscalers* use *Integrated IIoTTPs* like case company A for market entry and domain knowledge as well as trust acquisition because manufacturing companies are reluctant to cooperate with relatively new entrants such as case firm A and B.

“Cooperations like the one with [case firm C] are very important for us. These partnerships are essential, also from a commercial perspective. For example, we approach potential customers together with [case firm C]. When our industrial customers see that we have a partnership with them, this creates greater trust in our platform.” (Expert 1, Regional Manager, Firm A)

Hence, exploiting domain knowledge by acquiring it through cooperation – in the case of *Hyperscalers* – or emphasizing and maintaining its own domain knowledge – in the case of *Integrated IIoTPs* – describes an important variable that influences the dominant value creations of IIoTP offerings. However, despite the close cooperation between *Hyperscalers* and *Integrated IIoTPs*, the relationship also creates challenges in particular for *Integrated IIoTPs*. The positioning of case firm C at the downstream end of the IIoTP value creation process leads to significant hurdles in commercialization.

“[Case firm C] is clearly a reseller, because the [*Hyperscalers*] operate more upstream, which means that [case firm C] must be more expensive as a reseller.” (Expert 6, Executive, Firm C)

Hence, *Hyperscalers* are able to indirectly influence the margins of *Integrated IIoTPs*. Notwithstanding this disadvantageous situation for case firm C, the margins are in general higher in the IaaS layer, especially due to the economies of scale and the associated cost advantages. In order not to be outmaneuvered by *Hyperscalers*, *Integrated IIoTPs* need to determine their own position in the value creation process and hence clearly differentiate from *Hyperscalers* in their offerings, incorporating the decision of what to make or buy. Additionally, in some cases *Hyperscalers* increasingly provide services similar to those of *Integrated IIoTPs*. This applies particular to applications in the SaaS layer, that are still relatively widely applicable, so that scaling is possible.

“We want to market our IoT products, we want to sell them. [Case firm C] has competitive products that they want to sell. If these issues arise and both partners are in the room, we will not succeed. Here the areas of interest are relatively clearly defined and we respect that. But yes, we are in competition in some areas.” (Expert 2, Solution Architect, Firm A)

However, *Hyperscalers* cannot afford to antagonize *Integrated IIoTP* providers, as they are (still) dependent on their domain knowledge. Consequently, a cooptation

situation is growing between *Integrated IloTPs* and *Hyperscalers*, where cooperation and competition occurs at the same time. This demands for a demarcated relationship definition between those two actors to preserve competitive advantage and the success of value creation logics on both sides.

4.4 Dynamic strategic trajectories of *Hyperscalers* and *Integrated IloTPs*

Approaching our fourth second research question, we empirically derive the strategic trajectories from the conducted multiple case study. Overall, we identify two main dynamic trajectories that happen simultaneously and interdependently: (1) development of *Hyperscalers* towards all-in-one IloTPs and (2) the resulting displacement of *Integrated IloTPs* towards specialized niche providers (see Figure 5).

Figure 5. Data analysis of *Hyperscalers* and *Integrated IloTPs* regarding strategic trajectories.

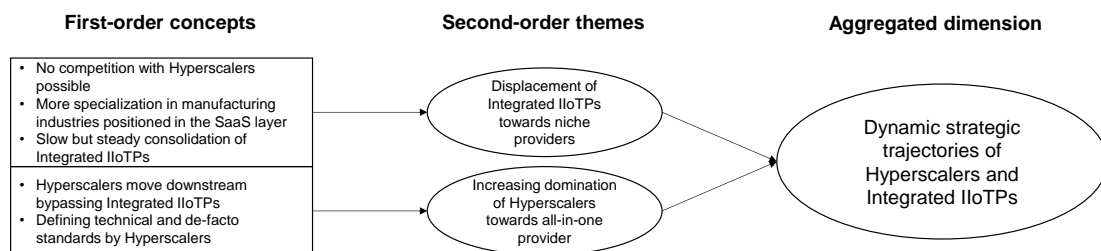


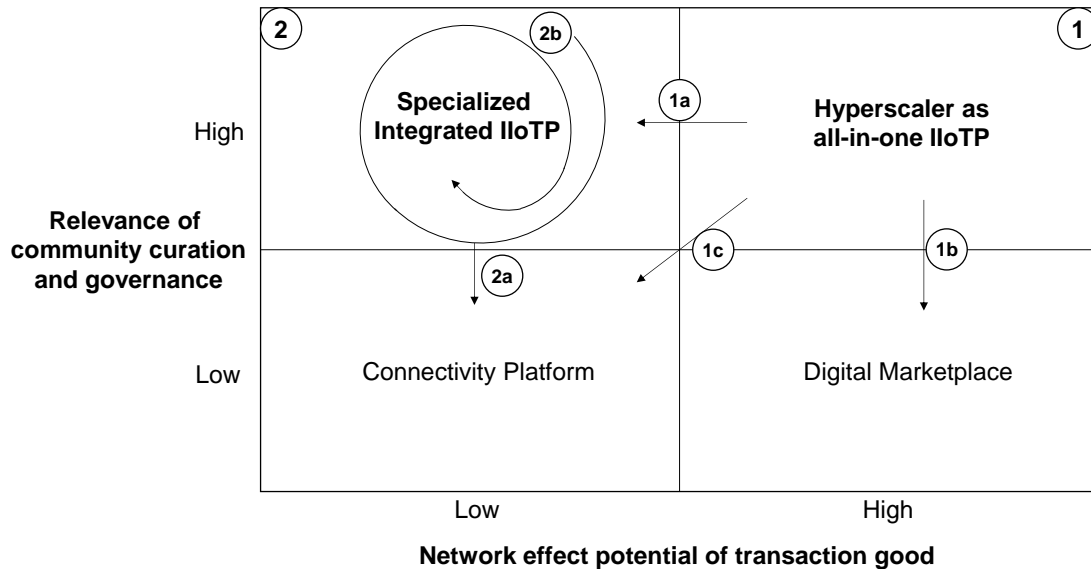
Figure 6 serves as the structural body of this sub chapter, integrating and visualizing the identified strategic trajectories within a classification framework based on the two dominant value creation logics (see section 2), namely the relevance of community curation and governance (low/high) and the network effect potential of transaction good (low/high).

Hyperscalers (1) aim to develop generic services that are more downstream and thereby more competitive to solutions offered by *Integrated IloTPs*. Consequently, once established at industrial customers, *Hyperscalers* may bypass *Integrated IloTPs* and displace them in certain areas which are particularly interesting in terms of profit and scalability potential (1a).

“But there is also confrontation, because [case firm B], for example, is now going all the way to the platform level and partly also to the application level. There are

many companies that use [*Hyperscalers*] for all layers and [*Integrated IloTPs*] are then left out.” (Expert 11, Partner, Consultancy)

Figure 6. Potential strategic trajectories of Hyperscalers and Integrated IloTPs.



As already described, in addition to their infrastructure services in the IaaS layer, *Hyperscalers* provide PaaS solutions on which SaaS solutions can be developed both by independent third-party developers and industrial customers. Since low-code solutions are not always feasible due to the customer specifications that require customization, it is necessary to empower potential developers with programming skills. Therefore, *Hyperscalers* are increasingly working with universities to provide them with adequate development sets and open source tools and to familiarize them with their technologies, thus establishing de facto standards.

“A high number of developers are trained on [*Hyperscalers*], [...] because they are very strongly represented in the universities. [...] Of course this is an important component, because when these people move to the companies and a CEO says: You look here, I have 15 [case firm A] developers, why should I retrain them all to [case firm C]? It costs time and money.” (Expert 5, Team Lead, Firm B)

Since *Hyperscalers* acquire growing domain knowledge in industry, systematically establish standards and are partially already operating in other IloTP markets (e.g., *Digital Marketplace*) (1b), they may not only target *Integrated IloTP* markets but under certain conditions also *Connectivity Platforms*, e.g., in the case of large

international customers (1c). Overall, *Hyperscalers* pursue a double-track strategy: on the one hand, they increasingly offer ready-to-use offerings and development environments, while at the same time educating emerging programmer generations with their architecture and programming language logic. This may cumulate in an all-in-one platform solution offered by *Hyperscalers* making other IIoTP firms dispensable, at least for some parts of the market.

Integrated IIoTPs (2), however, face a dilemma. On the one hand, they possess the domain knowledge to serve different manufacturing industries with high added value via tailored offerings. On the other hand, their considerable dependence on *Hyperscalers* and the lack of scalability due to the specialization and limited number of customers per application hinders their ability to thrive in industrial settings of digital platforms. Competing with *Hyperscalers* on a vertical level is not feasible as their IaaS layer and expertise is completely outsourced and the IaaS market is considered consolidated. Highly standardized and scalable offerings will be targeted sooner or later by *Hyperscalers* themselves, bringing in all their market power and data analysis competence. Originally, case firm C envisioned providing all three platform layers (IaaS, PaaS, SaaS) when it realized that significant investment and specific data management know-how was required to gain competitive advantage and prevail against *Hyperscalers*.

“[Case firm C] also changes [...] from “We want to do everything somehow, [...] we want to face a [*Hyperscaler*]”, but that doesn't make any sense. You learn that as well.” (Expert 10, Solution Architect, Firm C)

As the market for *Integrated IIoTPs* is slowly but steadily consolidating, there is potential to horizontally acquire or cooperate with other *Integrated IIoTP* providers or *Connectivity Platforms* that operate in specific industries (2a). Since *Integrated IIoTPs* are closely positioned at the individual user, they will have to further adjust their offerings with regard to the certain industry (2b), evolving into a kind of complementor role for *Hyperscalers*. Therefore, the strategy of *Integrated IIoTPs* shifts towards exploiting and expanding their competitive advantage serving applications in the SaaS layer through domain knowledge and existing trust of industrial customers. A similar trend applies to the PaaS layer, which will be even more industry-specific in the future, while offering ready-to-use development settings

to address industry customers with generally weak programming skills. This also includes the acquisition of existing third-party communities from specific industries, as was practiced by case firm C. In general, *Integrated IIoTPs* will evolve into many different niches addressing specific customer needs that are currently not served by *Hyperscalers*.

“I actually think that an [*Integrated IIoTP*] will develop even more industry-specific. This is also exactly the advantage over these very generic platforms like [*Hyperscalers*], which say: “We’ll just make an infrastructure for you that you can use as you like”. We don’t do that. We are making a platform that is specifically tailored to the industry. And the more feedback we get from industry customers, the more we will adapt to industry needs.” (Expert 10, Solution Architect, Firm C)

5. Concluding discussion

Previous research has primarily investigated digital platforms in B2C industries, ignoring the peculiarities of industrial B2B contexts (Gebauer et al. 2021; Pauli et al. 2021). Our study addresses this research need and extends existing research by making the following theoretical and managerial contributions.

5.1 Theoretical contributions

First, we specify digital platforms as research objects and thus extend IS literature (de Reuver et al. 2018; Hein et al. 2020) by identifying and describing the socio-technical elements of four different IIoTPs types referred to as *Digital Marketplace*, *Connectivity Platform*, *Hyperscaler*, and *Integrated IIoTPs*. Thereby, we address the conceptual ambiguity in literature regarding the lack of definitions and comparability of digital platforms (de Reuver et al. 2018). Specifically, by synthesizing existing classification approaches to derive the identified IIoTP types, we complement previous studies that either mix B2B and B2C platform markets and take a rather broad classification approach (Täuscher and Laudien 2018; Riasanow et al. 2020) or adopt a narrow industry or technical perspective leading to very specific IIoTP types (Arnold et al. 2021; Jovanovic et al. 2021). In doing so, we also incorporate knowledge from various market studies that provide valuable but dispersed insights into IIoTP markets (Falck and Koenen 2020; Koenen and Heckler 2020). Thus, we develop a holistic overview of the IIoTP ecosystem and combine this with explicit

contextualization through specific IIoTTP types, laying a profound foundation for the creation of further valuable insights.

Second, we enrich market-based platform studies (Parker et al. 2016; Eisenmann et al. 2006) and IS literature (de Reuver et al. 2018; Hein et al. 2020) by applying value creation logics of digital consumer platforms to the different IIoTTP types. Based on this, we develop a classification that consists of the two dominant value creation logics, being (1) the relevance of community curation and governance and (2) the network effect potential of the underlying transaction good. Thereby, we show that *Digital Marketplaces* exhibit similar value creation logics compared to digital consumer platforms whereas *Connectivity Platforms* show hardly any of them. Both have in common that they lack third-party involvement that is necessary to serve as an innovation basis for highly heterogeneous industrial landscapes. In contrast, *Hyperscalers* and *Integrated IIoTTPs* include third-party communities, however, network effects are low on *Integrated IIoTTPs*, as they lack standardized services fitting to a broad customer base. In particular, the specialization of *Integrated IIoTTPs* and *Connectivity Platforms* in various sectors makes these IIoTTP types unique compared to known digital consumer platforms, refining the common notion that platforms need to generate network effects right from the beginning in order to persist (Evans and Schmalensee 2010; Parker et al. 2016). Particularly, the complex technical platform integration at the customer side leads to high switching costs that hinder the generation of network effects and growth, resulting in a heterogeneous industry-specific market. Solely, *Hyperscalers* are able to achieve both high third-party participation and high network effects. These IIoTTP types, with their broad IaaS platform layer, leave the specialization to the industrial customers themselves by providing development tools, empowering them to develop their own specific applications. Therefore, we conclude that IIoTTPs need to be examined specifically with a clear distinction between IIoTTP types on the one hand and in comparison with digital consumer platforms on the other hand, implying that it is not expedient to speak of digital platforms and their value creation logics in general.

Third, by applying multiple case study research to two *Hyperscalers* and one *Integrated IIoTTP*, we identify five strategic measures relevant to the success of value creation logics of these two IIoTTP types: (a) ensuring data ownership and security via

edge computing to create trust, acquire third-party complementors, and overcome the initialization problem to generate network effects, (b) building an open and modular platform structure to further exploit the potential of supply- and demand-side network effects, (c) managing a multi-community landscape to serve the heterogeneity of the industrial sector and leverage their full innovation capacity, (d) acquiring and maintaining domain knowledge to be able to develop applications and add value in specific promising areas, and (e) establishing a demarcated relationship between *Hyperscalers* and *Integrated IIoTPs* in order to avoid losing access to domain knowledge in the case of *Hyperscalers* or losing cloud computing capabilities in the case of *Integrated IIoTPs*. In this regard, it is crucial to point to differences between digital platforms in B2C and B2B settings, when it comes to the strategic measures needed to bring value creation logics to success. For instance, ensuring data ownership and security or acquiring domain knowledge is given a much lower priority in the B2C sector. In this way, we complement the study of Zhao et al. (2020) that examines the competitive dynamics of digital B2C platform markets by shedding light on them in the B2B domain. In addition, we provide important contextualization between digital B2C and B2B platforms as well as between two different IIoTP types within the same ecosystem (Gebauer et al. 2021), extend the study of Hein et al. (2019) with further specific strategic measures focusing on value co-creation processes in the IIoTP context, and support their argument of important standardization practices by highlighting modular platform structures. Lastly, we add to previous studies that lack specific measures in IIoTP ecosystems, but already point, for example, to the importance of managing generativity on digital platforms, i.e., leveraging the overall capacity of often unexpected third-party innovation (Hein et al. 2020), or the critical role of providing integration tools to digital business ecosystem actors to ensure easy access to digital platforms (Tan et al. 2020).

Fourth, we contribute to IS (de Reuver et al. 2018) and market-based platform (Gawer 2021) literature by addressing the need for more insights into the dynamics of digital platforms. Specifically, by drawing strategic trajectories between *Hyperscalers* and *Integrated IIoTPs*, we portray market dynamics, formulate strategic implications, and show how both IIoTP types differ in their strategic approaches. We expect that *Integrated IIoTPs* will be driven to follow a horizontally focused differentiation

strategy. This means that they will continuously evolve towards specialized Integrated IIoTps in certain industrial niches to leverage their domain knowledge and differentiate from *Hyperscalers*, which are increasingly moving downstream and offering a growing number of services similar to those of *Integrated IIoTps*. As another viable counter-strategy to this increasing displacement, *Integrated IIoTps* seek to strengthen their market position by acquiring or collaborating with other *Integrated IIoTp* providers or even other types of IIoTps (*Connectivity Platform*, *Digital Marketplace*), ultimately building cloud-to-cloud or platform-to-platform ecosystems with interchangeable *Hyperscalers* as infrastructure providers. Initial projects like GAIA-X¹¹ have been launched at the political level to address this issue, but their success especially at the business model level remains uncertain. However, if successful it may help *Integrated IIoTps* to address the usually low scaling and hence economies of scale and scope potential to profit from fixed cost degression (Obermaier 2021) and demand-side network effects (Parker et al. 2016). Additionally, such projects are of particular importance for *Integrated IIoTps*, as the current strong market position of upstream-located *Hyperscalers* in the IaaS layer and their strategic acquisition of domain knowledge in various key industry sectors (e.g., automotive) through collaborations with downstream-located *Integrated IIoTps* enables *Hyperscalers* to pursue a vertical integration strategy. This may lead to *Hyperscalers* evolving into an all-in-one platform that takes a central and orchestrating role within the IIoTp ecosystem, with *Integrated IIoTps* serving as door openers to industrial customers and complementors before being substituted in scalable IIoTp market areas. By this, we reverse the common notion that downstream actors positioned at the end-user interface such as *Integrated IIoTps* are particularly advantaged to create network effects (Parker et al. 2016) or gain and exert power in digital markets (Mosch et al. 2021). Putting it bluntly: upstream *Hyperscalers* bite the hand of downstream *Integrated IIoTps* that currently feeds them and may even bypass it in specific circumstances as they constantly learn to feed themselves. These specific insights into

¹¹ Founded by various European countries, “the “GAIA-X project” envisages the networking of decentralized infrastructure services, in particular cloud and edge instances, to form a homogeneous, user-friendly system. The resulting networked form of data infrastructure strengthens both the digital sovereignty of the demanders of cloud services and the scalability and competitive position of European cloud providers.” (BMW and BMBF 2019, p. 3).

IIoT market dynamics complement Gawer's (2020) study, which calls for examining situations where digital platforms are declining and attempting to evolve into smaller niche markets. Moreover, due to the large amounts of data that *Hyperscalers* possess, they are able to generate strong data-driven network effects that continue to improve the algorithms implemented in their offerings in an endless, reinforcing the cycle (Gregory et al. 2020), which may lead to winner-takes-all situations in certain markets, similar to examples of digital platforms in B2C settings (e.g., search engines (Argenton and Prüfer 2012)). However, increasing market dominance of a single IIoTP actor may lead to distracting its complementors (Rietveld et al. 2020; McIntyre et al. 2020), adversely affecting the cooperative relationship between *Hyperscalers* and *Integrated IIoTPs*. We therefore conclude that the initially cooperative situation between *Hyperscalers* and *Integrated IIoTPs* is increasingly dissolving, leading to a more competitive battleground between both IIoTP types, where *Hyperscalers* have clear advantages to dominate the block between the two new kids. Thereby, we further add to Pauli et al. (2021) that demand a better understanding of the cooperative relationship between *Hyperscalers* (platform natives) and *Integrated IIoTPs* (industrial incumbents) as well as the diverging strategies they use to approach IIoTP markets.

5.2 Managerial contributions

By describing actors and dynamics of IIoTP markets, we furthermore make considerable managerial contributions. First, we help IIoTP managers and managers seeking entry into the IIoTP battlefield to clear the vision and blow away the powder smoke by showing which IIoTP types and value creations exist and providing guidance on which ones they should focus on in highly complex IIoTP markets according to their strategic alignments. In this regard, we also point to the importance of economies of scale and scope to achieve lower marginal costs required to succeed in IIoTP markets, especially as a *Hyperscaler*. Second, by identifying strategic measures and possible future developments of *Hyperscalers* and *Integrated IIoTPs*, we equip managers with concrete recommendations for action and a strategic framework they can use as a template for developing or rethinking their own strategic

actions. Specifically, we assist them in deciding whether to simply participate in existing IIoTPs to flexibilize fixed costs, e.g., as third-party complementor, or heavily invest in building and maintaining an IIoTP as an operator. Overall, we support manager in deciding on which efforts and risks to take and what IIoTP type to focus on to ultimately turn their IIoTP project into a success story.

5.3 Limitations and agenda for future research

Lastly, we encourage future research to address the following limitations of our study. First, although we believe that our four identified IIoTP types are comprehensive and cover the current IIoTP market, we are not in a position to determine which additional IIoTP types will emerge in the future and therefore how our classification will evolve. Since we already infer potential future market dynamics, at least for *Hyperscalers* and *Integrated IIoTPs*, we invite researchers to update our IIoTP type classification on a regular basis. Second, our interview partners originate only from *Hyperscalers* and *Integrated IIoTPs*, excluding *Digital Marketplaces* and *Connectivity Platforms*. Although, we argue that the latter two IIoTP types play a less important role in gaining competitive advantage in IIoTP markets, their characteristics or strategic trajectories may change in the future, allowing them to once again play an important role in specific markets of the IIoTP battlefield. For instance, *Digital Marketplaces* in logistics may increasingly disrupt and blur inflexible structures in inter-organizational supply chains, creating new actors, roles, and market dynamics, especially in the manufacturing industry (Pan et al. 2021). Hence, these two IIoTP types can serve as a basis for further case study research, adding valuable insights to the overall complex and dynamic IIoTP market. Third, we are not able to determine the strength of impact on the individual value creation logics and overall IIoTP performance associated with the strategic measures we have identified due to the chosen case study methodology. This may be subject of further investigation in the form of quantitative empirical studies to deepen our understanding of IIoTPs.

