Max Schumm

Organizing for Digital Innovation

Implications for Organizational Forms, Digital Transformation and Digital Innovation Units

kassel university press

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Abstract

Context: *Digital innovations* and their inherent *digital technologies* pose unprecedented questions about the interaction of information systems and organizational forms in the digitized world. Digital innovation is both a necessary and a challenging endeavor for most firms. To achieve progress in this regard, firms across contexts increasingly engage in strategic initiatives to supply organizational and capability determinants for digital innovation. Striving to overcome the organizing and capability gap in digital innovation, incumbents of industrial-age contexts have been developing internal *digital innovation units*, which aim to bring in new skills and working procedures related to digital technologies. Yet, these post-bureaucratic organizational alterations face certain hurdles and tensions. More specifically, their growth and even survival are challenged. First, the digital innovation outcomes need to be compatible with the main organization's pre-digital restrictions to ensure applicability. Thus, while being explicitly committed to digital innovation, firms need to be sensitive to the requirements of integration. Second, digital innovation units compete with multiple other internal and external digital innovation initiatives, such as collaborations with *tech giants* or digital *mergers and acquisitions*. In the face of these competitors, digital innovation units have to fight for scarce resources. Third, digital innovation units are separated from their main organizations both geographically and with regard to their techniques, skills and working styles. This separation is problematic because digital innovation in these contexts is about the combination of digital and physical components that impose fundamentally different demands but also belong together.

Research Gaps and Research Strategies: This dissertation aims to explore appropriate ways of organizing for digital innovation. It builds on four studies to close knowledge gaps that have recently emerged. First, a longitudinal and holistic analysis of the co-evolution of digital innovations (and their inherent digital technologies) and organizational forms remains lacking, which prevents the use of valuable established knowledge to address emergent challenges and identify important gaps in our understanding. Therefore, the dissertation systematically analyzes 42 high-quality papers on the correlation between information systems and organizational forms. Second, despite digital innovation units' popularity in practice, the prospects of this initiative are not yet clear. Building on dynamic capabilities theory, this dissertation offers hypotheses on the performance implications of digital innovation units and employs panel data regressions on a longitudinal and cross-industry dataset to investigate formerly stated predictions. Third, as prior research has fallen short in

explaining how digital innovation units survive and grow in light of the hurdles and challenges noted above, this dissertation conducts a case study and observes 16 digital innovation units inside one of the world's leading automotive manufacturers to determine the mechanisms that drive digital innovation units to garner legitimacy for themselves and their outcomes. Fourth, to resolve the paradoxical tensions nested in digital innovation in industrial-age contexts, organizations need to transcend mere separation. As prior research does not explain how digital innovation units and their main organizations can cooperate symbiotically to create digital innovation, this dissertation reports on a Delphi survey involving 23 automotive experts to discover those answers.

Findings and Implications: With the aim of contributing to the overall research goal of investigating appropriate ways of organizing for digital innovation, this dissertation explores three research perspectives through four discrete studies. First, by contributing to the broadest research perspective, *understanding digital technologies' and innovations' impact on organizational forms*, this dissertation reveals three meta-patterns of co-evolutionary transformation: a continuous decentralization of organizational forms, a primacy of transition and a shift toward inherent technological value. The meta-patterns portray a shift toward a new narrative about the influence of information systems on organizational forms. Second, considering the intermediate-focused research perspective, *establishing digital innovation units*, the dissertation provides quantified evidence that digital innovation units increase performance and that this effect is strengthened by the presence of digital ventures in the industry and the degree to which an industry relies on tangible assets. An additional analysis provides a more nuanced perspective on the implications of establishing digital innovation units. The dissertation also details three mechanisms from distinct empirical findings that facilitate the evolution of digital innovation units: directed innovation, rapid value focusing, and participatory enablement. It synthesizes these mechanisms into a generalized theoretical model and identifies important implications for digital innovation units' survival and growth. Third, with regard to the most focused research perspective, *managing digital innovation units to overcome digital innovation tensions*, the dissertation abstracts three meta-patterns: maintaining structural autonomy, strategic boundary spanning and operational synchronizing. It synthesizes these meta-patterns into a modular-layered organizing model and relates the findings to paradox and ambidexterity theory. By combining the various studies' findings, the dissertation synthesizes a dynamic, multilevel framework of co-evolutionary transformations, that a) could lead to a dynamic equilibrium of digital pressure and organizational adaptation and b), may aid in overcoming the paradoxical tensions

nested in digital innovation in industrial-age industries. Building on the findings and their synthesized implications, the dissertation offers important implications for both research and managerial practice.

Key words: *Digital innovation, Digital transformation, Organizational forms, Digital innovation units, Co-evolution.*

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List of Abbreviations

DI	Digital Innovation
DIU	Digital Innovation Unit
DT	Digital Transformation
IS	Information Systems
IT	Information Technologies
MO	Main Organization
RQ	Research Question

A. Foundation

The first part of this thesis consists of three chapters. The motivation for this research is presented in Chapter A.I, which also discusses research gaps, research questions (RQs), and the dissertation's structure, design and anticipated contributions. Chapter A.II presents the relevant theoretical background, while Chapter A.III concludes with an outline of the dissertation's methodological foundations.

I. Introduction[1]

The first section of this chapter examines the motivation for and relevance of this research. Afterward, research gaps and RQs are described, followed by an overview of the structure of this thesis. Finally, its anticipated contributions to research and practice are presented.

I.1 Motivation

"In myriad ways, the digital materiality enabled by pervasive digital technology presents new possibilities for creating [...] organizational forms."

(Yoo et al. 2012, p. 1399)

This decade-old quotation remains pertinent today. Even 10 years after Yoo and colleagues announced their search for novel ways of "organizing for innovation in the digitized world" (Yoo et al. 2012, p. 1398), that effort remains a work in progress (e.g., Grover and Lyytinen 2022; Hanelt et al. 2021a; Wessel et al. 2021). Since the pervasiveness and diffusion of digital innovations have only increased, it appears that the *possibility* of creating novel forms of organizing (Yoo et al. 2012) is increasingly being transformed into an *imperative* (Bailey et al. 2022; Berente 2020).

Competitive advantage or even survival seems to be unattainable for firms that neglect to prepare their organizing for digital innovation (Nambisan et al. 2017; Yoo et al. 2012). Digital firms like Google (Alphabet) and Facebook (Meta) show the competitive advantage companies have when they align their organizing directly and comprehensively with digital innovations (Hund et al. 2021; Sebastian et al. 2017). Other non-digital firms exemplify how adapting their structures and capabilities toward post-bureaucratic forms of organizing – that is, operating in a flexible, decentralized and agile manner – enable participation in digital innovation (Berente 2020; Verhoef et al. 2021). Counterexamples like the well-known downfall of Kodak demonstrate that lacking adequate ways of organizing for digital innovation – that is, not preparing the organizational form for the digitized world – is equivalent to failing to survive (Lucas and Goh 2009). Given the extraordinary and pervasive influence of digital technologies on contemporary life, which was exacerbated by the COVID-19 pandemic (Grover and Lyytinen 2022), the urgency to organize for digital innovation has only intensified.

[1] The introduction is partly based on research papers that have been previously submitted and (partly) published by the author. Detailed information on the papers is presented in Table 1.

Digital innovation, which is "the creation of [and consequent change in] market offerings, business processes, or models that result from the use of digital technology" (Nambisan et al. 2017, p. 224), is fundamentally built on digital technologies (Lyytinen 2022). Therefore, digital innovations share similar characteristics with digital technologies (Yoo et al. 2010).

These characteristics have significant implications for their immediate and indirect environments, such as the blurring and convergence of boundaries of devices, materials, organizations and industries (Nambisan et al. 2017; Seo 2017; Tilson et al. 2010). As a consequence, digital innovation is regarded as a shift in the nature of innovation itself (Nambisan et al. 2020) that has profound implications for organizing (Yoo et al. 2012). While conventional physical innovation requires organizing based on solid specifications and well-defined attributes (Baldwin et al. 2000; Hylving et al. 2012), digital innovation, in contrast, follows an evolving and reprogrammable architecture (Yoo et al. 2010) and is adaptable throughout the innovation process, resulting in organizational requirements that are flexible and adaptive (Henfridsson et al. 2014).

Consequently, firms in industrial-age contexts that were established prior to the digital revolution and are based on non-digital value creation – also known as incumbents (Metzler and Muntermann 2020) – are required to develop novel ways of organizing to participate in digital innovation (Sebastian et al. 2020; Svahn et al. 2017; Verhoef et al. 2021). Research describes the need for multiple adaptations in terms of structure (Lyytinen et al. 2016), culture (Lucas and Goh 2009), strategy (Bharadwaj et al. 2013) and capabilities (Warner and Wäger 2019) to enable successful participation in digital innovation by shifting toward a post-bureaucratic form of organizing more suitable for the digitized world (Berente 2020; Verhoef et al. 2021).

Altering an organization toward a more post-bureaucratic setup to enable participation in digital innovation and to be adaptable in digital times has been called *digital transformation* (Verhoef et al. 2021; Wessel et al. 2021) and defined as "organizational change that is triggered and shaped by the widespread diffusion of digital technologies" (Hanelt et al. 2021a, p. 1160). In recent years, that term has garnered a growing amount of research and media interest (Hanelt et al. 2021a; Verhoef et al. 2021). In addition, both research (Nagel 2020) and practice (BostonConsultingGroup 2020; McKinsey 2021) indicate that the COVID-19 pandemic increased the demand for and accelerated the pace of digital transformation initiatives. Hence, digital transformation is characterized as a vital, continuous and co-evolving process (Hanelt et al. 2021a) that results in a sequence of events that are neither fully planned nor determined to have been completed at some predetermined point (Verhoef et al. 2021); it is based on

interactions that do not adhere to simple root cause approaches but are instead comprised of more complex, multidimensional relations (Benbya and McKelvey 2006).

To close the organizing and capability gaps and enable participation in digital innovation, industrial-age incumbents have engaged in several strategic digital transformation initiatives (Fabian et al. 2022; Jöhnk et al. 2022), such as investment in digital mergers and acquisitions (Hanelt et al. 2021b), the forging of external digital partnerships (Chanias et al. 2019) or the recruitment of digital talents (Ciriello and Richter 2015). Apart from that, scholars, like practitioners, consider the internal establishment of dedicated digital innovation units as a viable approach (e.g., Jöhnk et al. 2022; Lau et al. 2021).