References

- Adner, Ron (2017): Ecosystem as structure: An actionable construct for strategy. In *Journal of Management* 43 (1), pp. 39–58.
- Argenton, Cédric; Prüfer, Jens (2012): Search engine competition with network externalities. In *Journal of Competition Law and Economics* 8 (1), pp. 73–105.
- Armstrong, Mark (2006): Competition in two-sided markets. In *RAND Journal of Economics* 37 (3), pp. 668–691.
- Arnold, Laurin; Jöhnk, Jan; Vogt, Florian; Urbach, Nils (2021): A Taxonomy of Industrial IoT Platforms' Architectural Features. In *Internationale Konferenz Wirtschaftsinformatik*, pp. 1–17.
- Bell, Emma; Bryman, Alan; Harley, Bill (2018): *Business research methods*. Oxford: Oxford University Press.
- Bengtsson, Maria; Kock, Sören (2014): Coopetition—Quo vadis? Past accomplishments and future challenges. In *Industrial Marketing Management* 43 (2), pp. 180–188.
- BMWi; BMBF (2019): Das Projekt GAIA-X. Eine vernetzte Dateninfrastruktur als Wiege eines vitalen, europäischen Ökosystems. Edited by Bundesministerium für Wirtschaft and Energie, Bundesministerium für Bildung and Forschung. Berlin.
- Bohr, Kurt (1996): Economies of Scale and Economies of Scope. In Werner Kern, Hans H. Schröder, Jürgen Weber (Eds.): *Handwörterbuch der Produktionswirtschaft*. Stuttgart: Schäffer-Poeschel, pp. 375–386.
- Boudreau, Kevin J. (2012): Let a thousand flowers bloom? An early look at large numbers of software app developers and patterns of innovation. In *Organization Science* 23 (5), pp. 1409–1427.
- Brodthmann, Thilo; Schnittler, Volker; Becker, Michael; Herring, Dorothee; Mayer-Haug, Katrin; Schleyer, Thorsten (2020): *Kundenzentrierung als Chance für den digitalen Durchbruch. Was sich die Endkundenindustrie vom Maschinenbau bei digitalen Plattformen and Mehrwertdiensten wünschen*. Edited by Verband Deutscher Maschinen- and Anlagenbau, McKinsey & Company. Frankfurt am Main.
- Caillaud, Bernard; Jullien, Bruno (2003): Chicken & egg: Competition among intermediation service providers. In *RAND Journal of Economics* 34 (2), pp. 309–328.
- Clement, Reiner; Schreiber, Dirk (2016): *Internet-Ökonomie*. Berlin: Springer.
- Cusumano, Michael A.; Gawer, Annabelle; Yoffie, David B. (2019): *The business of platforms: Strategy in the age of digital competition, innovation, and power*. New York: HarperCollins Publishers.
- Cusumano, Michael A.; Yoffie, David B.; Gawer, Annabelle (2020): The future of platforms. In *MIT Sloan Management Review* 61 (3), pp. 46–54.

- Dann, David; Teubner, Timm; Adam, Marc T. P.; Weinhardt, Christof (2020): Where the host is part of the deal: Social and economic value in the platform economy. In *Electronic Commerce Research and Applications* 40, in press.
- de Reuver, Mark; Sørensen, Carsten; Basole, Rahul C. (2018): The digital platform: a research agenda. In *Journal of Information Technology* 33 (2), pp. 124–135.
- Eisenhardt, Kathleen M. (1989): Building theories from case study research. In *Academy of Management Review* 14 (4), pp. 532–550.
- Eisenhardt, Kathleen M.; Graebner, Melissa E. (2007): Theory building from cases: Opportunities and challenges. In *Academy of Management Journal* 50 (1), pp. 25–32.
- Eisenmann, Thomas; Parker, Geoffrey; van Alstyne, Marshall (2011): Platform envelopment. In *Strategic Management Journal* 32 (12), pp. 1270–1285.
- Eisenmann, Thomas; Parker, Geoffrey; van Alstyne, Marshall W. (2006): Strategies for two-sided markets. In *Harvard Business Review* 84 (10), pp. 92–101.
- Eisenmann, Thomas R.; Parker, Geoffrey; van Alstyne, Marshall (2009): Opening platforms: how, when and why? In Annabelle Gawer (Ed.): *Platforms, markets and innovation*. Cheltenham: Edward Elgar Publishing, pp. 131–162.
- Evans, David S. (2003): Some empirical aspects of multi-sided platform industries. In *Review of Network Economics* 2 (3), pp. 191–209.
- Evans, David S.; Schmalensee, Richard (2010): Failure to launch: Critical mass in platform businesses. In *Review of Network Economics* 9 (4), pp. 1–26.
- Evans, Peter C.; Gawer, Annabelle (2016): *The rise of the platform enterprise: a global survey*. Edited by The Center for Global Enterprise. New York.
- Falck, Oliver; Koenen, Johannes (2020): *Industrielle Digitalwirtschaft - B2B-Plattformen*. Edited by ifo Institut, Bundesverband der Deutschen Industrie. Berlin.
- Foerderer, Jens; Kude, Thomas; Schuetz, Sebastian Walter; Heinzl, Armin (2019): Knowledge boundaries in enterprise software platform development: Antecedents and consequences for platform governance. In *Information Systems Journal* 29 (1), pp. 119–144.
- Gartner (2020): *Magic Quadrant for Cloud Infrastructure and Platform Services*. Available online at <https://www.gartner.com/doc/reprints?id=1-1ZDZDMTF&ct=200703&st=sb>.
- Gassmann, Oliver; Frankenberger, Karolin; Csik, Michaela (2017): *Geschäftsmodelle entwickeln: 55 innovative Konzepte mit dem St. Galler Business Model Navigator*. München: Carl Hanser Verlag GmbH Co KG.
- Gawer, Annabelle (2014): Bridging differing perspectives on technological platforms: Toward an integrative framework. In *Research Policy* 43 (7), pp. 1239–1249.
- Gawer, Annabelle (2021): Digital platforms' boundaries: The interplay of firm scope, platform sides, and digital interfaces. In *Long Range Planning*, in press.

- Gebauer, Heiko; Paiola, Marco; Saccani, Nicola; Rapaccini, Mario (2021): Digital servitization: Crossing the perspectives of digitization and servitization. In *Industrial Marketing Management* 93, pp. 382-388.
- Gilder, George (1993): Metcalfe's law and legacy. In *Forbes ASAP* 152 (13), pp. 158–166.
- Gioia, Dennis A.; Corley, Kevin G.; Hamilton, Aimee L. (2013): Seeking qualitative rigor in inductive research: Notes on the Gioia methodology. In *Organizational Research Methods* 16 (1), pp. 15–31.
- Graff, Jochen; Krenz, Wolfgang; Kronenwett, Daniel (2018): *IIoT Platforms: Source of Profit or Inflated Hype? How Machinery Companies Should Target Their Investments To Maximize Benefits*. Edited by Oliver Wyman. München.
- Gregory, Robert Wayne; Henfridsson, Ola; Kaganer, Evgeny; Kyriakou, Harris (2020): The role of artificial intelligence and data network effects for creating user value. In *Academy of Management Review* 46 (3), pp. 534-551.
- Hagiu, Andrei; Wright, Julian (2015): Multi-sided platforms. In *International Journal of Industrial Organization* 43, pp. 162–174.
- Hein, Andreas; Schrieck, Maximilian; Riasanow, Tobias; Setzke, David Soto; Wiesche, Manuel; Böhm, Markus; Krcmar, Helmut (2020): Digital platform ecosystems. In *Electronic Markets* 30, pp. 87–98.
- Hein, Andreas; Weking, Jörg; Schrieck, Maximilian; Wiesche, Manuel; Böhm, Markus; Krcmar, Helmut (2019): Value co-creation practices in business-to-business platform ecosystems. In *Electronic Markets* 29, pp. 503–518.
- Helfat, Constance E.; Raubitschek, Ruth S. (2018): Dynamic and integrative capabilities for profiting from innovation in digital platform-based ecosystems. In *Research Policy* 47 (8), pp. 1391–1399.
- Jacobides, Michael G.; Cennamo, Carmelo; Gawer, Annabelle (2018): Towards a theory of ecosystems. In *Strategic Management Journal* 39 (8), pp. 2255–2276.
- Jones, Charles I.; Tonetti, Christopher (2019): Nonrivalry and the Economics of Data. In *American Economic Review* 110 (9), pp. 2819–2858.
- Jovanovic, Marin; Sjödin, David; Parida, Vinit (2021): Co-evolution of platform architecture, platform services, and platform governance: Expanding the platform value of industrial digital platforms. In *Technovation*, in press.
- Karhu, Kimmo; Ritala, Paavo (2020): Slicing the cake without baking it: Opportunistic platform entry strategies in digital markets. In *Long Range Planning* 54 (5), in press.
- Koenen, Thomas; Heckler, Steven (2020): *Deutsche digitale B2B-Plattformen. Auf Deutschlands industrieller Stärke aufbauen. Ein Ökosystem für B2B Plattformen fördern*. Edited by Bundesverband der Deutschen Industrie. Berlin.
- Leminen, Seppo; Rajahonka, Mervi; Wendelin, Robert; Westerlund, Mika (2020): Industrial internet of things business models in the machine-to-machine context. In *Industrial Marketing Management* 84, pp. 298–311.

- Lerch, Christian; Meyer, Niclas; Horvat, Djerdj; Jackwerth-Rice, Thomas; Jäger, Angela; Lobsiger, Michael; Weidner, Nadia (2019): *Die volkswirtschaftliche Bedeutung von digitalen B2B-Plattformen im Verarbeitenden Gewerbe*. Edited by Bundesministerium für Wirtschaft and Energie. Berlin.
- McAfee, Andrew; Brynjolfsson, Erik (2017): *Machine, platform, crowd: Harnessing our digital future*. New York: WW Norton & Company.
- McGrath, Rita Gunther (2020): The new disrupters. In *MIT Sloan Management Review* 61 (3), pp. 28–33.
- McIntyre, David P.; Srinivasan, Arati; Chintakananda, Asda (2020): The persistence of platforms: The role of network, platform, and complementor attributes. In *Long Range Planning* 54 (5), in press.
- Miles, Matthew B.; Huberman, A. Michael (1994): *Qualitative data analysis: An expanded sourcebook*. Thousand Oaks: Sage.
- Mosch, Philipp; Schweikl, Stefan; Obermaier, Robert (2021): Trapped in the supply chain? Digital servitization strategies and power relations in the case of an industrial technology supplier. In *International Journal of Production Economics* 236, in press.
- Nunnally, Jum C. (1978): *Psychometric Theory*. New York: McGraw-Hill Publishing Company.
- Obermaier, Robert (2019): Industrie 4.0 and Digitale Transformation als unternehmerische Gestaltungsaufgabe. In Robert Obermaier (Ed.): *Handbuch Industrie 4.0 and Digitale Transformation. Betriebswirtschaftliche, technische and rechtliche Herausforderungen*. Wiesbaden: Springer Gabler, pp. 3–46.
- Obermaier, Robert (2021): Management der Kostenstruktur in einer „Industrie 4.0“. In *Controlling - Zeitschrift für erfolgsorientierte Unternehmenssteuerung* 33 (3), pp. 31–38.
- Obermaier, Robert; Hofmann, Johann; Wagenseil, Victoria (2019): Systematische Abschätzung von Wirtschaftlichkeitseffekten von Industrie-4.0-Investitionen mithilfe von Prozess- and Potenzialanalysen. In Robert Obermaier (Ed.): *Handbuch Industrie 4.0 and Digitale Transformation. Betriebswirtschaftliche, technische and rechtliche Herausforderungen*. Wiesbaden: Springer Gabler, pp. 189–203.
- Obermaier, Robert; Mosch, Philipp (2019): Digitale Plattformen – Klassifizierung, ökonomische Wirkungslogik and Anwendungsfälle in einer Industrie 4.0. In Robert Obermaier (Ed.): *Handbuch Industrie 4.0 and Digitale Transformation. Betriebswirtschaftliche, technische and rechtliche Herausforderungen*. Wiesbaden: Springer Gabler, pp. 379–417.
- Pagani, Margherita; Pardo, Catherine (2017): The impact of digital technology on relationships in a business network. In *Industrial Marketing Management* 67, pp. 185–192.

- Pagano, Dennis; Maalej, Walid (2013): User feedback in the appstore: An empirical study. In *Proceedings of the 21st International Requirements Engineering Conference (IEEE)*, pp. 125–134.
- Pan, Shenle; Trentesaux, Damien; McFarlane, Duncan; Montreuil, Benoit; Ballot, Eric; Huang, George Q. (2021): Digital interoperability and transformation in logistics and supply chain management. In *Computers in Industry* 129, in press.
- Panzar, John C.; Willig, Robert D. (1981): Economies of scope. In *The American Economic Review* 71 (2), pp. 268–272.
- Parker, Geoffrey; van Alstyne, Marshall (2018): Innovation, openness, and platform control. In *Management Science* 64 (7), pp. 3015–3032.
- Parker, Geoffrey; van Alstyne, Marshall; Choudary, Sangeet Paul (2016): *Platform revolution. How networked markets are transforming the economy - and how to make them work for you*. New York: W.W. Norton & Company.
- Pauli, Tobias; Fiel, Erwin; Matzner, Martin (2021): Digital Industrial Platforms. In *Business & Information Systems Engineering* 63 (2), pp. 181–190.
- Porter, Michael E. (1985): *Competitive advantage of nations: creating and sustaining superior performance*. New York: The Free Press.
- Rauen, H.; Glatz, R.; Schnittler, V.; Peters, K.; Schorak, M. H.; Zollenkop, M. et al. (2018): *Plattformökonomie im Maschinenbau*. Edited by Roland Berger, Verband Deutscher Maschinen- and Anlagenbau, Deutsche Messe. München.
- Riasanow, Tobias; Jäntgen, Lea; Hermes, Sebastian; Böhm, Markus; Krcmar, Helmut (2020): Core, intertwined, and ecosystem-specific clusters in platform ecosystems: analyzing similarities in the digital transformation of the automotive, blockchain, financial, insurance and IIoT industry. In *Electronic Markets* 31, pp. 89–104.
- Rietveld, Joost; Ploog, Joe N.; Nieborg, David B. (2020): Coevolution of platform dominance and governance strategies: effects on complementor performance outcomes. In *Academy of Management Discoveries* 6 (3), pp. 488–513.
- Rifkin, Jeremy (2014): *The zero marginal cost society: The internet of things, the collaborative commons, and the eclipse of capitalism*. New York: St. Martin's Press.
- Rochet, Jean-Charles; Tirole, Jean (2003): Platform competition in two-sided markets. In *Journal of the European Economic Association* 1 (4), pp. 990–1029.
- Rust, Roland T.; Cooil, Bruce (1994): Reliability measures for qualitative data: Theory and implications. In *Journal of Marketing Research* 31 (1), pp. 1–14.
- Shapiro, Carl; Varian, Hal R. (1999): *Information rules: a strategic guide to the network economy*. Boston: Harvard Business Press.
- Sklyar, Alexey; Kowalkowski, Christian; Tronvoll, Bård; Sörhammar, David (2019): Organizing for digital servitization: A service ecosystem perspective. In *Journal of Business Research* 104, pp. 450–460.

- Stake, Robert E. (1995): *The art of case study research*. Thousand Oaks: Sage.
- Strauss, Anselm; Corbin, Juliet (1998): *Basics of qualitative research techniques*. Thousand Oaks: Sage.
- Stummer, Christian; Kundisch, Dennis; Decker, Reinhold (2018): Platform launch strategies. In *Business & Information Systems Engineering* 60 (2), pp. 167–173.
- Tan, Burcu; Anderson Jr, Edward G.; Parker, Geoffrey G. (2020): Platform pricing and investment to drive third-party value creation in two-sided networks. In *Information Systems Research* 31 (1), pp. 217–239.
- Täuscher, Karl; Laudien, Sven M. (2018): Understanding platform business models: A mixed methods study of marketplaces. In *European Management Journal* 36 (3), pp. 319–329.
- Teece, David J. (1980): Economies of scope and the scope of the enterprise. In *Journal of Economic Behavior & Organization* 1 (3), pp. 223–247.
- Teece, David J. (2018): Profiting from innovation in the digital economy: Enabling technologies, standards, and licensing models in the wireless world. In *Research Policy* 47 (8), pp. 1367–1387.
- Teubner, Timm; Hawlitschek, Florian; Dann, David (2017): Price determinants on Airbnb: How reputation pays off in the sharing economy. In *Journal of Self-Governance and Management Economics* 5 (4), pp. 53–80.
- van Alstyne, Marshall W.; Parker, Geoffrey G.; Choudary, Sangeet Paul (2016): Pipelines, platforms, and the new rules of strategy. In *Harvard Business Review* 94 (4), pp. 54–62.
- Villegas, David; Bobroff, Norman; Rodero, Ivan; Delgado, Javier; Liu, Yanbin; Devarakonda, Aditya et al. (2012): Cloud federation in a layered service model. In *Journal of Computer and System Sciences* 78 (5), pp. 1330–1344.
- Yin, Robert K. (2018): *Case study research and applications*. Design and methods. Los Angeles: Sage.
- Yoo, Youngjin; Henfridsson, Ola; Lyytinen, Kalle (2010): Research commentary—the new organizing logic of digital innovation: an agenda for information systems research. In *Information Systems Research* 21 (4), pp. 724–735.
- Zhao, Yang; Delft, Stephan von; Morgan-Thomas, Anna; Buck, Trevor (2020): The evolution of platform business models: Exploring competitive battles in the world of platforms. In *Long Range Planning* 53 (4), in press.

**Driving or Driven by Others? A Dynamic Perspective on How Data-
Driven Start-Ups Strategize Across Different Network Roles in
Digitalized Business Networks**

Philipp Mosch (philipp.mosch@uni-passau.de)
Chair for Business Economics, Accounting and Control
DE-94032 Passau, Germany

Corinna Winkler
Chair of Marketing and Innovation
DE-94032 Passau, Germany

Curd-Georg Eggert
Chair of Marketing and Innovation
DE-94032 Passau, Germany

Jan H. Schumann
Chair of Marketing and Innovation
DE-94032 Passau, Germany

Robert Obermaier
Chair for Business Economics, Accounting and Control
DE-94032 Passau, Germany

Wolfgang Ulaga
Faculty of Marketing
FR-77300 Fontainebleau, France

Abstract

Digitalization transforms how actors conduct activities and exchange resources in business networks. Data-driven start-ups are key actors in this transformation as they are often the first to commercialize novel digital technologies and influence business networks through their strategizing. Extant Industrial Marketing & Purchasing (IMP) literature has investigated roles and strategizing in business networks. However, understanding how data-driven start-ups' specificities impact their roles and strategizing is still at its infancy. Specifically, the authors conceptually show that assumptions on how data-driven start-ups strategize contradict strategizing tenets of prior IMP literature. Therefore, previous knowledge on strategizing needs further differentiation. Addressing this research need, theories-in-use and multiple case study research on 23 data-driven start-ups is conducted to examine (1) in what network roles they operate and (2) how they strategize within and across different network roles. The study extends IMP and data-driven business model research by identifying four network roles (enabler, extender, transformer, orchestrator) and developing a specific classification framework for data-driven start-ups. Furthermore, the study shows that IMP tenets apply in specific network roles only to some extent to data-driven start-ups. Finally, three strategizing trajectories are identified, which provide a dynamic perspective to IMP literature for guiding entrepreneurs on strategizing opportunities.¹²

Keywords: Digitalization; IMP; Business Networks; Data-driven Start-ups; Strategizing; Case Study Research

¹² Published in the *Industrial Marketing Management*, 102, in 2022, see here: <https://www.sciencedirect.com/science/article/abs/pii/S0019850122000232>

1. Introduction

The emerging digitalization of society and the economy is transforming how companies conduct activities, use resources, and manage relationships among different actors in business networks (Pagani and Pardo 2017; Ritter and Pedersen 2020; Möller et al. 2020). Thus, Industrial Marketing & Purchasing (IMP) research, which for the past decades has focused on how business networks and their actors evolve and transform (Håkansson and Snehota 1995; Håkansson 1982), has contributed profoundly providing a highly relevant foundation through which to study this change (Pagani and Pardo 2017). Business networks' digitalization is largely fueled by data-driven start-ups, which are often the first to commercialize new ideas through innovative data-driven business models based on digital technologies and data as their key resource (Hartmann et al. 2016). Accordingly, we define data-driven start-ups as start-ups that create and capture value through data-based activities (e.g., data aggregation, processing, or analytics), thereby linking dispersed resources and actors. In doing so, data-driven business models potentially equip data-driven start-ups with the capabilities to change existing business networks and create new business opportunities (Nenonen et al. 2019; Fehrer et al. 2020). Indeed, by digitalizing business networks, data-driven start-ups can drive and transform not only individual firms and their relationships, but also entire industries in a short period of time (Kumaraswamy et al. 2018).

Digitalized business networks are specifically characterized by complex relationships, close cooperation, and fast-moving, data-driven interactions between different actors (Peppard and Rylander 2006). These characteristics are challenging for data-driven start-ups and lead to high failure rates, particularly in the early stages (Giardino et al. 2014). The reason for failure is often due to an inappropriate strategizing that focuses on trying to imitate the few successful start-ups that have become driving actors (Aaboen et al. 2016), instead of acting in another role that may better fit the data-driven start-up's initial network position or key resource access. Thus, it is crucial for founders to understand network dynamics and strategize accordingly to position their data-driven start-up appropriately and distinctively in digitalized business networks vis-à-vis incumbent actors, acquire critical resources,

and achieve the desired network role (Pagani and Pardo 2017; Lamine et al. 2019). In this regard, we understand strategizing to be a proactive and purposeful activity that may change the actor's network position or the strength of relationships or ties (these terms are used as synonyms), ultimately resulting in a shift from one network role to another (Laari-Salmela et al. 2019; Elfring and Hulsink 2003).

Despite data-driven start-ups' increasing relevance and proliferation, prior research does not account for these issues. Although IMP literature, which traditionally has investigated incumbent firms, increasingly has shifted attention to start-ups in recent years (Snehota 2011; Aaboen et al. 2017b; Baraldi et al. 2019), the start-ups studied predominantly are from non-data-driven or blended contexts (Oukes et al. 2019; McGrath et al. 2019). Moreover, studies on start-ups' network positions and roles have deduced their insights merely from the resource level, adopting a rather static network role perspective (Guercini and Runfola 2015; Aaboen et al. 2016) and potentially leading to an incomplete understanding of the dynamics that data-driven start-ups face in digitalized business networks. Therefore, we argue that existing research is challenged in several ways, including the question of whether existing IMP knowledge remains applicable in the context of fast-changing digitalized business networks.

Two examples illustrate the difficulties in accounting for the new dynamics of strategizing in data-driven contexts outlined in the literature on data-driven business models and digital business strategies with existing knowledge from IMP research. First, recent IMP studies state that start-ups enter pre-existing network structures in a more peripheral network position and, therefore are driven by more centrally located actors (Snehota 2011). However, studies on data-driven business models and digital business strategy show that data-driven start-ups can take central network positions and drive other actors in early stages by creating a large number of new bonds between previously unconnected actors through digital platforms (Parker et al. 2016; Pagani 2013). Second, data-driven start-ups possess data-specific knowledge and capabilities necessary to succeed in digitalized business networks, making incumbents dependent and enabling data-driven start-ups to gain new forms of power (Kupp et al. 2017). This contradicts the traditional argument in IMP literature concerning start-ups' typically weak power position relative to incumbents in non-

data-driven contexts (Oukes et al. 2019). Both contradictions indicate that data-driven start-ups in digitalized business networks tend to drive other actors, rather than being driven by them. However, it remains unknown under which conditions and in which network roles data-driven start-ups actually can and cannot be drivers. Evidently, digitalization and data-driven business models change the playing field and impact relationships in such a fundamental way that IMP knowledge must be broadened to explain data-driven start-ups' roles and their strategizing in digitalized business networks (Ritter and Pedersen 2020). Therefore, we aim to answer the following research questions:

(1) What roles do data-driven start-ups take in digitalized business networks?

(2) How do data-driven start-ups dynamically strategize within and across different network roles on various strategic trajectories in digitalized business networks?

To address our research questions, we carefully review IMP literature on start-ups and derive four tenets for start-up strategizing in non-data-driven settings, contrasting them with tenets documented in the fast-growing literature on data-driven business models and digital business strategy. Our detailed overview of these contradictions serves as the foundation for adopting theories-in-use and explorative multiple case study research to better understand the various nuances of how data-driven start-ups strategize in different network roles. Theories-in-use is particularly suitable for our study, as network roles and strategizing emerge from founders' mental models, i.e., individual interpretations of how to address and proactively shape change in digitalized business networks (Laari-Salmela et al. 2019). In our study, we therefore clearly adopt the perspective of the individual founder. This approach is then embedded in multiple case study research that enables aggregation and contextualization of the individual perspectives at the firm level across multiple cases. In total, we investigate 23 data-driven start-ups and interview their founders to discover in which network role they act, how their strategizing varies from non-data-driven start-ups in different network roles, and which dynamic strategizing trajectories they follow in digitalized business networks.

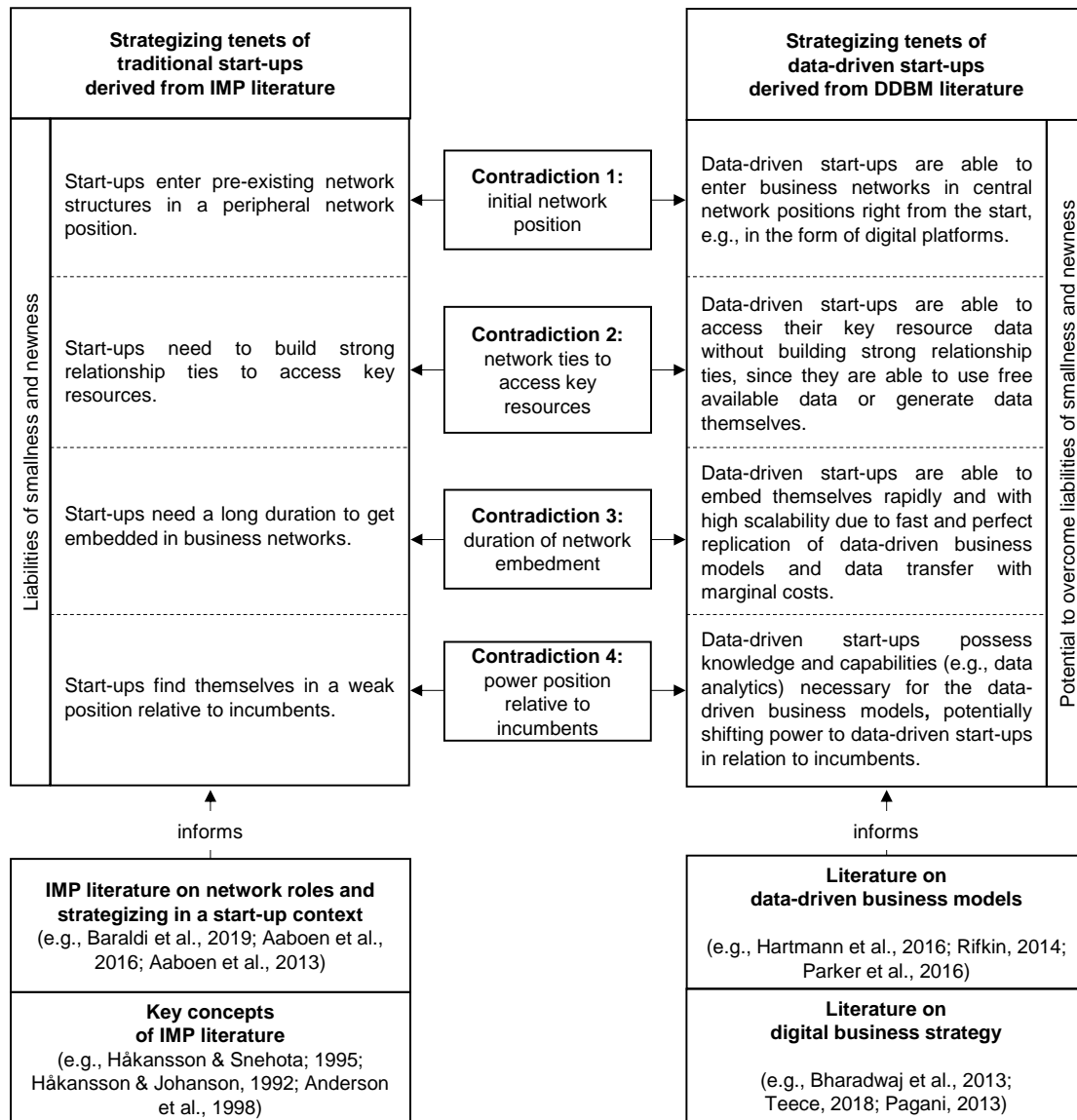
Based on our analysis, we make the following three contributions: First, by identifying four network roles of data-driven start-ups (extender, enabler, transformer, orchestrator), we add the digitalization perspective to IMP literature on start-ups (Baraldi et al. 2019) and network roles (Aaboen et al. 2016). Thereby, we use the Activity-Resource-Actor (ARA) model and data-driven business model components to include not only the resource level, but also a nuanced activity and actor perspective, to build a unique classification framework that provides a comprehensive picture of data-driven start-ups' possible network roles. We demonstrate that specifically, the strength of network ties to access data and the network position are key variables in strategizing in complex and interdependent digitalized business networks. Second, we put the network roles in the context of our elaborated contradictions, extending previous IMP literature (Baraldi et al. 2020) by finding data-driven start-ups' strategizing in specific network roles needs to be studied on the basis of different assumptions compared with previous IMP studies. Third, based on our classification framework, we spotlight to the importance of a dynamic perspective in digitalized business networks by examining data-driven start-ups not only at a specific point in time, but also across three identified main strategizing trajectories that they follow. By identifying the awareness of the extent to which network roles change as being key to success in digitalized business networks, we contribute to previous IMP studies on strategizing (Baraldi et al. 2007; Aaboen et al. 2016) and address Möller et al.'s (2020) argument that emphasizes the importance of purposeful strategizing in highly dynamic digitalized business networks.

The remainder of our paper is structured as follows. In section 2, we lay out our study's theoretical foundation, describing key concepts from IMP literature, outlining the strategizing tenets derived from existing IMP literature on start-ups, and contrasting them with the strategizing tenets from literature on data-driven business models and digital business strategy. In section 3, we explain the applied methodology. Section 4 reveals our study's results. In section 5, we discuss our results and provide implications for academia and management. Furthermore, we outline our study's limitations and provide suggestions for future research.

2. Theoretical foundation

Our study's theoretical foundation is based on two literature streams: (1) IMP literature mainly focusing on non-data-driven (traditional) start-ups and (2) literature on data-driven business models and digital business strategy (DDBM)¹³.

Figure 1. Contrasting strategizing tenets of traditional vs. data-driven start-ups from IMP and DDBM literature.



¹³ In the following, we will describe both literature streams “data-driven business models” and “digital business strategy” in a more simplistic manner using the acronym DDBM.

We first describe our study's relevant key IMP concepts: *network position*; *network role*; and *strategizing*. In the second step, we demonstrate how insights from the DDBM literature challenge widely accepted strategizing tenets from IMP literature. Figure 1 illustrates the four elaborated contradictions and serves as this chapter's structural body.

2.1 Key concepts and start-ups in IMP literature

Key concepts in IMP literature

Business networks are understood as a “set of two or more connected business relationships, in which each exchange relation is between business firms that are conceptualized as collective actors (Emerson, 1981).” (Anderson et al. 1994, p. 2). Being at the core of every business network, relationships are interaction processes in which two actors combine, exchange, or create resources in an activity with mutual orientation and commitment (Håkansson and Snehota 1995; Håkansson and Johanson 1992). The higher (lower) the level of interaction intensity and diversity between the actors, the stronger (weaker) the ties and, thus the exchange of fine-grained information or trust-based governance (Elfring and Hulsink 2003; Rowley et al. 2000).

Based on the Activity-Resource-Actor (ARA) model (Håkansson and Johanson 1992; Håkansson and Snehota 1995) – which spotlights activity links, resource ties, and actor bonds –, researchers increasingly take a dynamic perspective and investigate how firms connect with other actors and manage relationships in business networks (Aaboen et al. 2017a). Activities can be for example “offering a product or service” or “building strong ties to suppliers”. Several interlinked activities form a transaction chain, which is directed towards a purpose (e.g., reaching a certain network role). Resources can be tangible (e.g., equipment or manpower) or intangible (e.g., knowledge or data) and are heterogenous and controlled by one or more actors. Actors are individuals or companies, since both are able to set priorities leading to a purpose while interacting (Håkansson and Johanson 1992; Schepis et al. 2014). The dynamic purpose building based on activities, resources, and actors is closely linked to three key concepts, namely *network position*, *network role* and *strategizing*.

In IMP literature, *network position* is determined by the location in the business network relative to other actors (Anderson et al. 1998). For instance, when an actor has a large number of ties to others or controls critical resources (e.g., knowledge or interfaces between buyer and seller), it increases network control and could be assigned a more central network position (Håkansson and Johanson 1992; Bizzi and Langley 2012) that may lead to better firm performance (Fund et al. 2008). *Network roles* are intertwined closely with network positions, as they reflect how an actor interprets its network position (Abrahamsen et al. 2012), making network role identification highly dependent on the perspective taken. Generally, a focal actor dynamically acts in a role, but statically holds a position (Anderson et al. 1998). The process of how actors make sense of their network positions and roles is referred to as *strategizing*. Laari-Salmela, Mainela & Puhakka (2019, p. 201) describe strategizing as an “ongoing effort that follows the routinized ways of both proactively making moves to find future direction for the development of the firm as well as reacting to changes in the network”. This may involve alterations in network positions or changes in the degree of relationship strength with key resource-providing actors in the business network (Elfring and Hulsink 2003; Aaboen et al. 2016), potentially leading to a change in the associated role.

Start-ups in business networks according to IMP literature

In recent years, several studies have emerged in IMP literature that focus on start-ups in business networks and place the key concepts described above in a new light. Start-ups exhibit unique characteristics due to their significantly different size and age compared with incumbents (Aldrich Howard and Ruef 2006; Su et al. 2011; Zaremba et al. 2016), often referred to as *liability of smallness* and *liability of newness*, conveying that start-ups have limited access to resources and capabilities, e.g., financial, human, and technological capital (Aldrich and Auster 1986) or lack legitimacy, track records, and effective networks (Stinchcombe 1965). Based on these liabilities, start-ups strategize and act considerably differently than incumbents (Baraldi et al. 2019). For instance, start-ups need to adapt their offerings to existing network structures due to their peripheral network position or lack of key resources, which can impact their power position negatively. According to recent literature

review on start-ups in IMP research of Baraldi et al. (2019), previous studies in examining these differences focus predominantly on how start-ups create a position in established business network structures, how they acquire, develop, or combine resources with other actors, and how they may influence or change existing network structures. In particular, the process of initiating ties with other actors is usually at the center of research interest, as such ties represent crucial assets and liabilities for the further development of the individual start-up (e.g., ties to access key resources) (Baraldi et al. 2020).

However, most of these studies investigate start-ups that produce physical products, such as wireless communication devices (McGrath et al. 2019) and medical products (Oukes et al. 2019). Furthermore, they base their findings on a mixture of start-ups from different industries with diverse business models (Diáñez-González and Camelo-Ordaz 2019; Brown et al. 2019) or examine start-ups emerging from specific contexts, such as academia (Guercini and Milanesi 2019; Landqvist and Lind 2019; Aaboen et al. 2016). Therefore, it remains unclear, and of high interest to both IMP researchers and managers, whether these findings also apply to data-driven start-ups, as they might strategize differently depending on their role within the digitalized business network.

2.2 Contradictions between traditional start-ups' strategizing tenets from IMP literature and data-driven start-ups' tenets from DDBM literature

Insights from IMP literature on how start-ups strategize in business networks differ from data-driven start-ups' tenets derived from DDBM literature, comprising data-driven business models (Hartmann et al. 2016) and digital business strategy (Bharadwaj et al. 2013) literature streams. For instance, DDBM literature suggests that data enable data-driven start-ups to form and commercialize data-driven business models in a short period of time (Hartmann et al. 2016; Bharadwaj et al. 2013), thereby shaping and driving other actors and their relationships in digitalized business networks. This view is closely related to recent market-shaping literature, which states that digital platforms can re-configure whole networks by generating new resource linkages (Fehrer et al. 2020; Nenonen et al. 2019). Since data-driven start-

ups usually focus on a specific data-driven business model, we describe the components of data-driven business models developed by Hartmann et al. (2016) in more detail to illustrate the basis on which data-driven start-ups determine their strategizing: (1) key resource, (2) key activities, (3) offering, (4) customer segment, (5) revenue model, and (6) cost structure. Key resources can be internal or external (big) data, often freely available and easy to access, combined with data-related domain knowledge (e.g., big data analytics, cloud computing) or key partnerships. Relative to the respective key resource of data, each data-driven start-up performs several key activities, such as data aggregation, analysis, or visualization, leading to the creation of an offering or value proposition. The offering may take the form of data (e.g., crawled raw data), information (e.g., analyzed data), or data-enriched physical products (e.g., smart lock). The customer segment describes the desired target group of the data-driven start-up's offering, e.g., B2B and/or B2C customers. The revenue model determines how the data-driven start-up generates its income. Typical examples include subscription-, advertising-, or transaction-based models. The cost structure strongly depends on how costly it is to access the key resource of data. For example, if the data is generated internally, there is no cost for additional data collection and the analytics services can be provided at a marginal cost of almost zero, resulting in a specific cost advantage for fast and high growth. Therefore, these specific characteristics of data-driven business models might enable data-driven start-ups to strategize differently compared to traditional start-ups.

Based on a careful review of IMP literature on traditional start-ups and DDBM literature on data-driven start-ups, we derive four contradictions that are related to (1) initial network position, (2) network ties to access key resources, (3) duration of network embedment, and (4) power position relative to incumbents.

Contradiction 1: initial network position

Prior IMP research has suggested that traditional start-ups need to fit their solutions fully into pre-existing network structures and adapt to incumbent actors that already occupy the respective network's center (Snehota 2011; Håkansson and Waluszewski 2007). This creates the need for strategic actions to gain central actors' acceptance and expand their business (La Rocca and Perna 2014). For instance, IMP researchers

have argued that start-ups may monitor their limited set of existing relationships to acquire additional ties that fuel their success (Aaboen et al. 2017a), or may undertake measures to adjust their business networks and structure to their advantage (Baraldi et al. 2019). This allows start-ups to overcome inertia in inherently stable and conservative existing business networks (Baraldi et al. 2019), thereby moving from an initially peripheral network position to the center. Altogether, we conclude that IMP research points to the fact that start-ups tend to enter pre-existing network structures in a more peripheral network position.

Contradicting this tenet, insights from research on data-driven business models (Hartmann et al. 2016) and digital business strategy (Bharadwaj et al. 2013; Pagani 2013) suggest that data-driven start-ups can establish themselves in business networks in central positions from the beginning as they create new direct and indirect ties between a large number of actors. For instance, data-driven start-ups typically draw on multiple data sources, leading to many different actors' involvement operating in a business network. Furthermore, fast-paced technology shifts confront actors with an increasing number of attractive opportunities for new entrants (Bharadwaj et al. 2013; Teece 2018), potentially leading to the creation of new bonds with previously unconnected actors. In particular, data-driven start-ups that connect a large set of actors (e.g., electronic marketplaces or housing platforms) are key to coordinating value cocreation and appropriation in digitalized environments (Nambisan et al. 2017). Through the creation of direct and indirect network effects, they can reach enormous growth rates in terms of actor numbers and value (Shapiro and Varian 1999). These so-called digital platforms (Parker et al. 2016) can occupy customer interfaces immediately after entering business networks and alter existing relationships to their advantage (Andersson and Mattsson 2016) while breaking traditional industry boundaries and defining new ones (Bharadwaj et al. 2013).

Contradiction 2: network ties to access key resources

IMP studies on business relationship initiations and resource combinations indicate that traditional start-ups do not own or control all required resources (Ciabuschi et al. 2012). Accordingly, start-ups need to interact with other actors in the surrounding

network to acquire key resources (Håkansson et al. 2009), resulting in a greater vulnerability than incumbents (La Rocca et al. 2019). Following this argumentation, start-ups need to build initial relationships (Aaboen et al. 2013) or alliances (Callon 1986) based on strong ties to secure reliable access to valuable resources, e.g., through close supplier relationships (La Rocca et al. 2019). Overall, start-ups need to develop strong network ties with other actors to access key resources and strategize successfully in business networks (Baraldi et al. 2020).

However, we argue data-driven start-ups can access data as their key resource directly and without strong ties in two ways: First, data-driven start-ups can acquire freely available data through open application programming interfaces, e.g., in the context of governmental or social network data (Hartmann et al. 2016) that are viewed as important resources for many data-driven start-ups and their strategizing (Lakomaa and Kallberg 2013). Strong and trusting ties with free data providers are not of high importance, as these providers usually are interested in the widest possible data dissemination to get analyzed by third parties. Second, data-driven start-ups can generate data internally by themselves via their own smart physical products or digital services, e.g., smartphone apps or smart devices. These self-generated data then can be used for further digital services (Porter and Heppelmann 2014). Therefore, data-driven start-ups hold a major advantage over asset-heavy start-ups that solely produce physical products, as they can acquire key resources (data) at marginal costs and in unidirectional relationships without a distinct exchange character. Even in the few cases in which data-driven start-ups use their own physical components to generate their data, production of simple hardware components often is outsourced to contract manufacturers on a large scale, significantly reducing hardware management complexities (Berg et al. 2020). However, all data need to be prepared and enriched, as such data contain no value per se (Janssen et al. 2012). Therefore, we draw the conclusion that the exploitation of freely available or self-generated raw data shifts data-driven start-ups' focus toward how to create value on the customer end, rather than how to access data.