Digital innovation units are a timely topic in information systems research, but scholarly inquiry on them remains in its infancy (Holotiuk and Beimborn 2019; Raabe et al. 2021). Digital innovation units have been defined "as autonomous entities that aid their respective main organization in the development of digital capabilities and in the search for and creation of new digital products, services, and processes" (Schumm et al. 2022, p. 1). They are vital initiatives for digital innovation and digital transformation endeavors (e.g., Jöhnk et al. 2022; Raabe et al. 2020a; Svahn et al. 2017), since they are inherently formed around a digital core (Fuchs et al. 2019; Raabe et al. 2020a), are built on digital capabilities (Hellmich et al. 2021), produce novel digital outcomes (Svahn et al. 2017) and can aid in the execution of digital transformation strategies (Chanias et al. 2019). Given their agile, flexible and open characteristics, they can be characterized as manifestations of post-bureaucratic organizational forms (Holotiuk and Beimborn 2019; Raabe et al. 2021).

Contemporary information systems research emphasizes that changing forms of organizing to participate in digital innovation is at the heart of the contemporary phenomenon of digital transformation (Bailey et al. 2022; Hanelt et al. 2021a; Hund et al. 2021). However, a systematic analysis of the state of existing knowledge to identify valuable insights and determine where current research falls short and needs further, targeted additions is still lacking. Further, little is known about how concrete strategic initiatives to embed post-bureaucratic forms of organizing – that is, establishing digital innovation units – can be integrated into the incumbent context or how they provide value (Svahn et al. 2017). This situation is critical, as it is widely accepted that industrial-age incumbents in particular are confronted with an increased demand to embed appropriate ways of organizing for digital innovation (Verhoef et al. 2021; Wessel et al. 2021) while simultaneously facing the threat of disruptive technological change (Gregory et al. 2018; Skog et al. 2018).

Accordingly, this dissertation seeks to investigate, first, the implications of digital innovations and their inherent digital technologies on the organizing of industrial-age incumbents. In doing so, it examines previous organizational transformations enabled by information technologies (IT) (Markus and Rowe 2018; Wessel et al. 2021) in order to investigate possible similarities to learn from and build upon and to investigate differences and novelties in digital times in order to embed required post-bureaucratic organizational forms (Berente 2020; Verhoef et al. 2021). The second purpose of this dissertation is to shed light on one strategic initiative adopted by industrial-age incumbents in order to enable their participation in and creation of digital innovations: digital innovation units (Jöhnk et al. 2022; Smith and Beretta 2021). This research explores how digital innovation units, as one kind of post-bureaucratic organizing (Holotiuk and Beimborn 2019; Raabe et al. 2021), can be established. In addition, it assesses whether they can support the main organization in the creation of digital outcomes that influence overall business performance. In this endeavor, the thesis employs the theoretical lens of dynamic capabilities, which are defined as "the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments" (Teece et al. 1997, p. 516), and characterized as a fundamental criterion that determines whether a business can survive or even thrive in an era of growing digital challenges, turbulence and pressure (Ellström et al. 2021). Third, the dissertation investigates the pitfalls and challenges of digital innovation in industrial-age contexts (Hylving and Schultze 2020; Piccinini et al. 2015). Therefore, it explores how digital innovation units can collaborate with their main organizations sustainably and effectively to overcome the digital–physical tensions nested in digital innovations in industrial-age contexts (e.g., Piccinini et al. 2015; Svahn et al. 2017). Therefore, the theoretical lens of paradoxical ambidexterity is applied (Gregory et al. 2015; Papachroni et al. 2014).

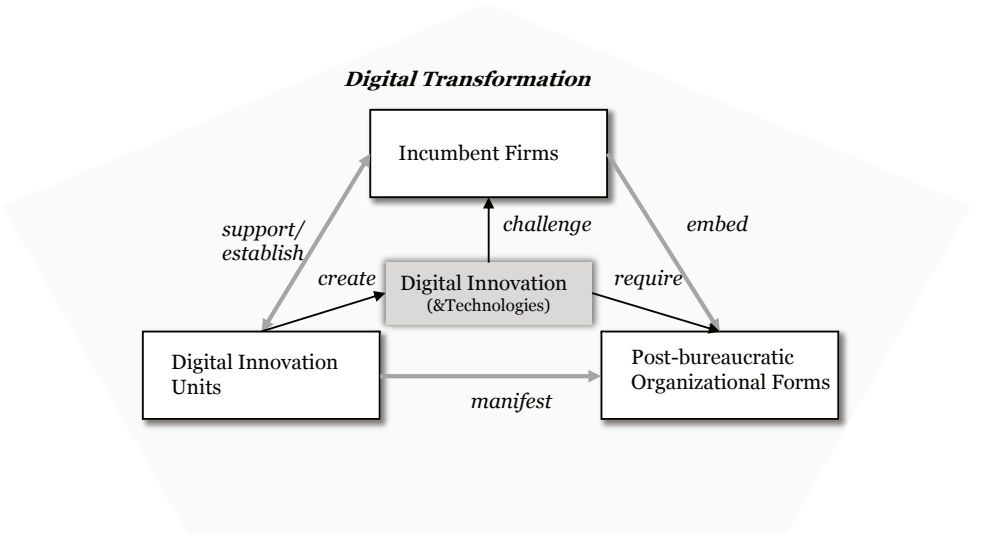


Figure 1 – Building Blocks and Research Focus

Figure 1 provides an overview of the theoretical building blocks of this dissertation – digital innovation and its inherent digital technologies, incumbent firms, digital innovation units, post-bureaucratic organizational forms and digital transformation – and how they relate to one another.

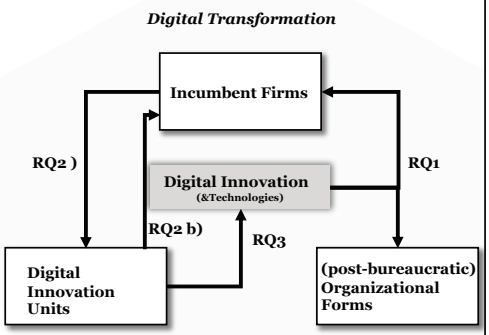
This thesis is intended to contribute to filling specific gaps in information systems research by investigating the crossroads of digital innovation and digital transformation (Drechsler et al. 2020; Hund et al. 2021), strategic management by investigating the specific strategic initiative of digital innovation units to cope with recent digital challenges (Chanias et al. 2019; Smith and Beretta 2021) and organization science by investigating one form of organizational alterations to enable more hybrid and adaptable forms of organizing (Bailey et al. 2022; Yoo et al. 2012) to overcome digital innovation challenges, hurdles and tensions in industrial-age industries.

This thesis, in addition to contributing to academic research, seeks to contribute to managerial practice. It enables managers and organizations, especially in industrial-age contexts, to explore appropriate ways of organizing for digital times. It does so by providing approaches for establishing and managing digital innovation units, measures for assessing their impact and success and guidance on how to integrate them into the main organization. Therefore, it supports relevant practitioner outlets in describing this contemporary phenomenon (Capgemini and MIT 2021; Lau et al. 2022). Additionally,

managers and executives can directly benefit from this dissertation when implementing concrete aspects of their strategies for organizing in the digitized world.

I.2 Research Gaps and Research Questions

As described in the preceding section, digital innovations and their inherently embedded digital technologies (Lyytinen 2022) are essential to creating value in today's digitized world (Nambisan et al. 2017), but they pose significant organizational issues and challenges for industrial-age incumbents (Sebastian et al. 2020; Verhoef et al. 2021). Research has increasingly identified the requirements for organizational adaptation triggered by the need to be digitally innovative (Wessel et al. 2021; Yoo et al. 2012). This has implications not only for forms of organizing (Lyytinen et al. 2016) but also for the fundamental character of innovation itself (Berente 2020). Recent work has associated current efforts at organizational adaptation to these digital challenges as a *digital transformation* (Hanelt et al. 2021a; Wessel et al. 2021), which leads to a pervasive organizational change "in how a firm employs digital technologies to develop a new digital business model that helps to create and appropriate more value for the firm" (Verhoef et al. 2021, p. 889). However, to enable the employment of digital technologies and the development of digital business models, novel and post-bureaucratic forms of organizing must be embedded in them (Bailey et al. 2022; Berente 2020; Lyytinen et al. 2016). This dissertation has the research goal of enhancing the knowledge and understanding of how industrial-age incumbents organize for digital innovation through the strategic establishment of digital innovation units. To achieve and derive novel knowledge with regard to this research goal, the thesis investigates three fundamental RQs, which are depicted in Figure 2 and described in detail below.



Research Questions:

- **RQ1: Understanding** Digital Technologies' and Innovations' impact on organizational forms.
  How do industrial-age incumbents adapt their organizational forms to emerging digital technologies and innovation?
- **RQ2: Establishing** Digital Innovation Units.
  How can the establishment of Digital Innovation Units a) facilitate the development of digital innovation within industrial-age incumbents and b) how do they (co-)evolve over time?
- **RQ3: Managing** Digital Innovation Units to overcome Digital Innovation tensions.
  How do industrial-age incumbents and their Digital Innovation Units overcome digital innovation related tensions to collaboratively engage in digital innovation?

Figure 2 – Research Questions

Recent scholarly research (Verhoef et al. 2021; Wessel et al. 2021) and business practitioners (BostonConsultingGroup 2020; McKinsey 2021) have emphasized the ongoing and increasing pressure exerted by the pervasive distribution of digital innovations and technologies on industrial-age incumbents. In addition to business models and strategies, the form of organizing is under particular pressure to adapt and offer the conditions necessary for digital innovation (Berente 2020; Lyytinen et al. 2016). Previous research has associated adapting organizationally for digital innovation with the need to embed "a new organizational form that departs dramatically from traditional industrial production" (Berente 2020, p. 92) and indicated a transformation toward more "malleable organizational designs" (Hanelt et al. 2021a, p. 1168). In addition, it illustrates the need for hybrid organizational forms that permit the embedding of novel post-bureaucratic forms of organizing, in a flexible, decentralized and agile manner, into existing bureaucratic contexts (Schumm and Hanelt 2021). Despite the pressing need to develop means of organizational adaptation for industrial-age incumbents, overarching insights into how they might transform their forms of

organizing, based on meta-level observations and a sufficiently large data set, remain scarce.