Contradiction 3: duration of network embedment

When traditional start-ups enter business networks and build initial relationships, IMP researchers argue that these start-ups are confronted with a lack of legitimacy among existing actors (La Rocca et al. 2019; Elfring and Hulsink 2003), generally hindering their ability to be perceived as meaningful, predictable, and trustworthy actors (Suchman 1995), and limiting acceptance and support from other actors operating in the same business network (La Rocca et al. 2019). The start-ups' legitimacy within the corporate network is particularly important regarding their production and logistics activities, as they require trusting relationships with potential suppliers. In cases when the start-ups decide to take on these functions internally, large investments and complex implementation processes often are involved (La Rocca et al. 2019). Therefore, the strategizing process of business network embedment often takes a long time, as it includes time-consuming linkage of the start-up's own position and role to other actors' agendas and interpretations (Håkansson and Waluszewski 2007; Havenvid and La Rocca 2017).

However, data-driven start-ups can establish themselves rapidly and with high scalability, mainly because of data-driven business models' characteristics, as they are considerably different from those of non-data-driven ones (Amit and Han 2017; Zott et al. 2011). Unlike traditional business models that may rely on tangible assets, e.g., production facilities or logistics, data-driven business models are based on the following specificities: (1) marginal costs close to zero for duplication; (2) perfectly possible replication; and (3) availability almost anywhere in the world (McAfee and Brynjolfsson 2017; Rifkin 2014). Thus, data-driven business models significantly reduce transaction costs, enabling data-driven start-ups to realize fast speed to market and business growth (Huang et al. 2017; Peppard and Rylander 2006). For instance, data-driven start-ups that develop smartphone applications can adapt rapidly to different platforms' technical requirements and customer attractiveness (Bharadwaj et al. 2013), thereby increasing growth potential. Overall, we argue that digitalization leads to an acceleration in relationship formation and dynamics, allowing data-driven start-ups to become established in business networks more quickly.

Contradiction 4: power position relative to incumbents

IMP literature posits that successfully establishing a position in business networks often requires alliances with incumbent actors that already are positioned at the center of business networks (Baum et al. 2000), as incumbents possess more critical resources and competencies, particularly in non-technical aspects of the underlying relationship (Oukes et al. 2019), e.g., important customer or supplier contacts. However, it is often difficult to build relationships with incumbents, as traditional start-ups lack customer track records or do not have a clear organization yet (Havenvid and La Rocca 2017; La Rocca et al. 2013). This holds implications for the structural power base, which essentially involves assuming that power is derived from control over critical resources that other actors need (Pfeffer and Salancik 1978) and the organization's position in a network (Pfeffer 2009; Kähkönen and Virolainen 2011). Considering that start-ups typically lack these critical resources and often cannot leverage their physical product know-how, they find themselves in a weak bargaining position relative to incumbent actors (Oukes et al. 2019).

This contrasts with data-driven start-ups, which can gain power related to incumbents significantly by leveraging their inherent data-specific knowledge, such as data aggregation or analytics (Ardolino et al. 2018). Therefore, in addition to data themselves, the ability to process these data comprises a key resource and may shift power toward actors with such abilities (Coreynen et al. 2020). In particular, incumbents often lack the necessary expertise to exploit data, making them reliant on collaborations with data-driven start-ups (Kupp et al. 2017). Therefore, many incumbents shift their focus toward data-driven start-ups to use their knowledge to differentiate themselves from competitors, thereby maintaining and expanding competitive advantage (Jordanius et al. 2019). In the past, start-ups tended to drive interest in business relationships between incumbents and start-ups unilaterally, creating corresponding hurdles (Gardet and Fraiha 2012). This may no longer be true for data-driven start-ups, as the incumbent's lack of data-driven capabilities makes potential collaborations much more likely to be based on mutual interests. For instance, incumbents have been establishing a large number of corporate venture client and capital departments, such as BMW Startup Garage or Siemens next47 that aim to identify and partner with start-ups actively, especially in the digital

environment. Therefore, we argue that this phenomenon highlights incumbents' need to "market themselves" actively to coveted data-driven start-ups, potentially placing data-driven start-ups in a higher power position relative to incumbents.

Based on our derived contradictions, we conclude that data-driven start-ups may strategize differently compared with traditional start-ups depending on their network role in digitalized business networks. Therefore, findings from previous IMP studies regarding start-ups' network roles and strategizing may not be applicable to data-driven start-ups. Specifically, we argue that data-driven start-ups may have the ability to influence and drive entire digitalized business networks. However, this influence is highly context-specific (Nenonen et al. 2019). Potentially, network configurations exist, where data-driven start-ups might be more driven by incumbents rather than being their drivers. The question of "being driven by" or "driving" others might particularly depend on the data-driven start-ups' network role, which is influenced by its initial network position, the strength of ties needed to access data as its key resource, the time needed to get established, or the power position towards incumbents. Therefore, we aim to fill the gap in IMP literature by investigating (1) which network roles data-driven start-ups take in digitalized business networks and (2) how they dynamically strategize within and across different network roles on strategic trajectories in digitalized business networks. In particular, we investigate how and in which network roles the data-driven start-ups' strategizing differs in the light of the identified contradictions as well as which dynamic strategizing trajectories they follow. Thereby, we specifically address the call by Ritter and Pedersen (2020) for more research on how digitalization and its new actors such as data-driven start-ups influence business relationships and strategize in digitalized business networks.

3. Methodology

3.1 Research design

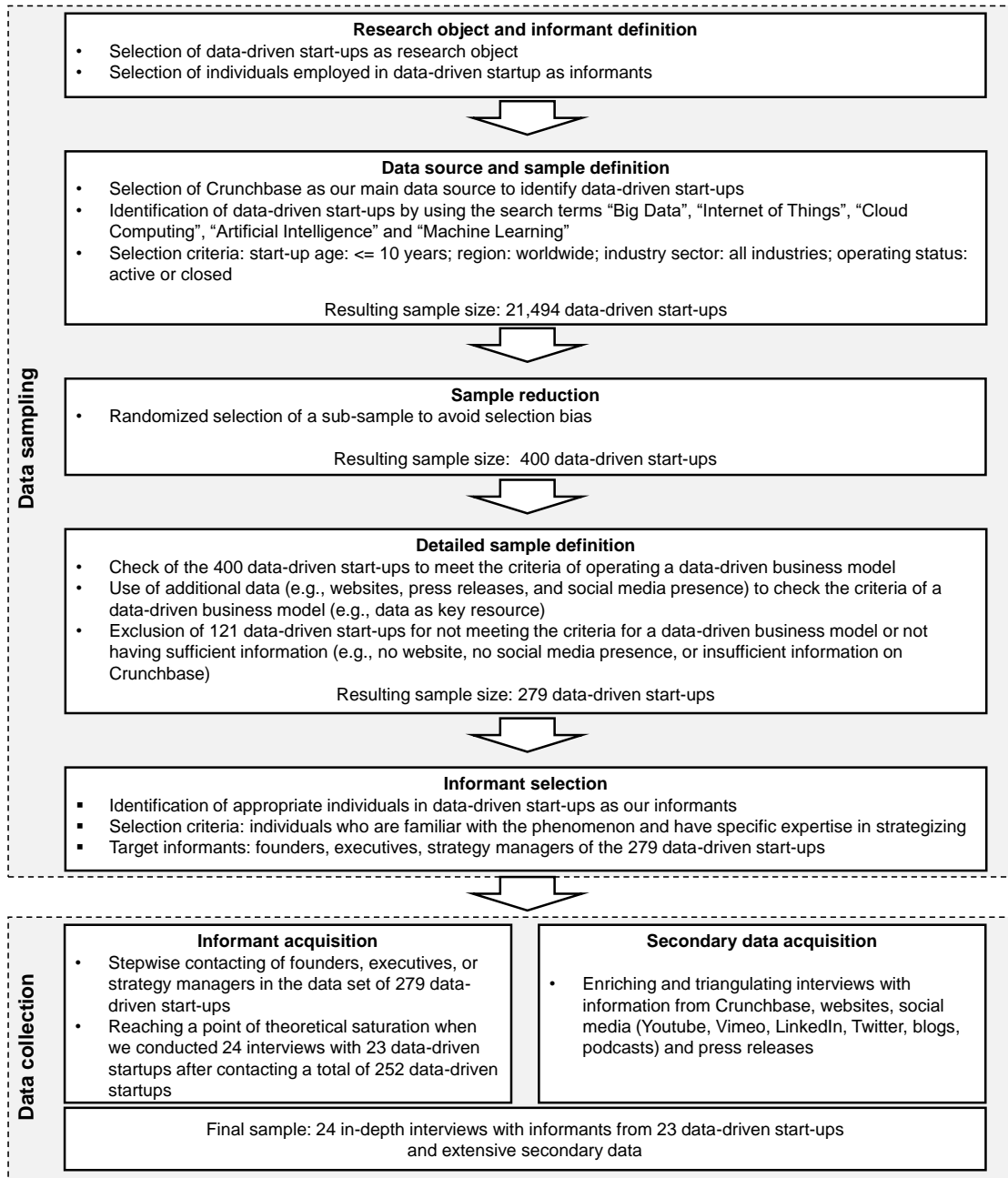
With the commercialization of new data-driven business models, data-driven start-ups are key actors in the digitalization of business networks. Challenging extant IMP tenets on traditional start-ups, we argue that these data-driven start-ups may adopt

distinct network roles and strategize differently in digitalized business networks. Grounding this argument in empirical research, we therefore employed a discovery-oriented theories-in-use approach (Zeithaml et al. 2020; Zaltman et al. 1982) to conduct multiple case study research on 23 data-driven start-ups (Eisenhardt and Graebner 2007; Yin 2018). The theories-in-use approach aims to capture the mental models of the respondents as “theory holders” that articulate how things work in a specific context at the individual level (Argyris and Schon 1974; Zeithaml et al. 2020). Multiple case study research is particularly effective in assessing new and unexamined phenomena in practical contexts (Yin 2018), as in our case the emergence of data-driven start-ups in digitalized business networks (Håkansson et al. 1999). Fueling our multiple case study, the insights on the individual’s thinking and acting within certain boundaries that are shaped by interactions and their contexts (Guercini and Medlin 2020) allowed to understand how founders view their data-driven start-up’s role and strategizing in digitalized business networks. Both, theories-in-use and multiple case study research are based on inductive and explorative theory building rooted in grounded theory, thereby deriving theoretical constructs from the continuous interplay between researcher and data (Glaser and Strauss 1967). Furthermore, since we aim to identify different roles and strategizing approaches of data-driven start-ups, we needed to replicate the analysis with multiple founders and thus cases in order to build theory that is more grounded, accurate, and generalizable (Eisenhardt and Graebner 2007; Zaltman et al. 1982).

3.2 Research setting and sampling procedure

Our units of analysis are data-driven start-ups to understand their roles and strategizing in digitalized business networks. Since responsible individuals in data-driven start-ups determine the data-driven start-ups’ strategic development by their thinking and acting, they inform our study. In the selection process, we applied theoretical sampling to first identify data-driven start-ups and then recruit appropriate individuals as interviewees (Lincoln and Guba 1985; Eisenhardt 1989). Figure 2 visualizes the different steps of our sampling and data collection procedure.

Figure 2. Sampling and data collection procedure.



For the identification of data-driven start-ups, we used the Crunchbase database. Crunchbase is a platform for business information, e.g., business model, investment or funding rounds of private and public companies on a global scale (Crunchbase 2020). The database has been increasingly applied in innovative economic and managerial research, specifically in research on start-ups (Dalle et al.). To identify suitable data-driven start-ups, we applied the search terms "Big Data", "Internet of

Things”, “Cloud Computing” (Chen et al. 2014), “Artificial Intelligence” and “Machine Learning” (Brynjolfsson and McAfee 2017) as they are related to digital technologies that characterize data-driven business models and thus data-driven start-ups. In addition, we only considered data-driven start-ups that were not older than 10 years to ensure that they could be considered start-ups. This threshold is widely accepted and common in both academia (Bertoni et al. 2015; Parida et al. 2016) and practice (Kollmann et al. 2016). Furthermore, to increase the transferability of our findings to other contexts and thus overall generalizability, we were open to all geographical regions or industry sectors, since data-driven start-ups represent a worldwide phenomenon and are able to operate independent of their location. In addition, we followed the suggestion of Zaltman et al. (1982) to elicit ineffective and effective practitioners, i.e. we included both active and closed data-driven start-ups in our sample. This approach enabled us to paint a realistic and encompassing picture as we were interested in which network roles the data-driven start-ups and their founders failed or succeeded and why their strategizing was unsuccessful or successful. Applying the aforementioned search criteria, our data set comprised 21,494 data-driven start-ups obtained from the Crunchbase database.

Building our final dataset, we then randomly drew a sub-sample of 400 data-driven start-ups. At first glance, this approach may seem counterintuitive to the theoretical sampling procedure (Eisenhardt 1989), however, we simply aimed to efficiently reduce our large initial sample without causing selection bias at this point. From these 400 data-driven start-ups we examined the websites, press releases, and social media presence to ensure that they met the criteria of data-driven business models as defined by Hartmann et al. (2016), e.g., if the data-driven start-up uses data as key resource for its activities. Furthermore, we excluded data-driven start-ups where we were unable to collect enough information (e.g., no website, social media presence or information on Crunchbase). This procedure led to the exclusion of 121 data-driven start-ups, resulting in our final data set comprising 279 data-driven start-ups suitable for our study.

In line with our theories-in-use approach (Zeithaml et al. 2020), we followed the principle in identifying interviewees that the data on which our study is based are best obtained from individuals who are familiar with the phenomenon (Pagani and

Pardo 2017) and have specific expertise in strategizing. Therefore, we chose to contact start-up founders, but also executives, or strategy managers as experts from the final 279 data-driven start-ups, considering that strategizing usually emanates from or is controlled by top management (Hart and Banbury 1994).

3.3 Data collection

We contacted stepwise experts from the data set of 279 data-driven start-ups. More specifically, we sent a research participation invitation via email with an attached flyer containing rough information about the study's purpose, the interview procedure as well as the assured confidentiality. We did not share the questions with the potential respondents beforehand to avoid any biases. A reminder was sent to those who had not replied to the invitation after two weeks. Between March and November 2020, we contacted a total of 252 data-driven start-ups and eventually conducted 24 in-depth, semi-structured interviews (see Table 1) with 23 data-driven start-ups (one included a follow-up interview). We refrained from contacting all 279 start-ups as we reached a saturation point where we found that respondents' ideas had become redundant (Zaltman et al. 1982). The number of our interviews is also in the range of typical multiple case study or theories-in-use approaches, which usually entail 15-25 participants (Zeithaml et al. 2020; Griffin and Hauser 1996). Throughout the entire study, we use alias company names to ensure confidentiality.

Following Yin (2018), we included secondary data sources, such as information from the Crunchbase database (e.g., business model, funding rounds, latest activities), the data-driven start-ups' websites, social media websites (e.g., Youtube, Vimeo, LinkedIn, Twitter, blogs, podcasts) and 114 full-text pages of press releases designed to provide a comprehensive picture of each data-driven start-up and control for ex-post rationalization of the respondents. Due to this extensive data triangulation and the fact that all data-driven start-ups in our sample had only one founder in general or at least focused on strategy, we refrained from conducting interviews with different respondents of the same data-driven start-up. In this approach, we specifically followed Elfring and Hulsink (2007) that conducted multiple case study research on 32 start-ups and their respective founders with a focus on network development.

Table 1. Overview of interview partners.

#	Alias company name	Region	Interview partner	Interview duration in min	Secondary data sources ^a (no. of pages)
1	TrendTech	North America	Founder	40 + 28	Youtube, press (6), LinkedIn
2	PredictiveTech	Middle East	Founder	58	Youtube, press (10), LinkedIn
3	ComplaintPlatform	Europe	Founder	40	Youtube, press (4), LinkedIn, Twitter, Vimeo
4	SmartLock	North America	Executive	67	Youtube, press (7), LinkedIn
5	CommunicationApp*	Europe	Founder	66	Youtube, blog
6	AIPlatform	Europe	Founder	47	LinkedIn, Twitter
7	CarePlatform	Asia	Founder	56	Press (8), LinkedIn, Twitter
8	SmartImage	Europe	Founder	62	Youtube, press (3), LinkedIn, Twitter
9	MobilityApp	Europe	Founder	55	Youtube, press (2), LinkedIn, Twitter
10	GovApp	South America	Founder	65	Youtube, LinkedIn, Twitter,
11	MonitoringTech	North America	Founder	65	Press (3), LinkedIn, Twitter, blog
12	SalesTech	North America	Founder	34	LinkedIn, Twitter, podcast
13	SearchTech	Europe	Founder	50	Youtube, press (10), LinkedIn, Twitter, blog
14	RoboTech	Europe	Founder	58	Youtube, press (7), LinkedIn
15	MRPPlatform	North America	Executive	60	Press (7), LinkedIn, podcast
16	FinApp*	North America	Founder	58	Twitter
17	FinancialPlatform	Asia	Founder	61	LinkedIn, Twitter
18	SpeechAIPlatform	Europe	Founder	68	Youtube, press (15), LinkedIn, Twitter
19	CloudTech	North America	Founder	72	Youtube, press (4)
20	MarketingTech	Europe	Founder	75	Press (3), LinkedIn, blog
21	PsychologyTech	North America	Founder	46	Youtube, press (13), LinkedIn, Twitter, podcast
22	AnalyticsTech	Europe	Manager	40	Youtube, press (8), LinkedIn, Twitter, Vimeo
23	GiftPlatform*	Europe	Founder	73	Youtube, press (4), podcast

^a Note: Crunchbase and homepage were always included in the analysis for each data-driven start-up.

* closed data-driven start-up

For the in-depth interviews, we used a semi-structured interview guideline comprising three main topics, in line with our research questions (see Appendix A): (1) the founder's personal background and description of the business idea, business model, and main stakeholders; (2) an explanation of the initial strategy, later strategy pivots and associated trigger events; and (3) elaboration on their network role in the past, present, and future. As the empirical study progressed, the interview guide evolved and was modified accordingly following each interview's outcome. All interviews were conducted in English using a video communication tool between March and November 2020, with the exception of two interviews that were conducted in German. The interviews lasted 56 minutes each on average and were recorded and transcribed verbatim, comprising 429 full-text, transcribed pages.

3.4 Analysis and interpretation

We employed the three-step procedure developed by Gioia et al. (2013) to progress systematically and with qualitative rigor from raw data to our theoretical constructs (see Figure 3). MAXQDA software served as our main tool to document the analysis, yielding overall 1,860 codings.

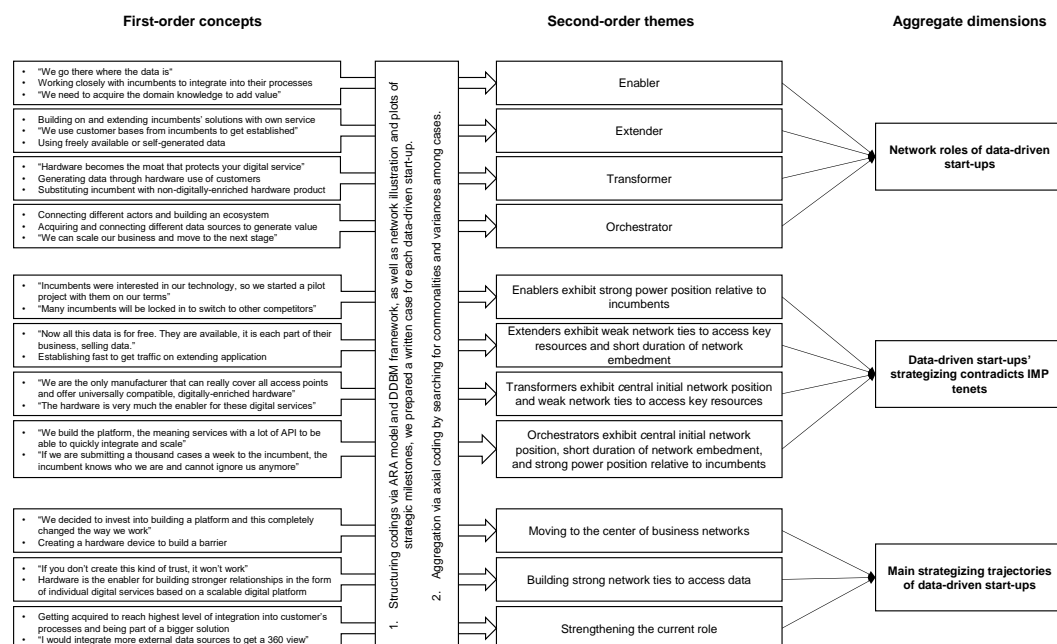
First, open and inductive coding was conducted by three members of the research team who read the transcribed interviews and secondary data simultaneously without using a predetermined coding scheme. In this way, so-called *in vivo* codes were created that contain words or statements that are noteworthy and relevant to our research questions (Corbin and Strauss 2008). Specifically, in this step, we captured each founder's theories-in-use to understand how they perceive, interpret, and construct meaning for the network roles of their data-driven start-up while strategizing in digitalized business networks. We coded every interview immediately after conducting it and discussed the *in-vivo* codes constantly throughout this first analysis step until consensus was reached. In the end, we elaborated first-order concepts that emerged from the founders' theories-in-use and thus from the data itself. In this context, we emphasize that we derive our insights specifically taking the perspective of the founders and triangulating it with our secondary data, making it clear from which point of view we approach our research questions (Guercini and Medlin 2020).