Transforming organizational forms under the pressure of technology is by no means a novel phenomenon in information systems research and has been studied for decades (Crowston and Myers 2004; Gregory et al. 2015; Venkatraman et al. 1993). Researchers have examined IT-enabled organizational transformations since the advent of emerging enterprise resource planning systems (Crowston and Myers 2004; Orlikowski 1996). Although contemporary research indicates that the digital transformation differs from past IT-enabled organizational transformations (Wessel et al. 2021), a systematic and longitudinal meta-study on similarities and differences, overlapping descriptions and comparable definitions to advance the understanding and derive learning for the phenomenon remains lacking (Vial 2019) or focuses more on recent developments and adopts a narrow focus (Wessel et al. 2021). Further, since the management literature informs about organizational forms and their development on a meta level but does not examine the influence of information systems in detail (e.g., Pedersen et al. 2019; Schilling and Steensma 2001), and the information systems literature reports on the interactions of specific information systems with particular organizational forms in a narrowly focused manner (e.g., Ravichandran and Giura 2019; Stebbins et al. 1995), a systematic analysis on a holistic level has yet to appear.

Closing this gap is important to look back on previous IT-enabled organizational transformations to explore possible similarities to learn from and build on and to investigate specifics and novelties that need to be considered in the contemporary digital transformation context. Gaining this knowledge prevents research from re-inventing the wheel while supporting efforts to build on a cumulative research tradition and to contribute by providing a more nuanced understanding of the interdependencies between information systems and organizational forms. Closing these knowledge gaps can further contribute to contemporary research streams, such as “How do [technology] implications for organizational change shift?” (Hanelt et al. 2021a, p. 1180) or "the need to expand the research agenda beyond what was the focus of IT-enabled organizational transformation in the past […]to understand better how digital innovation impacts and transforms established institutions” (Drechsler et al. 2020, p. 14). Further, findings on this issue can aid in comprehending “the intersection between digital transformation and innovation management [which] is still scattered and lacks a unified perspective and overarching framework” (Appio et al. 2021, p. 17). Accordingly, the following RQ is posed:

RQ1: Understanding digital technologies' and innovations' impact on organizational forms.

How do industrial-age incumbents adapt their organizational forms to emerging digital technologies and innovation?

Previous research has associated adapting organizationally for digital innovation with the embedding of novel post-bureaucratic forms of organizing into an existing bureaucratic context (Berente 2020; Schumm and Hanelt 2021). One strategic initiative for industrial-age incumbents to embed post-bureaucratic organizational entities is the establishment of digital innovation units, which are defined as a vital organizational prerequisite for participating in and enabling digital innovations and are consequently relevant to information systems research (Jöhnk et al. 2022; Lorson et al. 2022) and practice (Capgemini and MIT 2021). However, scholarly investigation regarding this topic remains in its infancy (Holotiuk and Beimborn 2019; Raabe et al. 2021). Preliminary research indicates that digital innovation units can build and enhance their main organizations' ability to generate digital innovations (Svahn et al. 2017) and thus positively impact their competitive advantages in the digital age (Haskamp et al. 2021a), with their impact increasing as these units grow (e.g., Chanias et al. 2019; Dremel et al. 2017). However, little is known about how digital innovation units are established, evolve and expand over time to generate digital innovations (e.g., Lorson et al. 2022; Trischler et al. 2022). Additionally, there is scant research on how they are able to expand their influence over time or how they adapt to their immediate environment in order to survive and thrive. Further, research has revealed significant hurdles and tensions when it comes to integrating digital innovation units into pre-digital contexts (Svahn et al. 2017). One practitioner study, for instance, describes a significant number of closures (10%) among over 250 monitored European digital innovation units (Lau et al. 2021). This raises the question of whether digital innovation units are more than *innovation theaters* (Santarsiero et al. 2021) – that is, a public relations phenomenon or signaling effort by firms (e.g., Mayer et al. 2021; Raabe et al. 2020b) – and whether they can achieve substantial and quantifiable results in digital innovation. Consequently, while previous research on digital innovation units has offered initial qualitative insights into their activities, objectives (Raabe et al. 2021) and purpose (Barthel et al. 2020; Fuchs et al. 2019), there is little long-term empirical evidence – whether qualitative or quantitative – on how they enable digital innovation and how that can lead to performance impacts and implications for building competitive advantage (Mayer et al. 2021). In addition, the literature provides only general

information on how digital innovation units are established and positioned and how they evolve over time within a given context (Trischler et al. 2022).

Obtaining knowledge of how digital innovation units as one possible strategic digital innovation initiative can be established organizationally, how they evolve over time to create applicable digital outcomes, and whether and how they create quantifiable value for the main organization is highly relevant to recent research on and the practice of digital innovation in industrial-age contexts. It can help provide answers to recent organizational deficiencies like capability gaps (Keller et al. 2022), structural and procedural shortcomings (Lyytinen et al. 2016) and competence gaps for digital innovation (Svahn et al. 2017). Closing these knowledge gaps can further contribute to contemporary research streams, as reported in highly relevant studies on digital innovation and transformation, such as "how can firms develop specific digital resources?", "how can transforming firms benefit from new organizational structures?" (Verhoef et al. 2021, p. 869), "which configurations of innovation and integration mechanisms in digital transformation yield high firm performance?", and "how do digital transformation-induced changes in the organizational setup influence firm performance?" (Hanelt et al. 2021a, pp. 1181-1182) as well as "What is the relationship between measures of re-organizing (e.g., new digital structural units […]) and new digital patents filed by incumbent firms?" (Hanelt et al. 2021b, p. 18). To contribute to these research avenues and help close knowledge gaps, this dissertation also investigates the following RQ:

> *RQ2: Establishing Digital Innovation Units.*
>
> **How can the establishment of digital innovation units a) facilitate the development of digital innovation in industrial-age incumbents, and b) how do they (co-)evolve over time?**

When participating in digital innovation, incumbents of industrial-age contexts combine their existing physical products with additional digital components to create *smart products*, which are often digitally enhanced versions of their physical antecedents (Hylving and Schultze 2020; Smith and Beretta 2021). This process of combining physical and digital components is typical of industrial-age incumbents and is known as the creation of a layered modular architecture (Yoo et al. 2010). However, since physical and digital innovation processes differ significantly in terms of velocity, presumptions, structure and cultural work underpinnings (Hanelt et al. 2021b; Henfridsson et al. 2014), their combination and the consequent creation of a layered modular architecture can reveal distinct tensions (Hylving and Schultze 2020).

Previous research indicates "that developing this architectural prerequisite of digital innovation is fraught with tensions and conflicts" (Hylving and Schultze 2020, p. 2). The resulting tensions have been characterized and framed as *physical–digital paradoxes* (Piccinini et al. 2015). Further, these tensions nested in the product architecture can also emerge at the organizational level (Toutaoui et al. 2022; Viljoen et al. 2022), as the organizational form and governance of developing and manufacturing physical items is rather hierarchical and sequential, while digital products call for more networked and loosely connected organizational structures (Hanelt et al. 2021b). This leads to a number of organizational conflicts on several levels, including roles, boundary openness, knowledge sharing and division of responsibilities, as two diverse organizational forms and logics must be connected, merged and coordinated (Hylving and Schultze 2020; Svahn et al. 2017). In addition, these tensions are associated with organizational inertia to change (Haskamp et al. 2022). Faced with increasing innovation, time and resource pressure, incumbents cannot afford frictions and costly delays (Piccinini et al. 2015) that can result from inertia, negotiations and conflicting interactions between separate units operating under contradictory assumptions (e.g., Svahn et al. 2017). Although the establishment of digital innovation units has been cited as not only beneficial but also critical for acquiring digital capabilities and developing digital components (Hellmich et al. 2021; Lorson et al. 2022), their separate establishment seems to exacerbate rather than relieve tensions between the physical and digital worlds (Svahn et al. 2017). In sum, while research states that industrial-age incumbents struggle to engage in digital innovation and consider digital innovation units to be one potential digital innovation initiative, there remain unanswered questions about how the critical process of effective and symbiotic cooperation between digital innovation units and main organizations can be achieved. Without overcoming the tensions between the digital and the physical worlds by cooperating effectively and symbiotically, combining digital and physical components to enable digital innovations can seem unattainable (Hylving and Schultze 2020; Svahn et al. 2017).

Contemporary research on the relationship between digital innovation units and their main organizations has not yet sufficiently explored how to manage collaboration between the two (Raabe et al. 2020a). Although initial research attempts to overcome this research gap on organizational integration have been made, the approaches are either superficial (Raabe et al. 2020a) or do not account for the paradoxical characteristics of physical–digital tensions (Trischler et al. 2022). Additionally, research on general organizational collaboration and integration principles has not been used in the context of digital innovation units or to consider digital innovation related to physical–digital tensions (e.g., Gassmann et al. 2012; Jones and Jones 2013).

Consequently, the present dissertation seeks to investigate mechanisms for managing digital innovation units in order to alleviate and overcome digital innovation tensions. The findings aid in the investigation of contemporary research avenues on questions like "how to balance agility with the need for control and efficiency? What is driving the success of specific digital growth strategies?" (Verhoef et al. 2021, p. 869), how digital technologies can be integrated in a physical product-oriented context (Haskamp et al. 2022), how to overcome "the latency and saliency of paradoxical tensions in the DT [digital transformation] context" (Viljoen et al. 2022, p. 8) and "how and why can conflicting views, both inside organizations and within digital business ecosystems, be reconciled?" (Hanelt et al. 2021a, p. 1181). Therefore, this dissertation investigates the following RQ:

> *RQ3: Managing digital innovation units to overcome digital innovation tensions.*
>
> **How do industrial-age incumbents and their digital innovation units overcome digital innovation-related tensions to collaboratively engage in digital innovation?**

I.3 Structure of the Thesis

This section outlines the structure of this dissertation, which is monographic in nature and is based on and related to four discrete studies. These studies further influence sections or subsections in their entirety and/or are tightly related to the RQs posed. The dissertation consists of three parts. Part A contains the first chapter, the Introduction (A.I), which comprises the motivation for this research (A.I.1), details the research gaps and RQs (A.I.2), describes the structure of this thesis (A.I.3), defines the research context and design (A.I.4) and indicates anticipated contributions (A.I.5). The second chapter, Theoretical Background (A.II), defines the core concepts and theories underlying the work. It includes sections on organizational transformation (A.II.1), digital information (A.II.2), determinants for digital innovation (A.II.3) and digital innovation units (A.III.4). The third and final chapter of the first part, Methodological Background (A.III), contains detailed information on the methodologies applied in this dissertation. It provides detailed information on the research context and design (A.III.1), literature reviews (A.III.2), qualitative research (A.III.3) and quantitative research (A.III.4).

Part B represents the main body of this dissertation; it comprises four chapters related to the four studies. Those studies address the overarching research goal of identifying suitable forms of organizing for digital innovation. All four are related to previously submitted and (partly) published research papers. Table A.1 provides an overview of these papers, including their outlets, rankings and current publishing status. The rankings consist of four different metrics: the impact factor (IF) according to Clarivate Analytics 2018, the Google Scholar h5-index (h5), the VHB JOURQUAL 3 (JQ3) ranking and the WI-Journal list 2008 of the Wissenschaftliche Kommission für Wirtschaftsinformatik (WKWI).

Table 1 – Submitted and Published Papers

No.	Publication	Status	Outlet Metrics	Chapter	RQ
1	Schumm, M. and A. Hanelt (2021). "Transformational Dynamics – Systemizing the Co-Evolution of Organizational Forms and Information Systems." *Proceedings of the Forty-Second International Conference on Information Systems, Austin 2021.*	Published; Best Paper Award in General IS Track	IF:/ h5: 25 JQ3: A WKWI: A	B.I	1
2	Schumm, M. and A. Hanelt (Submitted). "Survival and Growth of Digital Innovation Units: A Case Study Analysis." *Information Systems Journal.*	Submitted	IF:7.453 h5: 47 JQ3: A WKWI: A	B.II	2
3	Schumm, M., et al. (2022). "Digital Innovation Units: An Empirical Investigation of Performance Implications." *Proceedings of the Forty-Third International Conference on Information Systems, Copenhagen 2022.*	Published	IF:/ h5: 25 JQ3: A WKWI: A	B.II	2
4	Schumm, M. and A. Hanelt (Under Review). "Digital Innovation Units in Industrial-Age Contexts – Paradoxes, Ambidexterity and Symbiotic Collaboration." *Proceedings of the European Conference on Information Systems 2023.*	Under Review	IF:/ h5: 30 JQ3: B WKWI: A	B.III	3

Part B consists of three distinct chapters. Chapter B.I, Understanding Digital Technologies' and Innovations' Impact on Organizational Forms, is related to RQ1, which concerns the impact of information systems on organizational forms, especially regarding digital technologies and pre-digital incumbent firms. This first chapter (B.I) is broadly related to the publication "Transformational Dynamics – Systemizing the Co-Evolution of Organizational Forms and Information Systems" and systematically

analyzes 42 high-quality papers on the correlation between information systems and organizational forms. It derives three generalized meta-patterns and portrays a shift toward a new narrative about the influence of information systems on organizational forms. The second chapter (B.II), Establishing Digital Innovation Units, relates to RQ2 and refers to the creation, growth and outcomes of digital innovation units. It contains an empirical investigation of the long-term development and evolution of digital innovation units and an analysis of their performance implications. The chapter is based on and extends two publications. First, drawing on the research paper "Survival and Growth of Digital Innovation Units: A Case Study Analysis," it presents a case study of 16 observed digital innovation units at one of the world's leading automotive manufacturers to determine mechanisms that drive digital innovation units to obtain legitimacy for themselves and their outcomes. Second, "Digital Innovation Units: An Empirical Investigation of Performance Implications" employs panel data regressions on a longitudinal and cross-industry dataset to investigate digital innovation units' implications for firm performance and is based on a previously published research paper. The study confirms an increase in performance and finds that this effect is strengthened by the presence of digital ventures in the environment and the degree to which a given industry relies on tangible assets. Chapter B.III, Managing Digital Innovation Units to Overcome Digital Innovation Tensions, addresses RQ3 and investigates how digital innovation units and their main organizations collaborate to integrate applicable digital capabilities and outcomes. The third chapter (B.III) builds on a submitted paper, "Digital Innovation Units in Industrial-Age Contexts – Paradoxes, Ambidexterity, and Symbiotic Collaboration." It presents the results of a Delphi survey involving 23 automotive experts to discover meta-patterns that can be synthesized into a modular-layered organizing model to overcome physical–digital tensions related to digital innovation.

The results are discussed and synthesized in Part C. The implications for theory and practice are derived, followed by a discussion of limitations and future research opportunities. Figure 3 displays the structure of this dissertation.

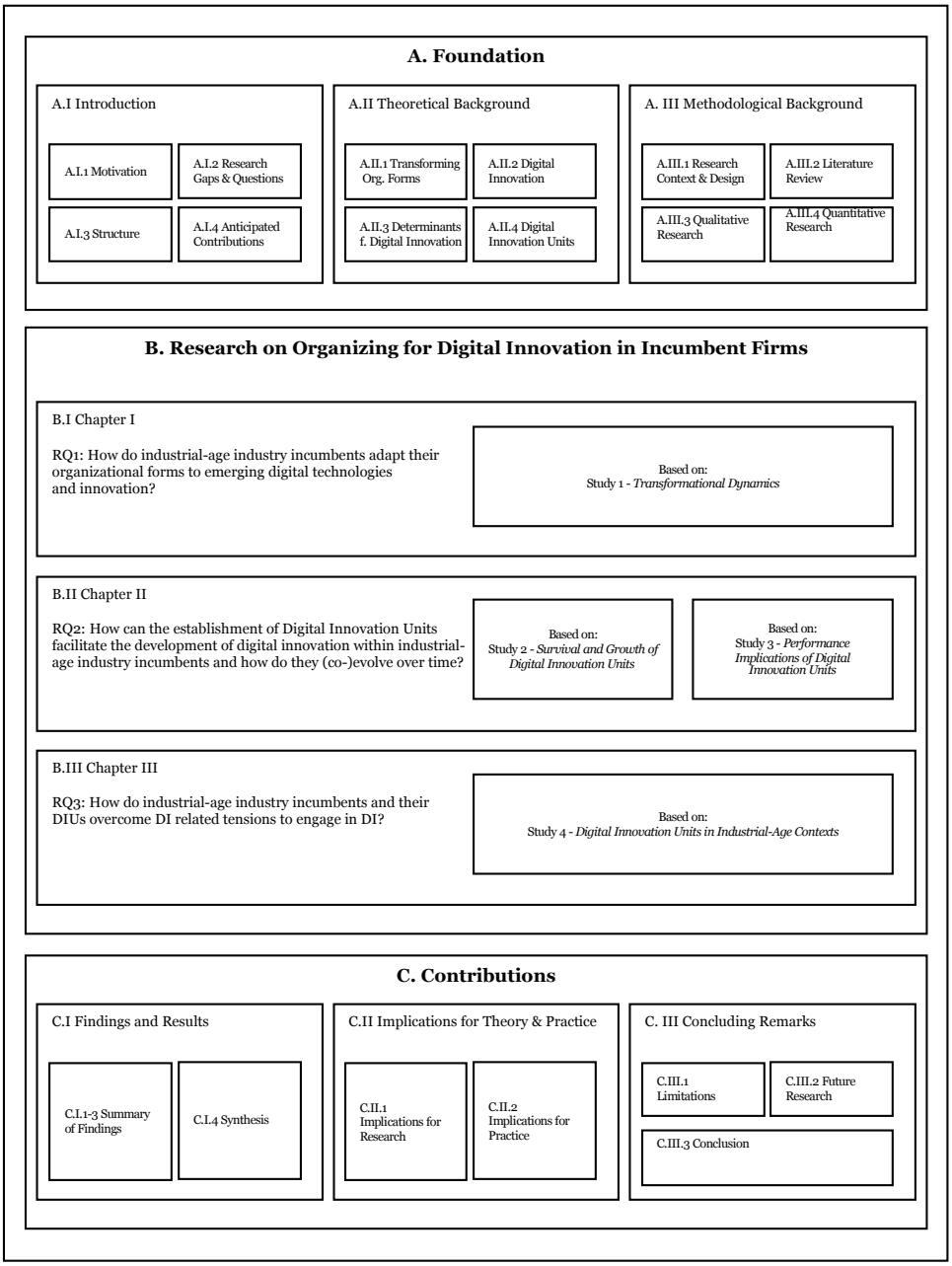


Figure 3 – Structure of the Thesis

I.4 Anticipated Contributions

This chapter provides a first look at the dissertation's anticipated contributions. To structure the anticipated contributions, the chapter aligns the findings with four audiences:

- Theoretical contributions to the field of information systems research
- Theoretical contributions to the field of organization science
- Theoretical contributions to the field of strategic management
- Managerial contributions to business practice

Since this dissertation and the studies it contains are situated in the field of information systems research, that area will receive the most consideration.

First, this dissertation contributes to the field of information systems research by shedding further light on the two interrelated phenomena of digital innovation and digital transformation (Drechsler et al. 2020). Further, by elaborating contemporary ways of organizing for digital innovation in industrial-age contexts and relating these findings to previously investigated IT-enabled organizational transformations, this dissertation helps better define and distinguish contemporary transformational notions from those studied previously (Wessel et al. 2021). In addition, it contributes to the information systems field by investigating digital innovation units as one strategic digital innovation initiative (Chanias et al. 2019; Jöhnk et al. 2022). It elaborates their potential to serve as a crucial organizational and capability determinant (Svahn et al. 2017) to enable digital innovation in industrial-age incumbents. While existing research indicates that digital innovation in industrial-age contexts is unique (Hanelt et al. 2021b; Yoo et al. 2010) and fraught with tremendous hurdles and pitfalls (Hylving and Schultze 2020), this dissertation refines that understanding by providing a more nuanced and profound assessment of the specific physical–digital tensions that exist in these industries (Piccinini et al. 2015). It also presents approaches for addressing these tensions through the lens of co-evolution (e.g., Sia et al. 2016) and the paradoxical view of ambidexterity (Gregory et al. 2015). By conducting a comprehensive investigation of digital innovation units as one way to organize for digital innovation, this dissertation claims that their establishment as a structural alteration to enable the creation of digital outcomes may help bridge the gap between digital innovation and digital transformation. Given that digital transformation is defined as "organizational change that is triggered and shaped by the widespread diffusion of digital technologies" (Hanelt et al. 2021a, p. 1160), digital innovation units may be a link between digital innovation and transformation (Appio et al. 2021).