Second, we used the ARA model from IMP literature (Håkansson and Snehota 1995), which has been proven to be a valid concept for business network analysis in the digital context (Pagani and Pardo 2017). We combined it with the framework and its components on data-driven business models from DDBM literature to structure our *in-vivo* codings, thereby describing each data-driven start-up's activities, resources, and actors. Building on this basic structure of each data-driven start-up, we aimed to get a clear understanding of the data-driven start-up's relations to other actors within the digitalized business network. This procedure enabled us to determine the network position and network ties to access data. Moreover, we included additional actors such as competitors and collaboration partners to illustrate the individual network of each data-driven start-up. In order to grasp the data-driven start-up's dynamic strategizing, we then investigated how the data-driven start-ups evolved from their initial business ideas to current or planned status by mapping the chronological sequence of strategic milestones (see example in Appendix B). Such strategic milestones included changes in key customers, data sources, or key activities of the data-driven start-up's business model. For each case, we compared the network constellations and plots, and discussed similarities and differences to reach a shared

understanding of each data-driven start-up's network positions and strategizing activities. Taking all relevant information into account, we then prepared a written case for each data-driven start-up to formulate an individual way of strategizing, resulting in a total length of 53 full-text pages across all 23 cases (each case description is available from the authors on request). Ultimately, we built on this to create second-order themes by searching for commonalities and variances in our structured in-vivo codings and across the 23 cases through axial coding, thus mirroring the raw data through the researchers' interpretation.

Third, we further theoretically abstracted from our second-order themes to elaborate distilled dimensions.

Figure 3. Data analysis structure.



Following the suggestion of Lindgreen, Di Benedetto, and Beverland (2020), we have moved the section on how we ensured rigor and robustness of our study results to Appendix C for saving page space.

4. Results

Based on our empirical analysis, we derived four distinct network roles and different strategizing approaches. First (4.1), we describe each network role. Second (4.2), we

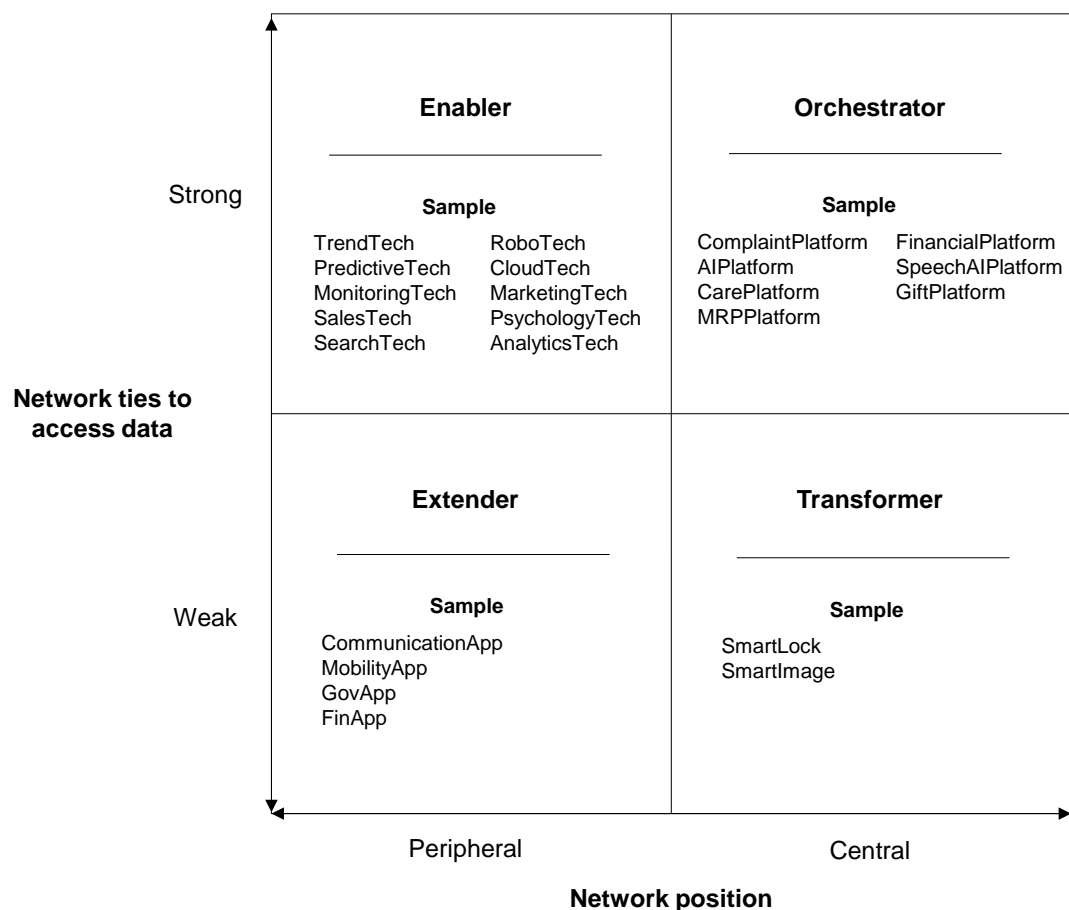
demonstrate to what extent strategizing in the four network roles of data-driven start-ups differ from IMP literature's strategizing tenets. Third (4.3), we describe strategizing trajectories by examining typical paths between these network roles.

4.1 Data-driven start-ups' roles in digitalized business networks

In the continuous interplay between our inductive case analysis and the corresponding theories from IMP and DDBM literature, we identify and describe the network roles of data-driven start-ups by taking the founder's perspective. Thereby, it became particularly evident that these network roles differ distinctly in the strength of ties to access their data as key resource and the centrality of their network position. In other words, data-driven start-ups' varying network roles distinguish themselves in terms of (1) how strong the network ties need to be to gain access to data as a key resource and (2) where the data-driven start-ups are positioned in relation to other actors within the digitalized business network. We operationalize the strength of network ties to access data by determining how costly the data acquisition is (e.g., close collaboration for access to data versus open data access or data self-generation). In terms of network position, we assess the number of ties to other actors in the network (e.g., customers, partners, suppliers) and specifically analyze whether the value proposition in the data-driven business model represents a separate offering (e.g., stand-alone offering vs. offering that builds on and/or depends on other actors). Thereby, the different dimensions (weak vs. strong connections to data access; peripheral vs. central network position) should be viewed as a continuum rather than strict either/or categories with clear thresholds. Nevertheless, we created a four-field matrix that serves as a classification framework for the identified network roles to provide a straightforward and simplified tool to analyze data-driven start-ups and their network roles for IMP research. The reasoning of the continuum can be illustrated, for example, by showing that data-driven start-ups within the same quadrant are more aligned with a particular network role than others. Furthermore, our classification framework acts as structural guidance for the following role description, starting with the *enabler* and continuing counterclockwise (see Figure 4). In our description, we assigned the data-driven business model's components "key activity", "offering",

“revenue model”, and “cost structure” to the ARA model’s activity, “key resource” to resource, and “customer segment” to actor. The combined use of the data-driven business model components and ARA framework enabled a rich and structured description of the four network roles for data-driven start-ups. Due to space limitations, we have moved the overview of our extensive analysis to Appendix D.

Figure 4. Classification framework of data-driven start-ups’ identified roles in digitalized business networks.



Enabler

Data-driven start-ups in the network role of enabler operate data-driven business models that provide incumbents with the data-driven capabilities needed to meet current and new customers’ demands. For example, PredictiveTech, offers predictive maintenance services to incumbents in the process industry, helping them to ensure a high level of machine availability and thus a high and steady product flow. To access data, enablers rely on trusting relationships with their customers or data suppliers,

ultimately leading to a high dependence on customer-owned data sources that are not freely available. For instance, SalesTech specifically relies on point-of-sale data providers to make recommendations to restaurants based on complex best-in-class benchmarking to increase sales and profits. However, besides data as key resource, enablers often rely on domain knowledge to understand the customer and add significant value at the customer end, which often requires cooperations with third-parties. As a concrete example TrendTech provides trend analysis to incumbent fashion brands. It works closely with market research agencies to benefit from their existing client portfolio, customer channels, and deep knowledge of clients' market research processes so that they can successfully market their own offering. The agencies also benefit from this partnership as they can complement their existing market research services with new data-driven offerings. The key activity of enablers usually focuses on the processing, analysis, or visualization of data. RoboTech, for instance, has developed a retrofit kit to process, analyze, and feed data from customer rule-based programmed robot systems back into the robot, making them smarter, i.e., ready for human-machine collaboration or more autonomous operations. Enablers often explicitly target incumbent industries or niches that already have big data sets, as well as the need to extract valuable information from them. As a result, enablers' key customer segments are in B2B industries, which are able to provide such large data sets. In our cases, the B2B customer segments range from fashion to process industries, logistics, and pharmaceuticals. Enablers typically base their data-driven business models on subscription-based revenue models to establish a regular and steady source of income. SalesTech, for example, relies on a Software-as-a-Service model with a monthly subscription fee. Due to the fact that enablers depend on external data and domain knowledge that is complex to acquire and not freely accessible, they exhibit a rather low specific cost advantage. For instance, the predictive maintenance solution of PredictiveTech is not transferable to other industries or even factories, resulting in slow and costly growth.

Overall, enablers rely on strong ties to gain access to the data they need, making it costly to deploy their offerings and thus grow at scale. In addition, enablers have few but selected ties to customers, suppliers, or partners. With their offerings, they do not aim to replace incumbents and their products, but to help them succeed with their

data-driven knowledge in digitalized business networks. They are therefore located in peripheral network positions.

Extender

The data-driven start-ups assigned to the extender role exhibit data-driven business models that build on existing data-driven solutions from other actors (often operating systems or digital platforms) and extend them. For example, CommunicationApp builds on a widely used email software to provide an email automation service that, among other things, automatically assigns emails to associated projects. A key differentiating factor of extenders is that their data-driven business models rely on freely available data and/or the usage data of a high number of end-users. MobilityApp, for instance, extends existing routing service applications by integrating freely available social media data regarding disruptions in public transportation systems. In addition, extenders ensure that they offer platform-agnostic services to avoid dependence on incumbents' applications upon which they are based. As an example, MobilityApp offers its application independently of the routing service application or mobile operating system used. The key activities of extenders include particularly the data generation or acquisition and its analysis. For example, GovApp extends incumbent policy advisory services by searching freely available legislative texts to assess their impact on specific industries (e.g., new laws on product testing in pharmaceutical or beauty), and then ultimately sells this information to the respective incumbents. Since extenders rely on the incumbents' application, they address the incumbents' usually large B2C user base. However, using GovApp as an example, we see that extenders are also offering their data-driven business models in the B2B space. With regard to the revenue model, we observe that extenders mainly use a freemium model to generate income. For example, CommunicationApp offers the basic features of its email automation service for free, while the full feature set can only be used if the end-user pays a monthly subscription fee. However, there are also variants in which only certain customer segments are charged. FinApp, for example, which extends existing banking applications by bringing them together, offers its application free of charge to individual end-users, while selling usage data to various banking institutions and thereby providing them

with a comprehensive overview of their customers' financials. The cost structure has a fairly high specific cost advantage because access to the data is inexpensive or even for free. By offering their own application to an existing large community provided by the incumbents they are adding to, extenders also save on marketing costs and can scale quickly.

In sum, extenders exhibit weak network ties to access data, since they focus on freely available data via open APIs or generate their data through the customer's usage. Such characteristic enables them to scale quickly and focus on data management instead of data acquisition. In addition, although extenders usually address a large number of potential end users, they tend to be located on the periphery. This is due to the fact that they are not able to provide their offering on their own, but must always build on existing established solutions positioned at the center of digitalized business networks.

Transformer

The data-driven start-ups assigned to the transformer role implement data-driven business models that transform incumbents' (mostly non-data-driven) product and service business networks by enriching them with digital components. SmartLock, for example, offers a physical door lock with IoT connectivity features to small and medium sized companies that provides easy and seamless access for authorized individuals using their smartphones. Access to the data is usually ensured via the physical device that collects the users' data and enables subsequent analysis, resulting in the development of further services (e.g., monitoring office capacity or employee movement habits as in the case of SmartLock). To be successful, transformers therefore need significant physical product expertise in addition to digital capabilities for data analysis. For instance, SmartImage that offers a smart picture frame to elderly people decided to develop their own smart and connected device when they realized that existing solutions were not meeting their expectations. However, the production of the physical device is usually outsourced to large contract suppliers. As a result, trusting relationships are required to manufacture the physical device rather than to access the data. The key activity of transformers generally constitutes generating the data by tracking its users' data and analyzing it to provide

complementary data-driven services. Moreover, SmartImage, for example, connects the various users of its smart picture frames via an integrated messenger plug-in, ultimately building a social network. Transformers target the customer groups of incumbents by offering a directly competitive product. These customer groups can be B2C (e.g. as with SmartImage) or B2B customer segments (e.g. as with SmartLock). The revenue model of transformers is typically based on a one-time sales component and a regular subscription-based fee for additional data-driven services. SmartImage, for instance, charges the physical device only once for a relatively high price and a small monthly fee for the connectivity feature. The cost advantage of transformers is rather high in two respects. First, because the required data is obtained via their own physical device, the data acquisition costs are marginal. Second, due to the outsourced production of their physical device, transformers benefit from economies of scale of their large suppliers.

In total, transformers exhibit rather weak ties necessary to access the required data, as they collect user data via the physical device installed at the customer side. Due to the competing offering and resulting replacement of the incumbents' usually non-data-driven products, transformers are inherently located in the center of digitalized business networks.

Orchestrator

Data-driven start-ups in the orchestrator role create value by indirectly connecting several other actors, often via digital platforms. FinancialPlatform, for example, brings together individual borrowers and lenders on a digital platform, creating easy access to capital for borrowers on the one hand and an opportunity for lenders to make profits on the other. Orchestrators build their data-driven business models primarily on proprietary data, which requires them to establish strong relationships with their customers and data providers to gain access to it. For instance, potential borrowers must provide detailed data about their personal and financial situation, which is then automatically collected via an application on the borrowers' respective smartphone to measure the probability of default. In many cases like this, non-proprietary data is also included, such as freely available information from social media, to triangulate the data obtained from the smartphone. The key activities are

usually the aggregation, processing and analysis of data obtained through mediation and exchange between many different actors that were not necessarily linked before. A further example in this regard is MRPlatform, which provides a SaaS manufacturing resource planning (MRP) solution for small and medium-sized manufacturing companies, thereby connecting different suppliers and original equipment manufacturers (OEMs). By using the digital platform within the individual company, data is collected and processed about their production capacities, which in turn is made available to all platform actors, thus improving the production utilization of the single company. Orchestrators rely on a large user base, as individual users will only participate if there is a large enough set of other users from which they can benefit through exchange. The customer segment can be either B2B or B2C. ComplaintPlatform serves as an example. It indirectly connects individual complainants, e.g., regarding a flight delay, and the respective complaint initiator, e.g., an airline, by aggregating all complaint issues and then directly addressing the complaint initiator in a bundled form, making it impossible for the latter to ignore the complaints. The more users the platform has for its complaints, the stronger and thus more successful it becomes against the incumbents causing the complaints, which in turn attracts more additional users. These so-called network effects can only be generated if the orchestrators are positioned at the end-user interface between individuals and companies, where the actual exchange between the two actors takes place. The revenue model typically aims to charge only one actor group using the platform. For example, since ComplaintPlatform does not provide legal assistance, but simply seeks to collect and analyze the data on the many different complaint cases across different companies, it offers the data-driven service free of charge to individual persons with complaints and charges the incumbents for the aggregated complaint reports. Thereby, the revenue model of orchestrators is often transaction-based, i.e., the paying actor group pays only for the actual transaction. Despite the fact that strong ties are necessary to access the data of the individual customer, orchestrators are characterized by a cost structure that is aligned to enable a high scalability potential. For instance, once a critical user base is achieved, the network effects help MRPlatform to acquire additional data through every single transaction

at marginal costs. Therefore, the specific cost advantage is rather high for orchestrators.

In summary, orchestrators require strong ties and substantial investments to gain access to the necessary data and eventually establish themselves at the end-user interface. However, after reaching a critical mass, orchestrators are able to grow at scale and marginal costs by exploiting network effects, thereby continuously attracting additional users and building a large customer base. Therefore, orchestrators are at the center of digitalized business networks, often transforming existing ties of incumbent actors.

4.2 Analyzing data-driven start-ups' network roles in the context of strategizing contradictions

Based on the rich description of data-driven start-ups' network roles, we demonstrate how our sample firms strategize in the four network roles against the contradictions that we identified and illustrated in the theoretical background (see Figure 1 in Chapter 2). These four contradictions refer to the *initial network position* (peripheral vs. central), *ties to access key resources* (strong vs. weak), *duration of network embedment* (long vs. short), and *power position relative to incumbents* (weak vs. strong). Table 2 illustrates how each network role either confirms the IMP strategizing tenets or contradicts them, thereby confirming the DDBM strategizing tenets.

Table 2. Network roles in the context of strategizing contradictions between IMP and DDBM literature.

Contradiction	Network role			
	Enabler	Extender	Transformer	Orchestrator
1. Initial network position	peripheral	peripheral	central	central
2. Network ties to access key resources	strong	weak	weak	strong
3. Duration of network embedment	long	short	long	short
4. Power position relative to incumbents	strong	weak	weak	strong
Number of confirmed DDBM tenets	1/4	2/4	2/4	3/4

Notes: Confirmed DDBM tenets are indicated in bold.

Network roles in the context of Contradiction 1 related to initial network position

Contradiction 1 refers to the fact that (data-driven) start-ups enter pre-existing business network structures in a rather peripheral (IMP tenet) or central (DDBM tenet) network position. For *enablers*, the IMP tenet holds true because they operate in peripheral network positions, adjusting and customizing their offerings to the individual customer that is located centrally in the business network. This approach leads to only a small number of ties with other actors in the business network. Also, the *extenders*' strategizing fulfills the IMP tenet, as they are positioned on the business network's periphery. With their data-driven offerings, extenders dock onto incumbents' digital solutions like large operating systems (OS) that have established themselves over a long time period at the center of an often digitally mature network.

“We are not really reinventing the e-mail because we are still based on Office 365, [...] so we have APIs etcetera. We are not doing our own e-mail client, we are just adding some features.” (Founder, CommunicationApp)

However, *transformers* tend to confirm the DDBM tenet, as they usually start in central network positions in smaller niche markets that are not served by incumbents to avoid strong competition from the beginning. If the establishment of the central position in these niche markets is particularly successful, transformers may further increase the number of ties and move toward bigger customer segments, where they can replace the incumbent in bigger sub-markets or even the whole market. In the long run, transformers aim to replace offerings from centrally positioned incumbents.

“First, our customers were technology start-ups and then [...] gyms, co-working spaces, we have a lot of real estate agents. [...] And now we're pretty firmly in that 15 to 500 people office segment.” (Executive, SmartLock)

Similar to transformers, *orchestrators* confirm the DDBM tenet, as they operate in central network positions. They are inherently designed to act as central nodes or intermediaries between many different actors in a business network. This includes viewing the business network as an (eco)system from the very beginning.

“So to be able to perform what we do, we needed to connect to other systems in the hospital. So [...] we built the platform [...] with a lot of APIs to be able to quickly integrate with different hospital systems. So ecosystem was in the core of the design of the system.” (Founder, CarePlatform)

Network roles in the context of Contradiction 2 related to network ties to access key resources

Contradiction 2 refers to the fact that data-driven start-ups need strong (IMP tenet) or weak (DDBM tenet) network ties to access data as their key resources. For *enablers*, the IMP tenet pertains, as they heavily depend on customers' proprietary data as a key resource. Therefore, they need to apply certain strategic measures to access and leverage these data. Moreover, enablers often need to acquire specific domain knowledge in the customer sector and combine it with their digital capabilities to reach a solution to add value at the customer end. This knowledge also includes expertise on how to meet incumbent customers where they are. This is necessary because enablers often offer data-driven business models that incorporate novel digital technologies, which could make incumbent customers reluctant to adopt and integrate them into their internal processes. As a result, enablers often require collaborations with third-party incumbent knowledge and technology providers (e.g., agencies) that already are established in the customer's business networks, thereby approaching incumbent customers through channels familiar to them.

“So we decided to meet them halfway, rather than forcing them to learn [our digital service] before they are ready. [...] So as close as we can fit it in their existing routine the better we are going to be off so that led us acting a little bit more like agencies and even kind of collaborating with existing agencies to be able to help them make the switch.” (Founder, TrendTech)

However, *extenders* and *transformers* confirm the DDBM tenet, as they can access data largely independently of other actors. Thus, both network roles do not need to build strong ties with other actors to get the necessary data for their offerings. Specifically, extenders and transformers process freely available data, e.g., from social media or operating system platforms that are involved in rather weak ties. Alternatively, they generate the necessary data via their own application or hardware component, making them fully independent from external data providers. This data self-generation also includes the characteristic of being platform- or hardware-independent, potentially serving a large circle of potential users and avoiding the creation of new dependencies.