The dissertation contributes to organization science by highlighting how technologies in general and digital innovations and technologies in particular alter traditional bureaucratic organizational forms (Bailey et al. 2022). It provides extensive additional insights into this specific enabler and trigger of organizational transformation (Yoo et al. 2012). By examining digital innovation units as one distinct organizational response to rising digital threats, the dissertation provides detailed insights into the structure, interconnections and evolution of one post-bureaucratic (Lewin and Volberda 1999) and hybrid organizational form (Kolbjørnsrud 2018). Moreover, applying the theoretical lens of co-evolution to organizational change (Hodgson 2013) and the paradoxical perspective of ambidexterity (Papachroni et al. 2014) deepens the research and their relevance to organization science.

As to the strategic management discipline, examining digital innovation units as one strategic initiative of industrial-age incumbents to engage in digital innovation (Chanias et al. 2019; Jöhnk et al. 2022), the dissertation contributes to the timely and relevant topic of strategizing in digital times (Hess et al. 2020). By providing novel insights into this strategic initiative, this research supports and improves current coping strategies for digital challenges (Fischer et al. 2020), and by focusing on the performance implications of this strategic initiative, the dissertation offers measurable evidence of its benefits. Employing the lens of dynamic capabilities on firm success, it offers valuable knowledge of how digital innovation units might serve as the foundation (Ellström et al. 2021; Yeow et al. 2018b) for this strategy-related issue.

Lastly, business practitioners can benefit from this dissertation. First, it increases awareness and appreciation of the magnitude and nature of digital innovations' influence on established organizational forms. Second, managers should be able to identify and respond to the emergence of digital innovations and their inherent digital technologies and therefore be empowered to adjust their own organizing to participate in digital innovation. This work aims to clarify (1) ways to overcome current capability and organizational gaps by establishing digital innovation units, (2) tensions between emerging digital and established physical innovation processes and (3) mechanisms and approaches to manage the integration and evolution of digital innovation units to ensure their growth and impact. Therefore, it provides relevant metrics for measuring and managing the success of digital innovation units, greenfield and brownfield approaches for their development and evolution and concrete mechanisms for resolving physical–digital tensions and overcoming gaps between the old physical and the new digital worlds.

Table 2 summarizes the anticipated contributions and their distinct audiences.

Table 2 – Anticipated Contributions

Audience		Anticipated Contributions
Research	Information systems	(1) Insights into digital innovation and transformation and the increasing incorporation of digital technologies.
		(2) Insights into the nature of digital innovation and related tensions in industrial-age contexts.
		(3) Insights into digital innovation units serving as the foundation for digital innovation and manifestation of digital transformation.
	Organization science	(1) Insights into the organizational challenges and tensions nested in digital innovation in industrial-age contexts.
		(2) Insights into post-bureaucratic organizational alterations and novel hybrid forms of organizing.
	Strategic management	(1) Insights into digital innovation units as a strategic digital innovation initiative.
		(2) Insights into digital innovation units' performance implications and their ability to serve as foundation for dynamic capabilities.
Business practice		(1) Insights into organizational challenges in digitized times.
		(2) Insights into green- and brownfield approaches for establishing and managing digital innovation units.

II. Theoretical Background[2]

This dissertation emphasizes appropriate ways of organizing for digital innovation. It examines the establishment of digital innovation units as a strategic and organizational response of incumbents in industrial-age contexts to emerging digital innovations and technologies. This chapter addresses the theoretical underpinnings and pertinent research in order to provide a theoretical framework, particularly for the studies in Part B, by offering an overview of the fundamentals. It thus characterizes the transformation of organizational forms, digital innovation, determinants for digital innovation and digital innovation units. The chapter is partially based on previously published research, but every effort is made to minimize redundancy by emphasizing general concepts and topics rather than study-specific insights. Although the chapter provides a general overview of contemporary phenomena like digital transformation and digital innovation, it focuses mainly on topics related to the studies conducted and only briefly mentions relevant but unconsidered research streams, including for example other coping strategies for participating in digital innovation.

II.1 Transforming Organizational Forms

Organizational forms have been defined as "agreed upon or contracted mixes of coordination mechanisms" (Grandori 1997, p. 900), which describes demarcated forms with clear boundaries, like hierarchies, and interfirm relationships, like networks or alliances. Below, prominent archetypes of organizational forms are described to provide a general understanding of the definition applied and an overview of common transformational targets.

Bureaucratic organization – According to Weber's early description, this organizational form describes a centralistic and objectively structured archetype that follows strict rules and a clear hierarchy of tasks and roles, with decisions following centralistic and objectified guidelines executed by a central, vertical order (Weber 1947). The bureaucratic organizational form often represents the starting point for various organizational transformations (Schumm and Hanelt 2021).

Post-bureaucratic organization – This form is characterized as a decentralized archetype; examples are virtual teams or clusters (Fedorowicz and Konsynski 1992). The control mechanisms are more horizontal, distributed and task-specific (Lambert and

[2] Multiple sections are partly based on research papers that have been previously submitted by the author; detailed information on the papers is presented in Table 1.

Peppard 1993). Distinct varieties of post-bureaucratic organization are product- (Fiedler et al. 1996) and process-driven organizations (Seltsikas 1999). In contemporary studies, post-bureaucratic organizational forms in general are deemed to be more appropriate for digital innovation than their bureaucratic counterparts (Berente 2020; Verhoef et al. 2021).

Strategic alliances – These arise when individual organizations choose to associate on a specific topic in order to enhance their ability to act; another benefit of alliances is the increased opportunity for an organization to learn and thus adapt and evolve more quickly (Whitaker and Krishnan 2010). A sub-type is the formation of a joint venture, which is a particularly intensive, contractually bound kind of alliance (Finnegan and Longaigh 2002).

Networks – Network-like structures can be present within a single organization (Dremel et al. 2017; Lambert and Peppard 1993; Yeow et al. 2018a) or between different organizations (Adjerid et al. 2018; King 2013). Organizations in a network can act in a self-organized manner or in accordance with defined governance (Adjerid et al. 2018; King 2013).

Business Platform ecosystems – These arrangements prevail in a number of areas, such as the automotive (Dremel et al. 2017), telecommunications (Yoo et al. 2012), B2C platform market (Tan et al. 2019), entertainment (Tan et al. 2020) and video game sectors (Cennamo and Santaló 2019). The center of a platform ecosystem is typically an underlying digital platform technology on which an individual firm interacts with various complementors (Parker et al. 2017; Saadatmand et al. 2019). The resulting platform ecosystem has been described as a new organizational form (Parker et al. 2017; Saadatmand et al. 2019) and the contemporary peak of organizational transformation (Verhoef et al. 2021).

Hybrid forms of organizing – This archetype refers to a mixture of bureaucratic and post-bureaucratic organizational units (Kolbjørnsrud 2018). A further hybrid form, the matrix organization, has been described as a combination of a functional and product-oriented organization (Fiedler et al. 1996).

Organizational forms have undergone transformations in response to changing and even turbulent contexts for decades (Hsu and Hannan 2005). Thus, an organizational transformation has been defined as any "difference in form, quality, or state over time in an organizational entity" (Van de Ven and Poole 1995, p. 512), while a turbulent environment is characterized as a context of constantly changing customer requirements, emerging technologies and high competitiveness (Pavlou and El Sawy 2010). An early example of organizational transformation is the organizational change

in line with critical humanism, a countermovement to the emerging Taylorism that has led to various adaptations of organizational forms (Horkheimer and Adorno 1972; Marcuse 1955). Another example is the early transformational movement from mechanistic to organic organizational forms, which was identified early in the 1960s (Burns and Stalker 1961). The organization science literature describes organizational transformation as either episodic or continuous. The former is irregular, infrequent, inconsistent, fragmented and characterized by transitions from one static position to another, which is called punctuated equilibrium (Lyytinen and Newman 2008; Romanelli and Tushman 1994), while the latter is persistent, accumulating, dynamic and often recurs on a daily basis (Orlikowski 1996; Weick and Quinn 1999). A second commonly cited description of organizational transformation comes from Lewin (1947), who specifies the episodic view on transformation by providing a three-step concept of unfreezing – transforming – freezing. For decades, technology in general and IT systems in particular have been among the most impactful factors in transforming organizations (e.g., Crowston and Myers 2004; Gregory et al. 2015; Orlikowski 1996).

II.1.1 Information Systems and Organizational Transformation

The literature offers different approaches to delineating the term *information systems* (e.g., Boell and Cecez-Kecmanovic 2015; Orlikowski and Iacono 2001). First, the technical view emphasizes the use of technological artifacts such as computer hardware or software (Symons 1991). Second, the social view understands information systems as social systems (Land 1985). Third, the socio-technical view considers the social and technical components to be intertwined rather than parallel domains (Lee 2001). Robey et al. (2013) argue that this third view is most appropriate for analyzing organizational transformation and adaptation in the context of information systems (Robey et al. 2013), which have thus been defined "as an integrated and cooperating set of people, processes, software, and information technologies to support individual, organizational, or societal goals" (Watson et al. 2010, p. 24). This can be aligned with the general understanding of information systems research, which is aimed at investigating the interaction of (digital) technologies and human enterprises (e.g., Banker and Kaufman 2004; Gregor 2006; Grover and Lyytinen 2015).

Technology in general and IT systems in particular have been researched for decades as among the most influential factors in organizational transformation (e.g., Crowston and Myers 2004; Gregory et al. 2015; Orlikowski 1996). While management research has a long tradition of investigating organizational forms and their transformations (Puranam et al. 2014), it usually considers that transformation at a general level without examining the specific influence of information systems in detail. The management literature offers

comprehensive views of organizational transformation at the metal level (e.g., Powell 1987; Puranam et al. 2014) and in specific cases (e.g., Jansen et al. 2012). Information systems artifacts or components are often noted but mostly play a subordinate role, and there is no detailed consideration of their influence on organizational forms (e.g., Pedersen et al. 2019; Schilling and Steensma 2001). The information systems literature, by contrast, typically focuses squarely on the connections between specific information systems and organizational forms (e.g., Wessel et al. 2021), which are generally investigated with a narrow focus (e.g., Schallmo et al. 2020) and usually described in terms of a specific organizational form, such as bureaucracies (e.g., Stebbins et al. 1995), strategic alliances (e.g., Ravichandran and Giura 2019), networks (e.g., King 2013) or platform ecosystems (e.g., Cennamo and Santaló 2019).

As early as the 1950s, organizational transformations related to the influence of information systems were observed as a result of simplified communication possibilities (Leavitt 1958; Miles et al. 1978; Thompson and Bates 1957). Such transformations were further facilitated in the 1990s by the emergence of enterprise resource planning systems and the resulting simplification of information sharing, which altered work processes and instruction cascades and impacted the entire organizational structures (Crowston and Myers 2004; Orlikowski 1996). This IT-enabled organizational transformation has been called "a process that engenders a qualitatively different organization" (Besson and Rowe 2012, p. 103) and emphasizes the need for organizational transformation to align IT with business strategies (Brown and Magill 1994; Chan et al. 1997). Recent research has countered this alignment approach (Henderson and Venkatraman 1999) by stating that digital technologies increasingly shape and alter business strategies (Bharadwaj et al. 2013) and organizational forms (Yoo et al. 2012). The ongoing contemporary expansion of global digital networking and the pervasive adoption of digital technologies in nearly every activity have altered how organizational transformation is understood and explored (Hanelt et al. 2021a; Verhoef et al. 2021; Wessel et al. 2021). The contemporary digital paradigm creates a new context (Lyytinen 2022) for organizational transformation that is characterized by the impact of digital technologies (Hanelt et al. 2021b; Yoo et al. 2012), which have been defined as "combinations of information, computing, communication, and connectivity technologies" (Bharadwaj et al. 2013, p. 417). Examples are the so-called SMACIT technologies (social, mobile, analytics, cloud, and Internet of Things) that are regarded as both novel opportunities for and existential threats to industrial-age incumbents (Sebastian et al. 2017).

II.1.2 Organizational Transformation in Digital Times

The contemporary wave of (technology-related) organizational transformation has been called *digital transformation* (Hinings et al. 2018; Wessel et al. 2021) and defined as "organizational change that is triggered and shaped by the widespread diffusion of digital technologies" (Hanelt et al. 2021a, p. 1160). In recent years, the term has garnered an increasing amount of academic and media interest (Vial 2019). It is commonly used to refer to the disruptive effects and challenges of digital technologies on organizations in terms of strategy (Bharadwaj et al. 2013), business model (Lyytinen 2022; Verhoef et al. 2021), organizing (Yoo et al. 2012) and culture (Sia et al. 2016; Vey et al. 2017). Both research (Grover and Lyytinen 2022; Nagel 2020) and practice (BostonConsultingGroup 2020; McKinsey 2021) indicate that the COVID-19 increased the demand for and hastened the pace of digital transformation initiatives. One prominent example is Kodak's missed opportunity to transform digitally. Due to its middle managers, traditional and non-innovative culture and heavily bureaucratic organizational design, Kodak missed the opportunity to be at the forefront of the digital photography revolution (Lucas and Goh 2009).

Three frequently confused terms must be clarified in order to characterize digital transformation: *digitization*, *digitalization* and *digital transformation* (Legner et al. 2017; Verhoef et al. 2021). The first two are regarded as prerequisites for the third (Loebbecke and Picot 2015; Matt et al. 2015; Verhoef et al. 2021). Digitization is the technical process of converting various types of analog information into digital formats to enable the processing of digital information using pre-programmed instructions, whereas digitalization is the socio-technical process by which information technologies or digital technologies can be used to alter existing business processes that were formerly mediated by non-digital artifacts or relationships (Tilson et al. 2010; Yoo et al. 2010). Therefore, digitization is primarily concerned with converting internal and external documentation procedures to digital formats in order to save resources, time and costs but has no direct impact on value creation, whereas digitalization includes process improvements that could enhance user experiences and value creation (Verhoef et al. 2021). Building on these two incremental phases, digital transformation has been understood as a rather pervasive "change in how a firm employs digital technologies to develop a new digital business model that helps to create and appropriate more value for the firm" (Verhoef et al. 2021, p. 899). Consequently, this phenomenon affects and impacts diverse contexts and industries (e.g., Benner and Waldfogel 2020; Correani et al. 2020; Westerman et al. 2014) and multiple organizational dimensions, including strategies (Singh and Hess 2020), business models (Vial 2019), capabilities (Ellström et

al. 2021; Warner and Wäger 2019) and organizational forms (Hanelt et al. 2021a; Schumm and Hanelt 2021; Yoo et al. 2012).

In spite of ongoing debates and overlapping descriptions and definitions, research indicates that digital transformation is distinct from previous IT-enabled organizational transformations (Wessel et al. 2021). To clarify the descriptions, Wessel et al. (2021) break digital transformation down into two key-elements – *transformation activities* and *transformation outcomes*:

- In terms of transformation activities, digital transformation's value creation is driven and triggered by the (re)defining capabilities of digital technologies, while within IT-enabled organizational transformations, value creation is supported by digital technologies.
- In terms of transformation outcomes, digital transformation is characterized by the creation and establishment of a novel and digital organizational identity, while within IT-enabled organizational transformations, it is characterized by a re-enforcement of the existing organizational identity.

This distinction can be further related, first, to the technologies involved and, second, to the consequences of digital transformation (Hanelt et al. 2021a). The generative and combinatorial properties (Kallinikos et al. 2013), along with the boundary-spanning characteristics (Henfridsson and Lindgren 2010; Hund et al. 2021) and overarching and open infrastructures of contemporary digital technologies (Tilson et al. 2010), differ significantly from the technologies that were previously involved. These peculiarities of digital technologies have led to changing assumptions about their influence on the organization, such as changing from an enabling to a triggering role in transformation (Schumm and Hanelt 2021; Yoo 2010) and broadening the scope of transformation from an intra- to an inter-organizational view, including ecosystem-wide perspectives (Hanelt et al. 2021a; Schumm and Hanelt 2021). Specifically, the generativity and boundary-spanning implications of digital technologies (Henfridsson and Bygstad 2013; Hund et al. 2021; Yoo et al. 2010) seem to challenge longstanding beliefs and assumptions. This leads to the consequence of novel, digital business models, even in non-digital industries, and to the impeding need to participate in novel forms of digital innovation (e.g., Lucas and Goh 2009; Svahn et al. 2017; Yoo et al. 2012). Considering the recent turbulent and challenging context triggered by the widespread diffusion of digital technologies (El Sawy and Pereira 2013), researchers have argued that digital transformation propels organizations into a continuous state of change and reconfiguration with the purpose of successfully developing and supplying digital outcomes and preserving ongoing adaptability to digital requirements (Hanelt et al.

2021a). Therefore, firms transform in a co-evolutionary process with digital technologies toward more adequate organizational forms that are embedded in and triggered by their digital environment (Hanelt et al. 2021a).

II.1.3 (Co-)Evolutionary Perspective on Organizational Transformation

A (co-)evolutionary perspective is commonly employed to portray change, survival and growth in organizational development (Hodgson 2013; Van de Ven and Poole 1995) because it enables the investigation of ongoing processes of change and transformation within a competitive environment. Using the theory of evolution, important examples exhibit ongoing and cumulative organizational adaptation (Aldrich 2008; Hannan and Freeman 1977; Van de Ven and Poole 1995). This theory incorporates the Darwinian evolutionary triplet of variation, selection and retention (Hodgson 2013). In the context of organizational transformation and change, the Darwinian triplet can be defined as follows. Variation is the emergence of a new and distinct form of organizational characteristics (Van de Ven and Poole 1995), whether randomly (Aldrich 2008) or (in contrast to the biological role model) actively and intentionally (Hodgson 2013). Selection refers to the process of evaluating and selecting the most suitable variant in light of limited resources and the immediate environment (Hannan and Freeman 1977; Van de Ven and Poole 1995). Retention refers to the assimilation and preservation of previously selected variants and constituting a distribution of the *new* throughout an organization (Hodgson 2013; Van de Ven and Poole 1995). On an organizational level, this conceptual lens of general Darwinism is applicable to observing a population of entities undergoing a continual cycle of transformation under the pressure of environmental adaptation (Winter and Nelson 1982). It is commonly used to characterize survival and growth in challenging environments, as Abatecola et al. (2016) explain in a special journal issue on Darwinism, organizational evolution and survival. However, this is an ongoing and iterative process, which Darwin himself noted: “as natural selection acts solely by accumulating slight, successive, favorable variations, it can produce no great or sudden modifications; it can act only by short and slow steps" (Darwin 1936, p. 361). Romanelli and Tushman (1985) concretize this procedural perspective and argue for a punctuated equilibrium within an evolutionary transformation, which consists of relatively long periods of convergence, with or without only minor notions of change, and, punctuated short phases of strategic re-organization that re-create the existing organization (Romanelli and Tushman 1994).

The concept of co-evolution emerged from the idea of evolution (Kauffman 1993) and is based on the assumption that interactions do not follow simple root cause approaches

but rather lead to more complex, multidimensional interactions (Benbya and McKelvey 2006). This assumption can be drawn from biological studies of transformation and evolution (Kauffman 1993) and follows the view that "the true and stunning success of biology reflects the fact that organisms do not merely evolve, they coevolve both with other organisms and with a changing abiotic environment" (Kaufmann 1993, p. 237). The idea of co-evolution has been applied to other disciplines, including organizational science and information systems (Benbya and McKelvey 2006). This can involve the co-evolutionary consideration of organizational forms and information systems (Peppard and Campbell 2014). The fundamental work of co-evolution of information systems and organizational forms was produced by Lewin and colleagues, who indicate "that firm strategic and organizational adaptations coevolve with changes in the environment (competitive dynamics, technological, and institutional) and organization population and forms" (Lewin et al. 1999, p. 535). Their study indicates how organizational forms change in co-evolution with the environment in general and also identifies the link to information systems in detail and underlines their specific role as an enabler of new organizational forms (Lewin et al. 1999).