“For us, the hardware is very much the enabler for these software services. The basic principle was the way we have set it up now, we have the hardware that is universally compatible. We think we are the only manufacturer that can really cover all access points.” (Executive, SmartLock)

For *orchestrators*, the IMP tenet holds true, as they need to access data from multiple actors and often proprietary data sources in the business network. Therefore, to maintain the ability to scale, orchestrators focus on not being perceived as a threat by data-supplying actors within the business network to build trust with many different actors and, consequently, gain data access.

“So where there were existing players in the market, it was basically not to become a threat to them because then you could blow up. If they would go “okay, they are not trying to threaten us”, [...] you get this positive reinforcement in the market rather than people seeing you as a threat and therefore saying, “oh yeah, you shouldn’t trust those guys” [...]. So it allows us to build up a position of trust within the market place.” (Founder, ComplaintPlatform)

Network roles in the context of the Contradiction 3 related to the duration of network embedment

Contradiction 3 relates to whether start-ups take a long (IMP tenet) or short (DDBM tenet) time to become embedded in a business network. *Enablers* fulfill this IMP tenet, as they exhibit rather low growth rates and limited scalability, as the industry- or even plant-specific data-driven offering cannot be transferred to other applications easily. As an enabler, understanding the customer’s problems and embedding a suitable solution into the customer’s processes are a tedious procedure, given that each customer is unique in its characteristics.

“The knowledge and the data by the way is worth nothing outside the context of the specific plant. [...] Even to create the machine learning model in one plant and use it for another plant, it can’t work. [...] You can learn from this specific plant only for this specific plant.” (Founder, PredictiveTech)

By comparison, *extenders* confirm the DDBM tenet because they can grow at fast scale. They profit from the incumbent OS provider’s high customer reach and growth rate: therefore, extenders grow rapidly, as they use the incumbent’s existing user base. For *transformers*, the IMP tenet applies, as the scaling depends on the

efficiency of their hardware management in terms of development, logistics, and (external) production. Often, hardware management is inefficient, hindering the business model's scaling and, consequently, the pace of business network establishment.

“[Only software] is much easier because you can stay in your room and just work and you don't have to manage any hardware, which is a lot of work in terms of logistics.” (Founder, SmartImage)

Orchestrators, in turn, confirm the DDBM tenet, as they can embed themselves quickly after they have established resource access. Due to their intermediary function, they play a key role, as orchestrators reduce complexity, thereby contributing to the rapid development of digitalized business networks, and if the necessary capital is available, establishment in digitalized business networks is possible in a short period of time.

“You don't have that [long duration], but you need to have money [...] and then you can be really, really fast.” (Founder, GiftPlatform)

Network roles in the context of the Contradiction 4 related to the power position relative to incumbents

Contradiction 4 refers to the fact that start-ups are in a weak (IMP tenet) or strong (DDBM tenet) power position relative to the incumbent. *Enablers* confirm the DDBM tenet as they often possess specific data-driven knowledge in certain industries or domains, which can become a valuable asset to gain power. After all, incumbent customers often lack the digital knowledge and skills for data analytics, relying on enablers to leverage their existing data sets. Therefore, established actors often actively approach suitable enablers for collaborations by setting up customized start-up events or specific incubator programs and providing their data based on their own motivation and problem definition.

“And what happened to us in the next base is that then a [big incumbent], they did scouting for a technology because they understood at that point the concept of Industry 4.0 [...], so they started to look for technologies and they selected our technology for a pilot.” (Founder, PredictiveTech)

However, for *extenders*, this IMP tenet applies. While they can align their data-driven offerings with competing OS providers, they must adapt to their governance policies or even can be dependent on their willingness to let the data-driven start-up participate.

“Of course, on the commercial side we approached [the OS provider] to see if they could help us to advertise our product through their sales. In fact, they may do it but first for bigger players and then for players targeting a specific sector like us.” (Founder, CommunicationApp)

Likewise, *transformers* confirm the IMP tenet because they (at least initially) are usually too small and insignificant in digitalized business networks, especially if they operate in niche markets. This approach may lead to a weak power position vis-à-vis incumbents.

However, *orchestrators* demonstrate confirmation of the DDBM tenet, as they can act as centrally positioned disruptors of an entire business network, altering established power structures once access to customer data via strong ties is established and many different actors are connected in a new way. The dominant and, thus, powerful business network position is particularly possible to achieve because their main focus is to use the central network position and the absence of physical resources to scale rapidly in user numbers through (direct and indirect) network effects.

“I think we are a disruptor and we are really changing the way how basic services are done, [...] so we do not really need to meet the customer in person, we just need to do a biometric scan [...]. So, we would classify ourselves as a disruptor and our focus is to grow into not just a disruptor but the primary institution driving financial inclusion.” (Founder, FinancialPlatform)

In summary, out of the four DDBM tenets, *enablers* exhibit only one and, thus, pursue similar strategizing approaches compared with those of traditional start-ups. *Extenders* and *transformers* fulfill two of the proposed DDBM tenets. *Orchestrators* demonstrate three DDBM strategizing tenets, i.e., data-driven start-ups in this network role are particularly tailored to match the characteristics of strategizing in digitalized business networks. As a result, orchestrators may have the highest probability of being able to drive other players in digitalized business networks to

their advantage, rather than being driven by them, leading to high disruption potential overall. In this context, we emphasize that we observed varying nuances in how strongly the IMP tenets have been contradicted by the individual data-driven start-ups in their respective network roles. For illustration, we take the enabler TrendTech that integrates its fashion trend analysis solution into the offerings of incumbent market research agencies. However, despite cooperating with such agencies, TrendTech is able to absorb budget share that is normally spent by the customer (e.g., incumbent fashion companies) on traditional, non-data-driven market research offerings. As a result, TrendTech may increasingly substitute the offerings of incumbent market research agencies in the long term, after initially supporting them and strengthening their network position. This may ultimately lead to a shift toward a more central network position, such as the role of a transformer. Consequently, data-driven start-ups gradually may change their network role over time to move into the network role that best suits them in digitalized business networks.

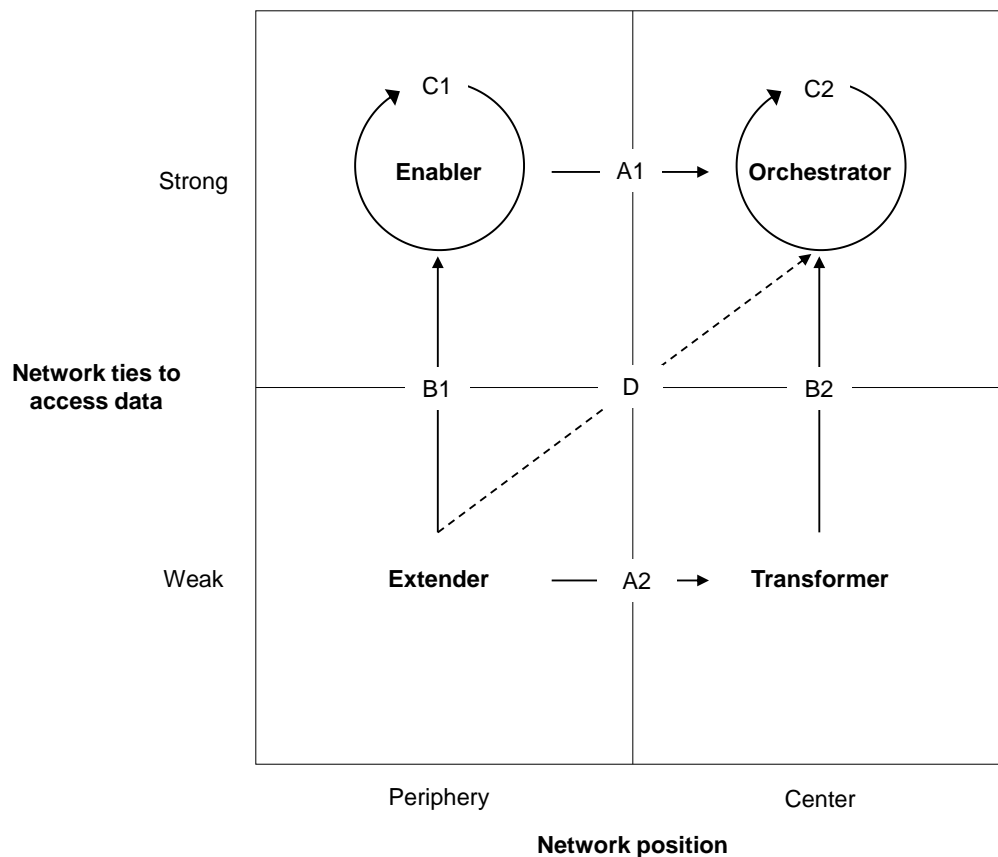
4.3 Strategizing trajectories between data-driven start-ups' different network roles

Based on our analysis related to the drawn time sequence of different data-driven start-ups' strategy milestones, i.e., changes in data-driven business model components, we can derive three main strategy trajectories, each with two sub-trajectories. Moreover, we identify an additional strategizing trajectory that is associated with failure. We visualize all strategizing trajectories based on our classification matrix (see Figure 5). The role adjustment usually results in either a change in network position (A) or in the strength of ties to access data (B). In addition, we find that particularly data-driven start-ups in the roles of enablers and orchestrators continue to focus on strengthening them (C). However, the simultaneous change in tie strength and network position may increase the probability of failure (D).

In this regard, we highlight that these strategizing trajectories are typically not linear or unidirectional. To the contrary, strategizing constitutes a highly iterative and non-linear process, shading the picture of dynamics in digitalized business networks

in various colors. The more rigorously the data-driven business model has been designed and implemented, i.e., which strategic milestones have been undertaken and in what order, the more straight forward the strategizing trajectory will unfold. For instance, CloudTech initially offered a public stand-alone cloud solution in the B2C market focused on convenient data storage of photos and videos, aiming to connect different actors (sharing of photos between individuals) on a digital platform in the network role of an orchestrator. However, the founder soon realized that the willingness to pay for such solutions in the B2C market was quite low. Therefore, the founder decided to adapt the data-driven business model and focus on the B2B market instead by cooperating with hard drive manufacturers and integrating a highly secure private cloud solution into their products.

Figure 5. Strategizing trajectories of data-driven start-ups in digitalized business networks.



This move changed not only the customer segment and offering, but also the key activities (e.g., from data storing to data processing) and transformed CloudTech into

the enabler it is today. The founder then monetized this successful move by selling the company to an incumbent data security firm, thereby further strengthening the role as an enabler. Therefore, we argue that in a few cases, in addition to the main strategizing trajectories we identified, there are alternative dynamic strategy paths that even move in the opposite direction between the different network roles, but only as part of an iterative process before the founders then follow the paths we identified. The distribution of our sample across the different trajectories is shown in Table 3.

Table 3. Distribution of sample firms across strategizing trajectories.

Strategizing trajectory	Number of sample firms	Sample firm
(A1) Enabler to Orchestrator	11	CarePlatform, MRPPPlatform, FinancialPlatform, SpeechAIPlatform, TrendTech, AIPlatform, SalesTech, SearchTech, RoboTech, MarketingTech, AnalyticsTech
(A2) Extender to Transformer	1	SmartImage
(B1) Extender to Enabler	3	MobilityApp, GovApp, MonitoringApp
(B2) Transformer to Orchestrator	1	Nexkey
(C1) Enabler to Enabler	2	PredictiveTech, PsychologyTech
(C2) Orchestrator to Orchestrator	2	ComplaintPlatform, GiftPlatform*
(D) Extender to Orchestrator	2	CommunicationApp*, FinApp*
Other: Orchestrator to Enabler	1	CloudTech

*Closed

(A) Moving to the center: “Taking the reins in hand”

The majority of our data-driven start-ups started in a peripheral position, i.e., in the role of enabler or extender. But, over time, the founders aimed to move toward the center to reach an increased customer amount, extend their business, and achieve a more powerful position in the digitalized business network. To put it bluntly, they aimed to take the reins of the ties in the digitalized business network in hand. In particular, *enablers* often pivot from a consulting-oriented and customized data-driven business model to the more scalable and modularized offering of an orchestrator, becoming better able to exploit data’s characteristics in terms of fast and perfect replication with marginal costs close to zero, supporting strategizing in digitalized business networks (A1). With the consulting model of close and trusting ties, the enabler role is only a means to an end to learn from few initial data-providing customers, in which their own offering can add the best value, ultimately gaining an understanding of how digitalized business networks function. The move toward the

orchestrator role often is related with large investments in scalable infrastructure and additional development resources. Acquisition of necessary financial resources often is associated with fewer hurdles than in other network roles, as venture capital investors view data-driven start-ups with high scaling and, thus, value enhancement potential to as being particularly attractive.

“And then we decided to invest into building a platform. And so this completely changed the way we worked. [...] It was a very heavy investment [...] With the consulting model we could learn [...]. For customers I think this consulting model built strong relationships, we were very close with our clients, but the goal is now to scale our solution. This is like a very precise goal, [...] to get some funding to grow the company.” (Founder, AIPlatform)

In the role of an *extender*, the data-driven start-ups’ founders may aim to differentiate themselves from competitors by moving toward the center into the role of transformer, thereby including a hardware component that complements the existing add-on application (A2). Specifically, the implementation of complex hardware components can serve as strong protection against new actor entry and imitation, which may provide a greater competitive advantage and, thus, more consistent establishment in business networks.

“So, on the other hand it is like a barrier [...], because someone who is working only on software, usually they don’t know the hardware. [...] So, we had to create a device.” (Founder, SmartImage)

(B) Building strong network ties to access data: “Getting the candies you desire”

Data-driven start-ups in the role of extenders and transformers exhibit both weak ties to access necessary data. To reinforce their position in the business network, they aim to increase their ties’ strength to actors that can provide proprietary data. To use an analogy, it is about “getting the candies you desire”, considering that proprietary data often mean competitive advantage. Particularly, *extenders* may include customer or third-party data that are not freely accessible or self-producible to shift to the role of an enabler (B1), while still remaining in a peripheral network position. Close and trusting ties with data providers can serve as protection against imitating actors, thereby stabilizing the network position at the periphery.

“Because it’s, you know, we sell a product that most of our customers don’t really understand. I mean they understand what it does, but [...] if you are a third party that sells [...] the software from [PredictiveTech] in addition, you don’t create this kind of trust. And if you don’t create this kind of trust in this market situation, it won’t work.” (Founder, PredictiveTech)

However, the move toward becoming an enabler often is associated with emancipation from the underlying platform provider, previously necessary in the role of an extender and usually ultimately leading to lower scalability. This contrasts with the strategizing trajectory away from *transformer* and toward orchestrator, both of which operate at the center of digitalized business networks (B2). The main driver through which to undertake such movement is to expand one’s own business by leveraging existing hardware-based data-driven solutions to establish a platform that links additional actors (e.g., users) that previously were unconnected. In particular, the platform enables building stronger ties with existing customers, thereby collecting additional data that can be used for services and to create lock-in effects.

“The hardware is the enabler for this whole experience and for the data that we get and this whole software platform. [...] We now have a web dashboard and there you can do all these reports [...]. And then in addition to that, we now have a messaging feature in the platform.” (Founder, SmartLock)

(C) Strengthening the current role: “Being the star in your neighborhood”

Besides changing one’s own role to move toward the center of the business network or increase ties’ strength to access additional proprietary data, we identified a third main strategizing trajectory that describes the strengthening of the current role. In some cases, the data-driven start-ups’ founders perceived the current role as sufficient to reach their strategic goals and become the “star in their neighborhood”. Specifically, we observed this strategizing trajectory through *enablers* and *orchestrators*. Although there is no change in network role, this third strategizing trajectory also carries implications for the data-driven start-up’s operation in digitalized business networks. For instance, *enablers* that purposefully decide to remain in their role accept limited scalability and focus on specific niches (C1). Due to their strong ties with incumbent customers, they are often the target of acquisitions by incumbents. Although they cease to exist as an independent actor, the acquisition

allows enablers to access resources at scale, such as financial investment or domain knowledge. In particular, access to downstream resources, such as sales staff or distribution channels, supports these data-driven start-ups' further growth and development.

“I think, now we are in a different situation. We are not a start-up now, we are using [the acquirer], they have sales offices all over the world. [...] I prefer to be part of a bigger strategy, bigger solution, bigger offering [...]. And they have great connections, great brand, 112 years of reputation. [...]” (Founder, PredictiveTech)

However, *orchestrators*, generally aim to grow their user base continuously through network effects without specifically aiming to get acquired and using the incumbents' resources on a large scale to get the dominant and central actor in digitalized business networks (C2). In doing so, *orchestrators* acquire additional proprietary data sources to enrich their offerings with additional services, ultimately resulting in a winner-take-all market.

“I think each market place has only a limited amount of space for certain types of businesses. [...] And therefore is only room in the market for one. [...] I would integrate more external data sources. So to get more a 360 degree view what is happening in the market rather than just [our] data. And I think that increasing that knowledge base [is suitable] to develop services that sit on top. [...] To basically become an essential tool in a consumer's life and an essential tool being the ability to help them more than anyone else can.” (Founder, ComplaintPlatform)

(D) Failure: “Don't boil the ocean”

Besides the three main strategizing trajectories, we also identify an additional trajectory that is considered with a high probability of failure (D). The diagonal movement from the *extender* to the *orchestrator* requires a change not only in the strength of ties, but also in the network position. However, coming from the extender with only weak ties to customers and a peripheral network position, it was difficult to approach both at once, as such a move is accompanied with considerable change management and new capabilities, e.g., governing value across all actors on the digital platform. Instead of focusing first on building strong ties with targeted customer groups, then thinking about how to scale, the founders wanted to scale and build strong ties without offering a solution that could be scaled.

“So we were trying a bit more than a year and we had some costumers but [...] it couldn't allow us to scale very well. [...] And so maybe we should have targeted directly some IT guys, or maybe head of projects to implement directly inside the whole team instead of focusing single users.” (Founder, CommunicationApp)

Focusing on growth while building strong customer ties is a challenging task for founders and often can result in failure. Therefore, the various strategizing trajectories should be approached in a rather focused and sequential manner.

“You will see that there are a lot of different avenues that they could have expanded upon. [...] But when you take a look, as a start-up you have to focus on one thing because you do not want to boil the ocean.” (Founder, FinApp)

5. Discussion and implications

Previous literature in IMP focuses primarily on the analysis of start-ups' strategizing and network roles in non-data-driven contexts (Baraldi et al. 2019; Aaboen et al. 2016), raising the question whether and how data-driven start-ups may strategize differently in specific network roles. Therefore, we apply theories-in-use and multiple case study research in order to investigate 23 data-driven start-ups through the uniquely combined lens of the ARA model and the DDBM framework, addressing research needs on the intersection of digitalization and business networks (Ritter and Pedersen 2020). Thereby, we identify network roles, contrast them in the light of our identified contradictions, and draw dynamic strategizing trajectories of data-driven start-ups in digitalized business networks. In the following, we discuss for each implication how it contributes and relates to knowledge from extant IMP and DDBM literature. Moreover, we describe the implications of our study for the management of data-driven start-ups and also incumbents. Finally, we outline the limitations of the study and the resulting potential avenues for future research.

5.1 Theoretical implications

Our study's findings offer three main implications for academic research in IMP literature on start-ups, as well as for literature on data-driven business models and digital business strategy.

First, we contribute to IMP research on start-ups by introducing four network roles (enabler, extender, transformer, orchestrator) that are unique to the context of data-driven start-ups. This extends prior studies that examined network roles and strategizing of start-ups mainly in the physical context (Baraldi et al. 2019), and from the resource level perspective (Aaboen et al. 2016), ignoring the changes that digitalization brings simultaneously at the activity, resource, and actor levels in business networks (Pagani and Pardo 2017). Specifically, we add to Aaboen et al. (2016) by providing an empirically grounded framework based on two distinct variables that determine data-driven start-ups' network roles and strategizing dynamics in the specific context of digitalization: (1) strength of network ties to access data as key resources and (2) the network position. While Aaboen et al. (2016) identified their network roles by placing resource interactions at the core of their attention, we emphasize that not only is the interaction itself important, but also how strong the ties within that interaction are (Elfring and Hulsink 2003). In particular, how access to data, as a key resource, is managed in digitalized business networks comprises a key aspect of data-driven start-ups' strategizing and makes our network roles explicit, specific, and more concrete. This in-depth knowledge is key to performing the respective network role successfully (Aaboen et al. 2016) and serves as a basis to better understand the peculiarities of digitalization in business networks (Ritter and Pedersen 2020), thereby achieving a greater contextualization of existing concepts in IMP research (Baraldi et al. 2020; Bocconcelli et al. 2020).