The co-evolutionary perspective on information systems research is particularly suitable and relevant, as summarized by Agarwal and Sambamurthy (2006): "The strategic role of information technology is to enable innovative business strategies and processes. In the past, information technology executives have focused on aligning their function with the business. But alignment can be too static for today's fast pace. A better goal is 'co-evolution'" (Agarwal and Sambamurthy 2008, p. 6). Montealegre and colleagues propose that co-evolution in the organizational adaptation context consists of six properties (Montealegre et al. 2014):

1) A multilevel perspective that considers the relations between different actors (Lewin and Volberda 1999).
2) The impacts that emerge from multidirectional and partly contradictory causalities lead to continuous, reciprocal changes (Kauffman 1993; Vessey and Ward 2013).
3) The non-linear impacts of change are not amenable to a basic cause-and-effect logic but instead relate to complex interactions (Anderson 1999; Guastello 2013).
4) Interactions involving recursive relations that result in reciprocal and dynamic interdependencies and circular causality (Lewin and Volberda 1999; Rodrigues and Child 2003).

5) A path- and history-dependent adaptation process (Calori et al. 1997; Kieser 1989) that influences co-evolving transformations and their results (Koza and Lewin 1999).
6) Adaptation principles that develop from interactions between (contractionary) individuals and autonomous areas (Vidgen and Wang 2009) .

Sia et al. (2016) provide a recent example of co-evolutionary transformation in banking, analyzing the impact of digital technologies and digital platforms on an established industry.

In addition, research portrays the current digital transformation as a co-evolution between organizations and emerging digital technologies (Hanelt et al. 2021a), in which intra-organizational adaptations are paired with an external perspective on digital innovation and their inherent digital technologies (Rai and Tang 2014; Tiwana et al. 2010).

II.2 Digital Innovation

Digital innovation has been defined "as the creation of [and consequent change in] market offerings, business processes, or models that result from the use of digital technology" (Nambisan et al. 2017, p. 224). Digital technologies and their characteristics are the foundation of most research on digital innovation (Nambisan et al. 2017; Yoo et al. 2010). Hence, digital innovation builds on a solid linkage to digital technologies (Nambisan et al. 2019) and their embedded digital objects (Faulkner and Runde, 2019). The conceptualization offered by Hund et al. (2021) suggests three perspectives: (1) the technical perspective is covered by the digital object, (2) the social-technical perspective is considered by digital technologies and (3) the socially constructed, value-adding perspective is presented by digital innovation (see Figure 4, adapted from Hund et al. 2021, p. 5). Consequently, digital innovation outcomes inherently entail digital technologies (Hund et al. 2021; Nambisan et al. 2019).

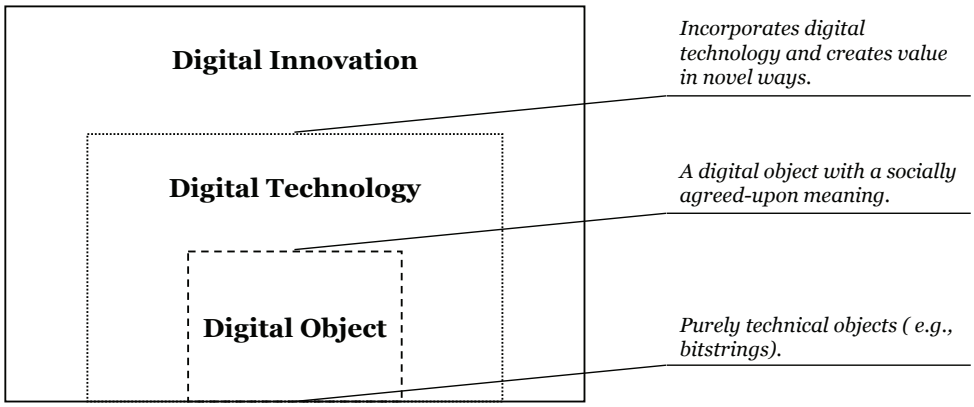


Figure 4 – Three-Layer Concept of Digital Innovation
(adapted from Hund et al. 2021, p. 5)

Since Nambisan et al. (2017, p. 223) state that digital innovation "is the use of digital technology during the process of innovating", digital innovation's key characteristics are strongly influenced by the nature of digital technologies and have been described as *reprogrammability*, *homogenization of data* and *self-referentiality* (Yoo et al. 2010):

- Reprogrammability: Unlike analog technologies, digital technologies can be manipulated with new instructions, allowing them to perform a diverse array of

functions in a flexible manner. Thus, reprogrammability enables multiple functions in one digital device.

- Homogenization: Digital technologies can be reduced to binary digits, which results in the homogenization of all accessible data on a digital device and enables the combination of data from disparate sources. Thus, homogenization enables the separation of content from the medium in which it is obtained.
- Self-referentiality: Digital technologies enable the innovation and creation of new digital technologies and have a favorable impact on their dissemination and availability. Thus, self-referentiality democratizes the ways in which (digital) innovation occurs.

Building on the nature of these key characteristics, digital technologies have been deemed to change the very nature of innovation (Berente 2020). On the one hand, their impact accelerates the rate at which innovation occurs; on the other, they have a significant impact on how value is created (Huang et al. 2022), business models are constructed (Lyytinen 2022), and (traditional) products are designed (Hylving and Schultze 2020). The increasing prevalence of digital innovations and their capacity to create a profound connection between social actors and digital technologies to create novel value (Sandberg et al. 2020; Wang 2021) has led researchers to conclude that obtaining competitive advantage without embracing digital innovation appears to be impossible in today's business environment (Nambisan et al. 2017; Yoo et al. 2012).

Research describes flexible and agile digital ventures as at the forefront of this novel form of value creation, since they can leverage digital technologies successfully and swiftly (Huang et al. 2017). Consequently, they are infiltrating existing competitive environments or are creating new ones that supersede previously dominant ones (Skog et al. 2018). These digital ventures have been deemed to be able to rapidly test new business models, scale successful concepts up to the global level and equipped with the organizational prerequisites to participate in digital innovation (Kelestyn et al. 2017). Successful born digital ventures like the well-known pioneers Amazon, Facebook (Meta) and Google (Alphabet) built explicitly on digital technologies and provide impressive instances of digital inventiveness, having grown to become the world's leading companies, which are continually disrupting established firms and even entire industries (Sebastian et al. 2020). Consequently, inactivity regarding digital innovation exposes firms to the risk of losing customers, market share and reputation to emerging digital ventures (Gregory et al. 2018) that are inherently built on digital technologies (Huang et al. 2017).

II.2.1 Digital Innovation Implications

Digital innovation has substantially changed the nature of innovation and thus the design and creation of digital offerings, products and services (Nambisan et al. 2017; Nambisan et al. 2020). This includes the introduction of a) completely novel business models and possibilities of creating value (Lyytinen 2022), such as the introduction of social media ecosystems (Tan et al. 2020), b) the modification of existing business models and industries (Seo 2017), such as the digitalization of the photography industry (Lucas and Goh 2009) and c) the introduction of digitally induced and enhanced physical products to enable connected and customized products (Porter and Heppelmann 2014), such as connected cars (Hylving and Schultze 2020).

Moreover, like the outcomes, the production processes of digital innovations are considered less structured and bounded (Nambisan et al. 2020), resulting in a more dispersed and heterogeneous field of included and impacted actors in the production of digital innovations (Lyytinen et al. 2016; Yoo et al. 2012). Traditional organizational and industrial boundaries are challenged since digital innovation involves "actively selecting resources of an offering and configuring them with other resources, or even rethinking their usages and purposes" (Henfridsson et al. 2018, p. 91). Further, digital innovations have been deemed to imply a certain generativity (Yoo et al. 2012), meaning "a technology's overall capacity to produce unprompted change driven by large, varied, and uncoordinated audiences" (Zittrain 2006, p. 1980).

These factors have a powerful impact on organizations, industries and social life that can be described by two overarching implications (Hund et al. 2021): the blurring of existing boundaries such that barriers between previously discrete entities are increasingly bridged (e.g., Henfridsson et al. 2018), and the convergence of two fields, meaning two previously discrete entities are combined (Yoo et al. 2012).

Research has examined the various dimensions in which digital innovation contributes to blurring existing boundaries (Hund et al. 2021). (1) With products, blurring boundaries can be exemplified by digital add-ons, like specific apps, that enlarge the functional portfolio of a device and can transform a digital product into a platform for more products (Lusch et al. 2010; Ng and Wakenshaw 2017; Yoo et al. 2010). (2) In terms of roles, blurring boundaries is evinced by the increasing interference of the distinction between private and professional life as a result of digital connections between personal and professional actors (Belk 2013) or the utilization of one digital device for private and professional life (Matt et al. 2019). (3) Organizational boundaries blur as a result of the diffusion of digital innovations, as digital technologies enable intra- and interorganizational actors to collaborate inside an innovation network (Tilson et al.

2010); this often occurs without the control of a single organization (Lyytinen et al. 2016). (4) The blurring of industrial boundaries is demonstrated by the entry of novel digital ventures into traditional industries, which muddies previously clear distinctions by enabling the joint production of digital outcomes (Porter and Heppelmann 2014).

In addition, four dimensions are described when digital innovation results in the convergence of previously separated entities (Hund et al. 2021). (1) Digital innovation can result in the convergence of digital and physical components (Yoo et al. 2010), which refers to the incorporation of digital technologies into existing physical products to create smart products like connected cars (Bohnsack et al. 2021). (2) This can lead to the convergence of devices, in which digital technologies enable the connection between two formerly separate devices (Tilson et al. 2010), such as the incorporation of a tablet into a manufacturing system serving as a control and demand device. (3) Digital innovation promotes user experience convergence (Yoo et al. 2012), which has ramifications for how different users acquire and employ the same digital device in diverse ways (e.g., Han et al. 2009; Ordanini and Nunes 2016). (4) The convergence of industries is driven by digital advances that are used across industrial boundaries, allowing for exchange and interaction across traditionally separated areas (Pershina et al. 2019; Yoo et al. 2012). It results in competition between formerly discrete organizations that continue to rely on unique industrial preconditions, such as resources and regulations (Hund et al. 2021), but now operate in merged and overlapping contexts; examples are the automotive and transportation sectors.