Second, we enrich research on start-ups by demonstrating conceptually and empirically, that widely accepted tenets in IMP literature about start-up strategizing do not hold true for data-driven start-ups in specific network roles. For example, prior IMP studies state that start-ups enter business networks at the periphery, have a weak power position relative to incumbents, and need a long duration to get established in business networks (Snehota 2011; Havensvid and La Rocca 2017; Oukes et al. 2019). In contrast, we show that particularly data-driven start-ups in the network role of orchestrators, which connect consumers and incumbents, can start in the center, are in a strong power position vis-à-vis incumbents, and get established in a shorter time through their network effects (Shapiro and Varian 1999). Therefore, we demonstrate that data-driven start-ups in the network role of orchestrators, indeed, can drive other

actors from the start and, thus, indicate a certain disruption potential in business networks, as they alter existing relationships or create new ones between previously unconnected actors (Heikkinen et al. 2007). This complements findings from market shaping literature (Storbacka 2019; Nenonen et al. 2019) that emphasize the need to understand not only how resource linkages, i.e., relationships, can be created between actors, but how these actors can be mobilized to continuously exchange resources so that they can then ultimately act as drivers in digitalized business networks. Specifically, the combination of strong ties with incumbent actors to access data and the central network position determines network-specific resources that lead to an increase in the structural power base vis-à-vis incumbents (Kähkönen and Virolainen 2011). However, we also demonstrate that certain tenets from IMP literature remain robust in the context of digitalized networks. For instance, extenders and enablers start at the network periphery, or transformers exhibit a long duration to get established and have a weak power position relative to incumbents in digitalized business networks. Therefore, we acknowledge that data-driven start-ups are also characterized by the liabilities of smallness and newness in those network roles, i.e., they tend to be driven by incumbents that usually are operating at the network center (Baraldi et al. 2019). Therefore, we also contribute to the literature on data-driven business models and digital business strategy by demonstrating that, contrary to the economies of digitalization (marginal costs, perfect replication, ubiquitous availability) (McAfee and Brynjolfsson 2017) and their strategic implications for scalability (Bharadwaj et al. 2013), not every data-driven start-up, e.g., as an enabler, can leverage them appropriately due to the network role's inherent design. However, this does not necessarily mean that data-driven start-ups that are being driven by incumbent actors are not able to succeed in digitalized business networks. On the contrary: if data-driven business model and the respective network role is aligned, data-driven start-ups are able to strategize successfully in all four network roles we identified. This is in line with findings from Diaz Ruiz et al. (2020), who highlight that business model design is critical, as the technological innovation alone is insufficient to drive markets. In summary, data-driven start-ups can both drive or be driven by incumbents depending on their network role. Jaworski et al. (2000) argue that start-ups in general have the potential to be market drivers, yet this is strongly

related to the founders' mental models that shape their respective network understandings. We extend and refine this insight by extending it to data-driven start-ups, finding that only those operating in certain network roles, and thus in specific founders' mental models, may be able to drive markets.

Third, we contribute a dynamic perspective to IMP literature by deriving three main strategizing trajectories that data-driven start-ups take in digitalized business networks. Although previous studies state that the dynamic component in business networks is inherent (Håkansson and Snehota 2017) and that the strategizing efforts in deliberate trajectories are key to succeeding in complex and rapidly changing digitalized business networks (Möller et al. 2020), the dynamic perspective is not yet taken into account sufficiently in the context of strategizing (Baraldi et al. 2007; Aaboen et al. 2016). By adopting this dynamic perspective, our framework allows for explaining how data-driven start-ups move from one network role to another through their strategizing. Therefore, in the case that the desired network role is not reached yet, we uncover that many data-driven start-ups begin in the network role of extender, build strong ties to access proprietary data in the role of enabler, then finally move into the role of orchestrator in a central network position. Due to this sequence, changing network positions requires more effort and resource investments than building strong ties to access data (Håkansson and Ford 2002). Similarly, from a strategizing perspective, it is important to secure access to key resources first, initiate knowledge sharing, and strengthen the current peripheral network position before expanding the number of ties in a more central network position (Aaboen et al. 2013). Our findings further support the common perception of the orchestrator with its digital platform as the “holy grail” and main target of strategizing in digitalized business networks (Bharadwaj et al. 2013), as this network role simply exhibits the strongest alignment with DDBM tenets. However, pitfalls also exist, like the lack of capabilities and financial support required to develop the digital platform. To sum up, data-driven start-ups should not exceed a certain magnitude of change in their strategizing efforts and instead take a step-wise approach, moving vertically or horizontally from one network role to another to increase the likelihood of achieving the desired network role and ultimately succeeding in digitalized business networks.

5.2 Managerial implications

Besides its theoretical contributions, our study provides three main managerial implications for data-driven start-ups' founders as well as for incumbents' managers.

First, our framework, comprising four network roles for data-driven start-ups, enables founders to gain insights on the different roles that data-driven start-ups can play in digitalized business networks. Specifically, founders can determine and evaluate their current network roles according to two variables (1) strength of ties to access data as key resources and (2) network position within a business network, providing guidance on which variables are critical to strategizing. Moreover, founders can assess to what extent the data-driven start-up's network position aligns with their strategic goals related to, e.g., scalability and collaboration intentions. Understanding the current network role and its distinct characteristics helps founders finding the network role that might suit their strategic goals most appropriately. Moreover, incumbents' managers can use the framework to analyze how data-driven start-ups position themselves relative to incumbents. This assessment helps incumbents' managers understand that data-driven start-ups' aims might differ from the substitution of established network actors; therefore, incumbents' managers get better insights concerning under which circumstances they should collaborate and strengthen ties with a specific data-driven start-up.

Second, our study helps data-driven start-ups' founders and incumbents' managers understand the conditions of digitalized business networks, resulting in new strategizing opportunities for start-ups that differ from the physical context. Specifically, founders and managers should realize that prior assumptions (peripheral network position, strong ties to access key resources, long embedment duration in the network, weak power position relative to incumbents) that were valid mainly in the physical context have only limited applicability to data-driven start-ups depending on their specific network role. Therefore, our structured comparison of strategizing tenets from the physical (IMP) and digital (DDBM) contexts, on the one hand, provides founders with a qualitative measurement tool with which to assess the disruption potential of each network role in digitalized business networks. The more DDBM tenets are confirmed, the higher the disruption potential. On the other hand,

incumbents' managers can use this measurement tool to identify whether the data-driven start-up could pose a threat and disrupt the incumbent's network, thereby eliciting the possibility of initiating appropriate countermeasures in a timely manner.

Third, by using our framework, data-driven start-ups' founders and incumbents' managers can comprehend how data-driven start-ups dynamically change their network role in a digitalized business network. Founders should be aware that adaptations of the network role as strategizing trajectories include fostering their current role, changing dependency on key actors through ties, or altering the network position of their start-up. However, considering that investing in both strong tie development and network position simultaneously is challenging, founders should focus on changing one variable first. This approach leads to the necessity of taking indirect paths via other network roles. As data-driven start-ups develop dynamically in digitalized business networks, incumbents' managers, therefore, should observe the network roles long-term. Our framework helps incumbents' managers recognize typical strategizing trajectories of data-driven start-ups, specifically the often used trajectory from the enabler to orchestrator, to assess potential competitive threats or collaboration opportunities.

5.3 Limitations and future research

This research provides novel insights into data-driven start-ups' network roles and their strategizing, but like any research project, our study has several limitations, providing fruitful avenues for further research.

First, we interviewed the founders at only one particular point in time and applied a retrospective approach, incurring the risk of memory loss among informants and ex-post rationalization of strategic steps, which might result in reliability problems (Halinen et al. 2012). We addressed this issue by comparing interviewees' statements with external data from Crunchbase, social media, or press articles, and by giving each interviewee the opportunity to reflect and provide feedback on our written case studies. Further research could track start-ups from their foundation and interview founders multiple times to generate longitudinal data. This procedure might offer additional insights about strategizing and the underlying reasons.

Second, our findings were based only on founders' subjective views and their own sense-making during their data-driven start-ups' development. Self-perceptions can differ from reality, as other actors might have a different perspective on network positions and also network roles of respective data-driven start-ups, creating new unique boundaries of digitalized business networks shaped by their own understandings and meanings (Guercini and Medlin 2020). Therefore, the integration of multiple network actors, such as incumbents' managers or venture capitalists, also might offer fruitful lines of investigation to gain further insights on network roles and positions from different perspectives.

Third, to the best of our knowledge, our study is the first to identify contradictions between strategizing tenets from IMP literature on start-ups and strategizing tenets deduced from DDBM literature. However, these contradictions are not meant to be exhaustive and open interesting avenues for further research dealing with digitalization and its contradictions with prior IMP literature's findings. This applies specifically to our classification framework, for which we call for a more quantitative assessment of the two variables, e.g., between strong and weak ties to access data. The framework might further serve as a foundation for future studies from which to identify further roles or sub-types and to assign them to different phases of the start-up's development. Although these limitations must be kept in mind when considering our results and implications, we are convinced that we provide valuable insights both for theory and practice.

References

- Aaboen, Lise; Dubois, Anna; Lind, Frida (2013): Strategizing as networking for new ventures. In *Industrial Marketing Management* 42 (7), pp. 1033–1041.
- Aaboen, Lise; Holmen, Elsebeth; Pedersen, Ann-Charlott (2017a): 1 Initiation of Business Relationships in Start Ups. In Lise Aaboen, Antonella La Rocca, Frida Lind, Andrea Perna, Tommy Shih (Eds.): *Starting Up in Business Networks*. London: Palgrave Macmillan, pp. 19–39.
- Aaboen, Lise; La Rocca, Antonella; Lind, Frida; Perna, Andrea; Shih, Tommy (Eds.) (2017b): *Starting Up in Business Networks*. London: Palgrave Macmillan.
- Aaboen, Lise; Laage-Hellman, Jens; Lind, Frida; Öberg, Christina; Shih, Tommy (2016): Exploring the roles of university spin-offs in business networks. In *Industrial Marketing Management* 59, pp. 157–166.
- Abrahamsen, Morten H.; Henneberg, Stephan C.; Naudé, Peter (2012): Using actors' perceptions of network roles and positions to understand network dynamics. In *Industrial Marketing Management* 41 (2), pp. 259–269.
- Aldrich, Howard; Auster, Ellen R. (1986): Even dwarfs started small: Liabilities of age and size and their strategic implications. In *Research in Organizational Behavior* 8, pp. 165–198.
- Aldrich Howard, E.; Ruef, M. (2006): *Organizations evolving*. Thousand Oaks: Sage.
- Amit, Raphael; Han, Xu (2017): Value creation through novel resource configurations in a digitally enabled world. In *Strategic Entrepreneurship Journal* 11 (3), pp. 228–242.
- Anderson, Helén; Havila, Virpi; Andersen, Poul; Halinen, Aino (1998): Position and role-conceptualizing dynamics in business networks. In *Scandinavian Journal of Management* 14 (3), pp. 167–186.
- Anderson, James C.; Håkansson, Håkan; Johanson, Jan (1994): Dyadic business relationships within a business network context. In *Journal of Marketing* 58 (4), pp. 1–15.
- Andersson, Per; Mattsson, Lars-Gunnar (2016): Digitalisation and service innovation: the intermediating role of platforms. In Peter Thilenius, Cecilia Pahlberg, Virpi Havila (Eds.): *Extending the Business Network Approach. New Territories, New Technologies, New Terms*. London: Palgrave Macmillan, pp. 141–158.
- Ardolino, Marco; Rapaccini, Mario; Saccani, Nicola; Gaiardelli, Paolo; Crespi, Giovanni; Ruggeri, Carlo (2018): The role of digital technologies for the service transformation of industrial companies. In *International Journal of Production Research* 56 (6), pp. 2116–2132.
- Argyris, Chris; Schon, Donald A. (1974): *Theory in practice: Increasing professional effectiveness*. Oxford: Jossey-Bass.
- Baraldi, Enrico; Brennan, Ross; Harrison, Debbie; Tunisini, Annalisa; Zolkiewski, Judy (2007): Strategic thinking and the IMP approach: A comparative analysis. In *Industrial Marketing Management* 36 (7), pp. 879–894.

- Baraldi, Enrico; Havenvid, Malena Ingemansson; Linné, Åse; Öberg, Christina (2019): Start-ups and networks: Interactive perspectives and a research agenda. In *Industrial Marketing Management* 80, pp. 58–67.
- Baraldi, Enrico; La Rocca, Antonella; Perna, Andrea; Snehota, Ivan (2020): Connecting IMP and entrepreneurship research: Directions for future research. In *Industrial Marketing Management* 91, pp. 495–509.
- Baum, Joel A. C.; Calabrese, Tony; Silverman, Brian S. (2000): Don't go it alone: Alliance network composition and startups' performance in Canadian biotechnology. In *Strategic Management Journal* 21 (3), pp. 267–294.
- Berg, Vebjørn; Birkeland, Jørgen; Nguyen-Duc, Anh; Pappas, Ilias O.; Jaccheri, Letizia (2020): Achieving agility and quality in product development-an empirical study of hardware startups. In *Journal of Systems and Software* 167, in press.
- Bertoni, Fabio; Colombo, Massimo G.; Quas, Anita (2015): The patterns of venture capital investment in Europe. In *Small Business Economics* 45 (3), pp. 543–560.
- Bharadwaj, Anandhi; El Sawy, Omar A.; Pavlou, Paul A.; Venkatraman, N. (2013): Digital business strategy: toward a next generation of insights. In *MIS Quarterly* 37 (2), pp. 471–482.
- Bizzi, Lorenzo; Langley, Ann (2012): Studying processes in and around networks. In *Industrial Marketing Management* 41 (2), pp. 224–234.
- Bocconcelli, Roberta; Carlborg, Per; Harrison, Debbie; Hasche, Nina; Hedvall, Klas; Huang, Lei (2020): Resource interaction and resource integration: Similarities, differences, reflections. In *Industrial Marketing Management* 91, pp. 385–396.
- Brown, Ross; Mawson, Suzanne; Rowe, Alexander (2019): Start-ups, entrepreneurial networks and equity crowdfunding: A processual perspective. In *Industrial Marketing Management* 80, pp. 115–125.
- Brynjolfsson, Erik; McAfee, Andrew (2017): *The business of artificial intelligence*. Harvard Business Review, Available online at <https://hbr.org/2017/07/the-business-of-artificial-intelligence>.
- Callon, Michel (1986): The Sociology of an Actor-Network: The Case of the Electric Vehicle. In Michel Callon, J. Law, A. Rip (Eds.): *Mapping the Dynamics of Science and Technology*. London: Palgrave Macmillan, pp. 19–34.
- Chen, Min; Mao, Shiwen; Liu, Yunhao (2014): Big data: A survey. In *Mobile Networks and Applications* 19 (2), pp. 171–209.
- Ciabuschi, F.; Perna, A.; Snehota, I. (2012): Assembling resources when new business is forming. In *Journal of Business Research* 65 (2), pp. 220–229.
- Corbin, Juliet; Strauss, Anselm (2008): Strategies for qualitative data analysis. In Juliet Corbin, Anselm Strauss (Eds.): *Basiscs of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*, Thousand Oaks: Sage.

- Coreynen, Wim; Matthyssens, Paul; Vanderstraeten, Johanna; van Witteloostuijn, Arjen (2020): Unravelling the internal and external drivers of digital servitization: A dynamic capabilities and contingency perspective on firm strategy. In *Industrial Marketing Management* 89, pp. 265–277.
- Crunchbase (2020): *About us*. Available online at <https://about.crunchbase.com/about-us/>.
- Dalle, Jean-Michel; Den Besten, Matthijs; Menon, Carlo: *Using Crunchbase for economic and managerial research*. Edited by OECD, Paris.
- Diánez-González, Juan Pablo; Camelo-Ordaz, Carmen (2019): The influence of the structure of social networks on academic spin-offs' entrepreneurial orientation. In *Industrial Marketing Management* 80, pp. 84–98.
- Diaz Ruiz, Carlos A.; Baker, Jonathan J.; Mason, Katy; Tierney, Kieran (2020): Market-scanning and market-shaping: why are firms blindsided by market-shaping acts? In *Journal of Business & Industrial Marketing* 35 (9), pp. 1389–1401.
- Eisenhardt, Kathleen M. (1989): Building theories from case study research. In *Academy of Management Review* 14 (4), pp. 532–550.
- Eisenhardt, Kathleen M.; Graebner, Melissa E. (2007): Theory building from cases: Opportunities and challenges. In *Academy of Management Journal* 50 (1), pp. 25–32.
- Elfring, Tom; Hulsink, Willem (2003): Networks in entrepreneurship: The case of high-technology firms. In *Small Business Economics* 21 (4), pp. 409–422.
- Elfring, Tom; Hulsink, Willem (2007): Networking by entrepreneurs: Patterns of tie—formation in emerging organizations. In *Organization Studies* 28 (12), pp. 1849–1872.
- Fehrer, Julia A.; Conduit, Jodie; Plewa, Carolin; Li, Loic Pengtao; Jaakkola, Elina; Alexander, Matthew (2020): Market shaping dynamics: interplay of actor engagement and institutional work. In *Journal of Business & Industrial Marketing* 35 (9), pp. 1425–1439.
- Fund, Bret R.; Pollock, Timothy G.; Baker, Ted; Wowak, Adam J. (2008): Who's the new kid? The process of developing centrality in venture capitalist deal networks. In Joel A. C. Baum, Timothy J. Rowley (Eds.): *Network Strategy*, Bingley: Emerald Group Publishing, pp. 563–593.
- Gardet, Elodie; Fraiha, Shady (2012): Coordination modes established by the hub firm of an innovation network: The case of an SME bearer. In *Journal of Small Business Management* 50 (2), pp. 216–238.
- Giardino, Carmine; Wang, Xiaofeng; Abrahamsson, Pekka (2014): Why Early-Stage Software Startups Fail: A Behavioral Framework. In C. Lassenius, K. Smolander (Eds.): *Software Business. Towards Continuous Value Delivery. Lecture Notes in Business Information Processing*. Cham: Springer, pp. 27–41.
- Gioia, Dennis A.; Corley, Kevin G.; Hamilton, Aimee L. (2013): Seeking qualitative rigor in inductive research: Notes on the Gioia methodology. In *Organizational Research Methods* 16 (1), pp. 15–31.

- Glaser, Barney G.; Strauss, Anselm L. (1967): *The Discovery of Grounded Theory: Strategies for Qualitative Research*. London: Wiedenfeld and Nicholson.
- Griffin, Abbie; Hauser, John R. (1996): Integrating R&D and marketing: A review and analysis of the literature. In *Journal of Product Innovation Management* 13 (3), pp. 191–215.
- Guercini, Simone; Medlin, Christopher John (2020): A radical constructivist approach to boundaries in business network research. In *Industrial Marketing Management* 91, pp. 510–520.
- Guercini, Simone; Milanesi, Matilde (2019): Newness and heritage in business networks: Case analysis of university spin-offs. In *Industrial Marketing Management* 80, pp. 139–148.
- Guercini, Simone; Runfola, Andrea (2015): Actors' roles in interaction and innovation in local systems: a conceptual taxonomy. In *Journal of Business & Industrial Marketing* 30 (3/4), pp. 269–278.
- Håkansson, Håkan (Ed.) (1982): *International marketing and purchasing of industrial goods: An interaction approach*. Chichester: John Wiley & Sons.
- Håkansson, Håkan; Ford, David (2002): How should companies interact in business networks? In *Journal of Business Research* 55 (2), pp. 133–139.
- Håkansson, Håkan; Ford, David; Gadde, Lars-Erik; Snehota, Ivan; Waluszewski, Alexandra (2009): *Business in networks*. Chichester: John Wiley & Sons.
- Håkansson, Håkan; Havila, Virpi; Pedersen, Ann-Charlott (1999): Learning in networks. In *Industrial Marketing Management* 28 (5), pp. 443–452.
- Håkansson, Håkan; Johanson, Jan (1992): A model of industrial networks. In Björn Axelsson, Geoffrey Easton (Eds.): *Industrial Networks: a New View of Reality*. London: Routledge, pp. 28–34.
- Håkansson, Håkan; Snehota, Ivan (1995): *Developing relationships in business networks*. London: Routledge.
- Håkansson, Håkan; Snehota, Ivan (Eds.) (2017): *No business is an island*. Bingley: Emerald Group Publishing.
- Håkansson, Håkan; Waluszewski, Alexandra (2007): *Knowledge and Innovation in Business and Industry. The importance of using others*. New York: Routledge.
- Halinen, Aino; Medlin, Christopher J.; Törnroos, Jan-Åke (2012): Time and process in business network research. In *Industrial Marketing Management* 41 (2), pp. 215–223.
- Hart, Stuart; Banbury, Catherine (1994): How strategy-making processes can make a difference. In *Strategic Management Journal* 15 (4), pp. 251–269.
- Hartmann, Philipp Max; Zaki, Mohamed; Feldmann, Niels; Neely, Andy (2016): Capturing value from big data—a taxonomy of data-driven business models used by start-up firms. In *International Journal of Operations & Production Management* 36 (10), pp. 1382–1406.
- Havensvid, Malena I.; La Rocca, Antonella (2017): New business development in business networks. In Håkan Håkansson, Ivan Snehota (Eds.): *No business is an island*. Bingley: Emerald Group Publishing, pp. 87–103.

- Heikkinen, Marko T.; Mainela, Tuija; Still, Johanna; Tähtinen, Jaana (2007): Roles for managing in mobile service development nets. In *Industrial Marketing Management* 36 (7), pp. 909–925.
- Huang, Jimmy; Henfridsson, Ola; Liu, Martin J.; Newell, Sue (2017): Growing on steroids: Rapidly scaling the user base of digital ventures through digital innovaton. In *MIS Quarterly* 41 (1), pp. 301–314.
- Janssen, Marijn; Charalabidis, Yannis; Zuiderwijk, Anneke (2012): Benefits, adoption barriers and myths of open data and open government. In *Information Systems Management* 29 (4), pp. 258–268.
- Jaworski, Bernard; Kohli, Ajay K.; Sahay, Arvind (2000): Market-driven versus driving markets. In *Journal of the Academy of Marketing Science* 28 (1), pp. 45–54.
- Jordanius, Hjalmarsson Anders; Juell-Skielse, Gustaf; Kailas, Aravind (2019): Digital innovation and incubators: A comparative interview study from the perspective of the automotive industry. In *Proceedings of the 52nd Hawaii International Conference on System Sciences*, pp. 6001–6010.
- Kähkönen, Anni-Kaisa; Virolainen, Veli Matti (2011): Sources of structural power in the context of value nets. In *Journal of Purchasing and Supply Management* 17 (2), pp. 109–120.
- Kollmann, Tobias; Stöckmann, Christoph; Hensellek, Simon; Kensbock, Julia (2016): *European Startup Monitor 2016*. Edited by German Startups Association. Berlin.
- Kumaraswamy, Arun; Garud, Raghu; Ansari, Shahzad (2018): Perspectives on disruptive innovations. In *Journal of Management Studies* 55 (7), pp. 1025–1042.
- Kupp, Martin; Marval, Moyra; Borchers, Peter (2017): Corporate accelerators: fostering innovation while bringing together startups and large firms. In *Journal of Business Strategy* 38 (6), pp. 47–53.
- La Rocca, Antonella; Ford, David; Snehota, Ivan (2013): Initial relationship development in new business ventures. In *Industrial Marketing Management* 42 (7), pp. 1025–1032.
- La Rocca, Antonella; Perna, Andrea (2014): New Venture Acquiring Position in an Existing Network. In *IMP Journal* 8 (2), pp. 64–73.
- La Rocca, Antonella; Perna, Andrea; Snehota, Ivan; Ciabuschi, Francesco (2019): The role of supplier relationships in the development of new business ventures. In *Industrial Marketing Management* 80, pp. 149–159.
- Laari-Salmela, Sari; Mainela, Tuija; Puhakka, Vesa (2019): Resolving the start-up identity crisis: Strategizing in a network context. In *Industrial Marketing Management* 80, pp. 201–213.
- Lakomaa, Erik; Kallberg, Jan (2013): Open data as a foundation for innovation: The enabling effect of free public sector information for entrepreneurs. In *IEEE Access* 1, pp. 558–563.

- Lamine, Wadid; Fayolle, Alain; Jack, Sarah; Byrne, Janice (2019): The role of materially heterogeneous entities in the entrepreneurial network. In *Industrial Marketing Management* 80, pp. 99–114.
- Landqvist, Maria; Lind, Frida (2019): A start-up embedding in three business network settings—A matter of resource combining. In *Industrial Marketing Management* 80, pp. 160–171.
- Lincoln, Yvonna S.; Guba, Egon (1985): *Naturalistic inquiry*. Beverly Hills: Sage.
- Lindgreen, Adam; Di Benedetto, C. Anthony; Beverland, Michael B. (2020): How to write up case-study methodology sections. In *Industrial Marketing Management* 96, pp. A7-A10.
- McAfee, Andrew; Brynjolfsson, Erik (2017): *Machine, platform, crowd: Harnessing our digital future*. New York: WW Norton & Company.
- McGrath, Helen; Medlin, Christopher J.; O'Toole, Thomas (2019): A process-based model of network capability development by a start-up firm. In *Industrial Marketing Management* 80, pp. 214–227.
- Möller, Kristian; Nenonen, Suvi; Storbacka, Kaj (2020): Networks, ecosystems, fields, market systems? Making sense of the business environment. In *Industrial Marketing Management* 90, pp. 380–399.
- Nambisan, Satish; Lyytinen, Kalle; Majchrzak, Ann; Song, Michael (2017): Digital Innovation Management: Reinventing innovation management research in a digital world. In *MIS Quarterly* 41 (1), pp. 223–238.
- Nenonen, Suvi; Storbacka, Kaj; Windahl, Charlotta (2019): Capabilities for market-shaping: Triggering and facilitating increased value creation. In *Journal of the Academy of Marketing Science* 47 (4), pp. 617–639.
- Nunally, Jum C.; Bernstein, Ira H. (1978): *Psychometric theory*. New York: McGraw-Hill.
- Oukes, Tamara; Raesfeld, Ariane von; Groen, Aard (2019): Power in a startup's relationships with its established partners: Interactions between structural and behavioural power. In *Industrial Marketing Management* 80, pp. 68–83.
- Pagani, Margherita (2013): Digital business strategy and value creation: Framing the dynamic cycle of control points. In *MIS Quarterly* 37 (2), pp. 617–632.
- Pagani, Margherita; Pardo, Catherine (2017): The impact of digital technology on relationships in a business network. In *Industrial Marketing Management* 67, pp. 185–192.
- Parida, Vinit; Lahti, Tom; Wincent, Joakim (2016): Exploration and exploitation and firm performance variability: a study of ambidexterity in entrepreneurial firms. In *International Entrepreneurship and Management Journal* 12 (4), pp. 1147–1164.
- Parker, Geoffrey G.; van Alstyne, Marshall W.; Choudary, Sangeet Paul (2016): *Platform revolution: How networked markets are transforming the economy and how to make them work for you*. New York: WW Norton & Company.
- Peppard, Joe; Rylander, Anna (2006): From value chain to value network: Insights for mobile operators. In *European Management Journal* 24 (2-3), pp. 128–141.

- Pfeffer, Jeffrey (2009): Understanding power in organizations. In Dean Tjosvold, Barbara Wisse (Eds.): *Power and Interdependence in Organizations*. New York: Cambridge University Press, pp. 17–32.
- Pfeffer, Jeffrey; Salancik, Gerald R. (1978): *The external control of organizations: A resource dependence perspective*. Stanford: Stanford University Press.
- Porter, Michael E.; Heppelmann, James E. (2014): How smart, connected products are transforming competition. In *Harvard Business Review* 92 (11), pp. 64–88.
- Rifkin, Jeremy (2014): *The zero marginal cost society: The internet of things, the collaborative commons, and the eclipse of capitalism*. New York: St. Martin's Press.
- Ritter, Thomas; Pedersen, Carsten Lund (2020): Digitization capability and the digitalization of business models in business-to-business firms: Past, present, and future. In *Industrial Marketing Management* 86, pp. 180–190.
- Rowley, Tim; Behrens, Dean; Krackhardt, David (2000): Redundant governance structures: An analysis of structural and relational embeddedness in the steel and semiconductor industries. In *Strategic Management Journal* 21 (3), pp. 369–386.
- Rust, Roland T.; Cooil, Bruce (1994): Reliability measures for qualitative data: Theory and implications. In *Journal of Marketing Research* 31 (1), pp. 1–14.
- Schepis, Daniel; Purchase, Sharon; Ellis, Nick (2014): Network position and identity: A language-based perspective on strategizing. In *Industrial Marketing Management* 43 (4), pp. 582–591.
- Shapiro, Carl; Varian, Hal R. (1999): *Information rules: a strategic guide to the network economy*. Boston: Harvard Business Press.
- Snehota, Ivan (2011): New business formation in business networks. In *The IMP Journal* 5 (1), pp. 1–9.
- Stinchcombe, Arthur L. (1965): Organizations and social structure. In James G. March (Ed.): *Handbook of organizations*, Chicago: Rand McNally & Company, pp. 142–193.
- Storbacka, Kaj (2019): Actor engagement, value creation and market innovation. In *Industrial Marketing Management* 80, pp. 4–10.
- Su, Zhongfeng; Xie, En; Li, Yuan (2011): Entrepreneurial orientation and firm performance in new ventures and established firms. In *Journal of Small Business Management* 49 (4), pp. 558–577.
- Suchman, Mark C. (1995): Managing legitimacy: Strategic and institutional approaches. In *Academy of Management Review* 20 (3), pp. 571–610.
- Teece, David J. (2018): Profiting from innovation in the digital economy: Enabling technologies, standards, and licensing models in the wireless world. In *Research Policy* 47 (8), pp. 1367–1387.
- Tidström, Annika; Rajala, Anni (2016): Coopetition strategy as interrelated praxis and practices on multiple levels. In *Industrial Marketing Management* 58, pp. 35–44.
- Yin, Robert K. (2018): *Case study research and applications. Design and methods*. Los Angeles: Sage.

- Zaltman, Gerald; LeMasters, Karen; Heffring, Michael (1982): *Theory Construction in Marketing: Some Thoughts on Thinking*. New York: John Wiley & Sons.
- Zaremba, Boris W.; Bode, Christoph; Wagner, Stephan M. (2016): Strategic and operational determinants of relationship outcomes with new venture suppliers. In *Journal of Business Logistics* 37 (2), pp. 152–167.
- Zeithaml, Valarie A.; Jaworski, Bernard J.; Kohli, Ajay K.; Tuli, Kapil R.; Ulaga, Wolfgang; Zaltman, Gerald (2020): A theories-in-use approach to building marketing theory. In *Journal of Marketing* 84 (1), pp. 32–51.
- Zott, Christoph; Amit, Raphael; Massa, Lorenzo (2011): The business model: recent developments and future research. In *Journal of Management* 37 (4), pp. 1019–1042.

Appendix

Appendix A.

Interview guideline.

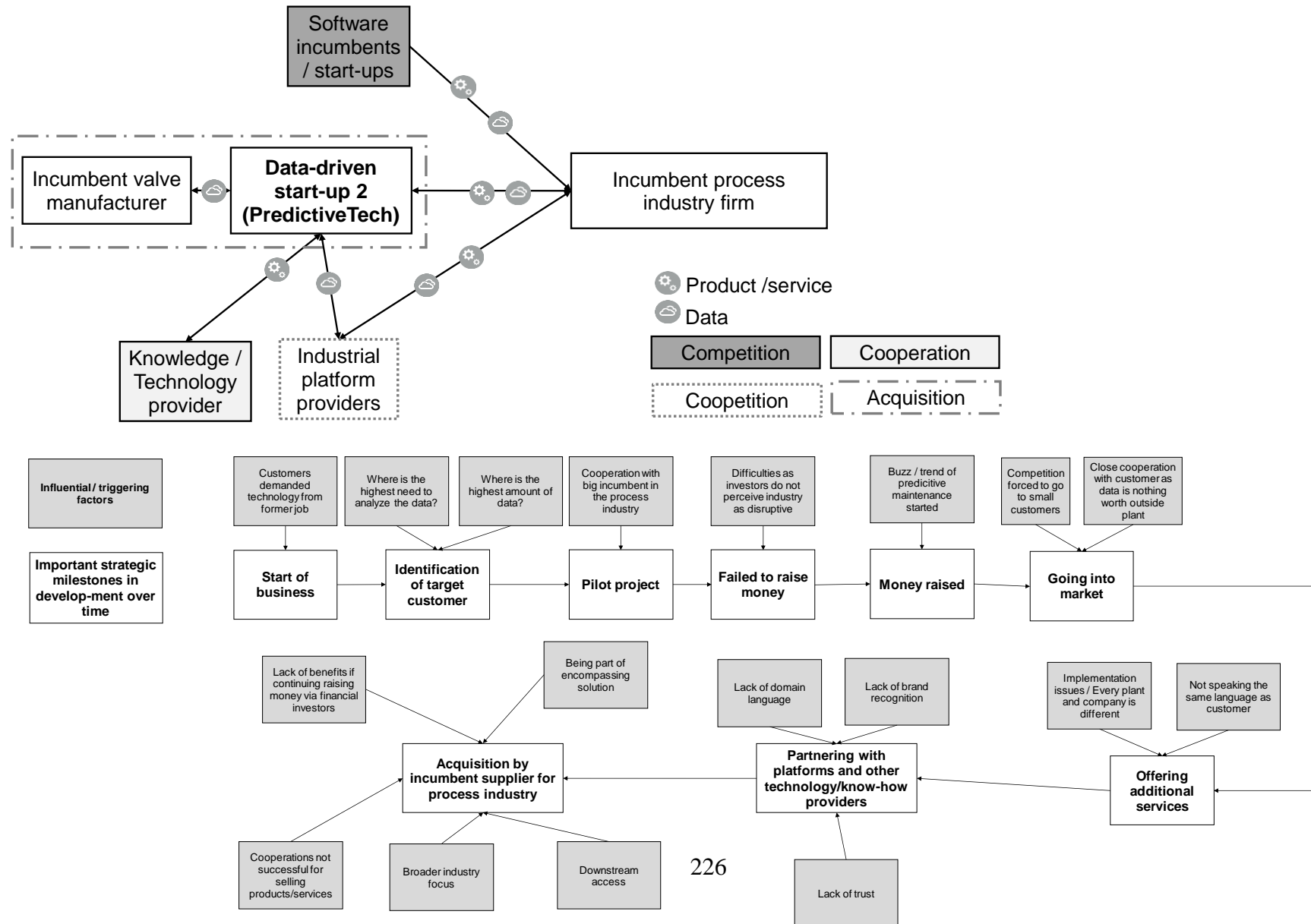
Introduction	<ul style="list-style-type: none">• <i>Brief introduction of the interviewer</i>• <i>General information about the interview</i>• <i>Information about the interview process</i>
Topic	Main questions
Founder's personal background and description of the business idea, business model and main stakeholders	<ul style="list-style-type: none">• Could you briefly introduce yourself and tell us what background you have?• Could you please shortly describe the business idea of your start-up?• What triggered you to start your own business?• Could you please describe the main customer group?• Who is/are your main competitor/s? (Physical- vs data-oriented?)• To what extent do you see any incumbent physical firms as competitors?• Where do you get the data from?
Explanation of the initial strategy, later strategy pivots and associated trigger events	<ul style="list-style-type: none">• Tell me about how you go into the market?• What are the underlying reasons for your strategy choice?• What is the goal you (personally) really have (related to the start-up / founder)?• When you entered the market, to what extent did you care about the other actors?• To what extent did you think about incumbents?• When you entered the market, to what extent did you perceived the market as a system?

(continued)

Topic	Main questions
Elaboration on their network role in the past, the present and the future	<ul style="list-style-type: none">• How did you position yourself within your value chain / ecosystem at the beginning?• How would you describe your role in this system?• What major hurdles and changes have occurred since the foundation of your start-up? Why?• How did you adjust your start-up to fit these changes?• What are the plans for your start-up in the future?
End	<ul style="list-style-type: none">• If you rethink the development of the strategy of your start-up, what would you do differently?• This brings us to the end from my side. Do you have any further comments or questions? Do you want to add anything? Is there anything important that we haven't talked about in the course of the interview?• Then let me thank you for taking part in the interview. Your input has been extremely helpful for us. If you wish to add something later, please do not hesitate to contact us by phone or e-mail. I wish you a pleasant day. Goodbye!
Probes and follow-up questions	<ul style="list-style-type: none">• What do you mean by...? Can you elaborate on this?• Why is that? Could you provide an example?

Appendix B.

Exemplary network constellation and plot of strategic milestones of the data-driven start-up PredictiveTech from our sample.



Appendix C.

Evaluation of rigor.

Following the criteria for rigor evaluation proposed by Lincoln & Guba (1985) and Zeithaml et al. (2020), we ensured our study results' credibility, transferability, dependability and confirmability. To increase credibility in our study, we conducted our interviews with three researchers present. While one researcher mainly conducted the interview, asking probing questions, the other two researchers took detailed notes and were allowed to ask clarifying questions at the end in case something was overlooked during the interview. In particular, the later discussion of the interviews and the comparison across participants helped to establish a shared, complete, and credible understanding of what was said (Tidström and Rajala 2016; Zeithaml et al. 2020). By including data-driven start-ups with different status levels and ages, and without a regional or cultural focus, we ensured the results' transferability and external validity (Zeithaml et al. 2020). Overall, our sample is based on 11 data-driven start-ups from Europe, eight from North America and four from mainly developing countries in Asia, South America and the Middle East. To ensure dependability and, thus, reliability in our data, we asked three independent judges who were familiar with qualitative research methods, but not involved in our research project, to assign a random sample of five cases to the specific network roles and strategizing trajectories that we identified. We computed inter-judge agreement among the researchers using the proportional loss reduction method by Rust and Cooil (1994), generating a value of 0.84 for the network roles and 0.98 for the strategizing trajectories, both well above the threshold of 0.7 recommended for exploratory research (Nunally and Bernstein 1978). We also shared individual case descriptions, including network constellations with the interviewees, to validate our analyses' accuracy, asking them whether the conclusions are consistent with their views (Elfring and Hulsink 2007; Zeithaml et al. 2020). We invited further remarks and discussions to increase our results' objectivity by this member check approach.

Appendix D.

Overview of network role analysis based on the ARA and DDBM framework.

Network role	ARA framework combined with DDBM components			Business network map (S = Solution; D = Data)	Alias names of data-driven start-ups from sample
	Activities	Resources	Actors		
Enabler	<p>Offering Enabling incumbent customers with huge historical data sets to work more effectively or efficiently (e.g., predictive maintenance, sales analytics).</p> <p>Key activity Processing, analyzing, and visualizing data from incumbent companies (e.g., analyzing robot data to make them ready for smart interactions with humans).</p> <p>Revenue model Mostly subscription-based revenue model.</p> <p>Cost structure Low specific cost advantage due to complex data acquisition and lack of scalability.</p>	<p>Key resources</p> <ul style="list-style-type: none"> Proprietary customer data from incumbent Data analytics skills Deep industry and process domain knowledge Trustful and close relationship with incumbent customer 	<p>Customer segment Incumbent customers in B2B sectors.</p> <p>Others Third parties with non-data-driven solutions as competitors or as partners (e.g., consulting firms).</p>		<p>TrendTech</p> <p>PredictiveTech</p> <p>MonitoringTech</p> <p>SalesTech</p> <p>SearchTech</p> <p>RoboTech</p> <p>CloudTech</p> <p>MarketingTech</p> <p>PsychologyTech</p> <p>AnalyticsTech</p>
Extender	<p>Offering Extending incumbent's offerings with new functionalities (e.g., social media data about disruptions for routing service applications).</p> <p>Key activity Collecting, acquiring, and analyzing data from open APIs and own customers (e.g., analyzing freely available legal texts to provide incumbents with implications).</p> <p>Revenue model Mostly freemium-based revenue model.</p> <p>Cost structure High specific cost advantage due to simple data access and high scalability.</p>	<p>Key resources</p> <ul style="list-style-type: none"> Free available data from open APIs Data generated through customer's usage Data analytics skills Providing an platform- or service-agnostic solution Data-driven platform solution from incumbent 	<p>Customer segment Mix of individual end-users in B2C sectors and specific B2B sectors.</p> <p>Others</p> <ul style="list-style-type: none"> Incumbent platform provider (technological or service basis) Open data provider 		<p>CommunicationApp</p> <p>MobilityApp</p> <p>GovApp</p> <p>FinApp</p>

(continued)

ARA framework combined with DDBM components			Business network map (S = Solution; D = Data)	Alias names of data-driven start-ups from sample	
Network role	Activities	Resources	Actors		
Transformer	<p>Offering Enriching incumbents' non-data-driven offerings with digital components (e.g., smart and connected door lock), thereby transforming and substituting incumbent actors.</p> <p>Key activity Collecting, processing, and analyzing data from customers using the physical device to create complementing data-driven services.</p> <p>Revenue model One-time sale with regular subscription-based fees for additional data-driven services.</p> <p>Cost structure High specific cost advantage due to marginal data acquisition via physical devices at the customer end and economies of scale of large contract suppliers manufacturing the hardware components.</p>	<p>Key resources</p> <ul style="list-style-type: none"> Self-generated/self-collected data sets Data analytics skills Knowledge concerning the digitally-enabled product or service Tangible resources (raw materials or end product) 	<p>Customer segment Mix of individual end-users in B2C sectors and incumbent companies in specific B2B sectors.</p> <p>Others</p> <ul style="list-style-type: none"> Competing incumbent Production partners for physical product (hardware supplier) 		SmartLock SmartImage
Orchestrator	<p>Offering Orchestrating and connecting actors previously unconnected via providing a digital platform.</p> <p>Key activity Acquiring, aggregating, processing, and analyzing data from a large user base, thereby generating network effects by enabling mediation and exchange between different / new actors (e.g., end-consumers with incumbent companies).</p> <p>Revenue model Transaction-based revenue model, charging typically only one actor group.</p> <p>Cost structure High specific cost advantage after reaching critical mass, resulting in the ability to grow at scale and marginal costs by exploiting network effects.</p>	<p>Key resources</p> <ul style="list-style-type: none"> Proprietary customer data Other data sources (e.g., free available) End-user interface Data analytics skills 	<p>Customer segment Mix of individual end-users in B2C sectors and incumbent companies in specific B2B sectors.</p>		ComplaintPlatform AIPlatform CarePlatform MRPPlatform FinancialPlatform SpeechAIPlatform GiftPlatform