These implications that emerge from the nature of digital innovation and their inherent digital technologies result in fundamental pressures on existing and traditionally established forms of organizing, industries and social life (Drechsler et al. 2020; Gregory et al. 2015; Yoo et al. 2012). Consequently, pre-digital born organizations in industrial-age contexts are especially challenged to adapt to digital times (Sebastian et al. 2020; Wessel et al. 2021).

II.2.2 Digital Innovation in Industrial-Age Incumbents

Digital innovation has been deemed a key factor in value creation (Nambisan et al. 2020). This holds true not only for actors in the information technology or service sectors, but also for incumbent firms in industrial-age contexts (Hylving and Schultze 2020). Whereas born-digital organizations explicitly build their growth on digital innovation (Huang et al. 2017), this process is considered especially challenging for industrial-age incumbents (e.g., Hanelt et al. 2021b; Piccinini et al. 2015), which are defined as those in traditional industries that were established before the digital

revolution and have a business model that is intentionally not based on digital technologies (Metzler and Muntermann 2020). Since industrial-age incumbents are built on rich traditions of predefined, incremental innovation in a physical product environment (Hylving and Schultze 2020), their urgency for change is higher when it comes to enabling the creation of digital innovations. Different by nature, digital innovation follows an evolving and reprogrammable architecture (Yoo 2010) and remains flexible during the process of innovation (Henfridsson et al. 2014), whereas traditional, physical innovation requires solid pre-specifications and defined attributes (Baldwin et al. 2000; Hylving et al. 2012). Therefore, industrial-age incumbents confront greater challenges to engage in digital innovation (e.g., Dremel et al. 2017; Svahn et al. 2017), since they draw on "a strong hardware legacy, where development processes and organizational structures are typically adjusted and reflected in the physical product, i.e., the car" (Hylving and Selander 2012, p. 2) and rely on a conventional notion that digital technologies serve as instrumental components; that is, they play a supporting role (e.g., Porter and Millar 1985; Tumbas et al. 2017a). Industrial-age incumbents frequently lack appropriate forms of organizing and digital capabilities to adapt quickly to rapidly changing and iterative digital innovation requirements (Svahn et al. 2017; Yoo et al. 2012).

In sum, research has found that industrial-age incumbents need novel forms of organizing for digital innovation (Lyytinen et al. 2016; Majchrzak and Griffith 2020; Wang 2021) and lack important (digital) capabilities to engage in digital innovation (Sambamurthy et al. 2003; Yoo et al. 2012), owing to the overall transition toward increasingly dispersed innovation activities (Lakhani and Panetta 2007) across innovation networks and ecosystems (Gawer and Cusumano 2014; Wang 2021). Therefore, they urgently need to find a way to develop appropriate forms of organizing (Lyytinen et al. 2016; Yoo et al. 2012) and digital capabilities (Warner and Wäger 2019; Wiesböck and Hess 2020) to enable change in their traditional innovation processes and engage in digital innovation (Nambisan et al. 2017).

II.2.3 Modular-Layered Product Architecture

In industrial-age contexts, digital innovation has been characterized as "the carrying out of new combinations of digital and physical components to produce novel products" (Yoo et al. 2010, p. 725). By integrating digital technologies into physical products and services, digital innovation creates a layered modular architecture that incorporates "four loosely coupled layers of devices, networks, services, and contents created by digital technology" (Yoo et al. 2010, p. 724). In the production of digitally infused physical products like connected cars (Bohnsack et al. 2021; Svahn et al. 2017), physical

components and digital product components must be combined to create novel value (Hylving and Schultze 2020; Yoo et al. 2010). In this regard, Stonig et al. (2022, p. 1953) argue that "established products become part of integrated value propositions."

Yoo et al. (2010) propose four layers in their architectural theory – the device, network, service and content layers – that are currently adopted by a wide range of products, including smartphones, automobiles and automated systems (Lyytinen 2022). The device layer represents the physical basis; as the relatively stable bottom of the stack (Henfridsson et al. 2014), it can create the initial platform (Hylving and Schultze 2020) that is the key enabler of generativity (Zittrain 2006) on which physical and digital components can be merged to create novel (digital) value (Henfridsson et al. 2014). The network layer connects the physical layer with the service and content layers (Yoo et al. 2010), which are the digital components of this modular-layered product architecture and exhibit the characteristics of reprogrammability, homogenization of data and self-referentiality detailed above (Yoo et al. 2010). Figure 5 presents a general version of this modular-layered architecture.

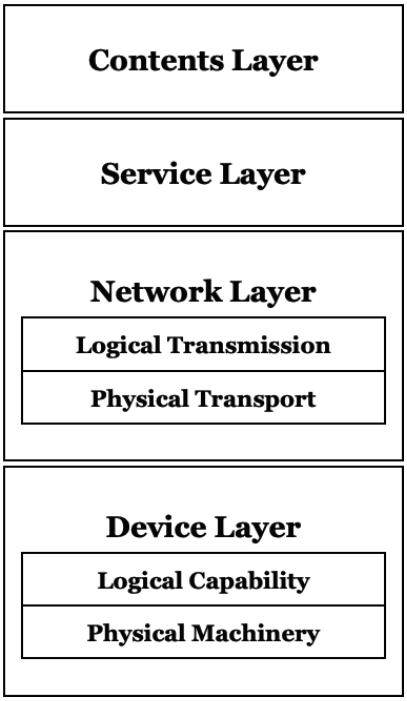


Figure 5 – Modular-Layered Product Architecture
(adapted from Yoo et al. 2010, p. 727)

Since each layer can be developed independently and without any concrete knowledge of the end product (Yoo et al. 2010), the modular-layered architecture enables a decoupling of form from function (Zittrain 2006) and a *procrastinated binding* (Yoo et al. 2012).

Yoo et al. (2010) describe the ongoing development of physical architecture toward a more integrated and modular-layered one as critical to firm success. Additionally, they explain separations between traditional modular and layered modular architecture, which are based on the characteristics of digital innovations; namely, reprogrammability, homogenization of data and self-reference. Table 3 summarizes these differences.

Table 3 – Product Architectures

(Yoo et al. 2010)

Modular Architecture	**Modular-Layered Architecture**
Predefined and non-changeable product boundaries and meanings.	*Adaptable and malleable product boundaries and meanings.*
Defined and fixed components following a single design hierarchy.	*Reconfigurable and heterogenous components following multiple design hierarchies.*
Product-specific components.	*Product-agnostic components.*
Designed using product-specific and predefined knowledge.	*Designed based on heterogenous actors connected through shared standards.*

However, in addition to providing additional digital value to physical products, digital innovation in industrial-age incumbents entails considerable tensions in the merging of physical and digital components (Hanelt et al. 2021b; Hylving and Schultze 2020). Nested in the differences displayed in Table 3, distinct contradictions beyond the product perspective emerge. Physical components are constructed in a fairly static and hierarchical architecture and require solid pre-specifications and defined attributes before production begins (Baldwin et al. 2000), while digital components follow an iterative, evolving and reprogrammable functional logic and architecture (Yoo 2010) that remains flexible throughout the innovation process (Henfridsson et al. 2014). Research indicates “that developing this architectural prerequisite of digital innovation is fraught with tensions and conflicts” (Hylving and Schultze 2020, p. 2), as was observed in a study on the implementation of sensor and connectivity platforms in automobiles (Hylving and Schultze 2020, p. 2). Analyzing another instance, Volvo's connected car initiative, Svahn et al. (2017) theorize that similar tensions, which they

call competing concerns, emerge when distinct, contradictory elements that nevertheless belong together must be combined during the digital innovation process (Svahn et al. 2017; Yoo et al. 2010). Although decoupled, the two layers are connected (Yoo et al. 2010), leading scholars to assert that "a pervasive cause of [...] tensions and conflicts is inherent in the hybrid architecture" (Hylving and Schultze 2020, p. 2); these have also been called physical–digital paradoxes (Piccinini et al. 2015). These paradoxical tensions embedded in product architecture can also emerge at the organizational level (Toutaoui et al. 2022; Viljoen et al. 2022; Wimelius et al. 2021), as the organizational governance of manufacturing physical items is fairly hierarchical and sequential, while digital products impose more networked and loosely coupled organizational structures (Hanelt et al. 2021b). Researchers contend that paradoxical tensions are located and embedded in digital artifacts (Ciriello et al. 2018) and digital infrastructures (Lyytinen et al. 2017; Tilson and Lyytinen 2021). Due to the need to integrate, coordinate and merge two distinct logics organizationally, a number of organizational conflicts arise on several levels (Hylving and Schultze 2020; Svahn et al. 2017), resulting in intraorganizational paradoxical tensions (Svahn et al. 2017; Toutaoui et al. 2022).

Consequently, in addition to developing distinct determinants for digital innovation, an incumbent firm's pre-digital and physical product environment requires a specific applicability and integration of novel capabilities and digital outcomes (Piccinini et al. 2015; Svahn et al. 2017). This process of interwoven digital and physical innovation (Hylving and Schultze 2020; Yoo et al. 2010) necessitates aligning organizing for digital and non-digital innovation (Keller et al. 2022).

II.3 Determinants for Digital Innovation

In addition to the characteristics, implications and peculiarities of digital innovations discussed above, it is necessary to consider the underlying strategic, organizational and capability prerequisites and determinants (Hund et al. 2021). Digital ventures can provide valuable insights to define these prerequisites and determinants since they are characterized by the ability to (1) digitally innovate with nearly no effort (Tumbas et al. 2017a), (2) disrupt existing business models and industries through their digital outcomes (Skog et al. 2018) and (3) build their own rapid growth on digital innovations (Huang et al. 2017).

One prominent example (Huang et al. 2017) provides detailed insights into the inner workings of digital ventures and describes three distinct mechanisms for their successful rapid growth:

- Data-driven Operations: The ability to constantly analyze significant amounts of information to enable data-based activities in terms of decision making, framing, risk evaluation and monitoring.
- Instant Releases: The ability to reduce timely delays between innovating and deploying a novel function while constantly testing and evaluating existing ones.
- Swift Transformations: The ability to accelerate the organizational contextualization of novel digital technologies while minimizing the efforts and challenges of redefining one's identity.

These ongoing, iterative and intimately connected mechanisms can be enhanced by a certain notion of specialization in repeating internal processes (Tumbas et al. 2017b), along with a distinct kind of standardization known as templating (Huang et al. 2022) (see Figure 6).

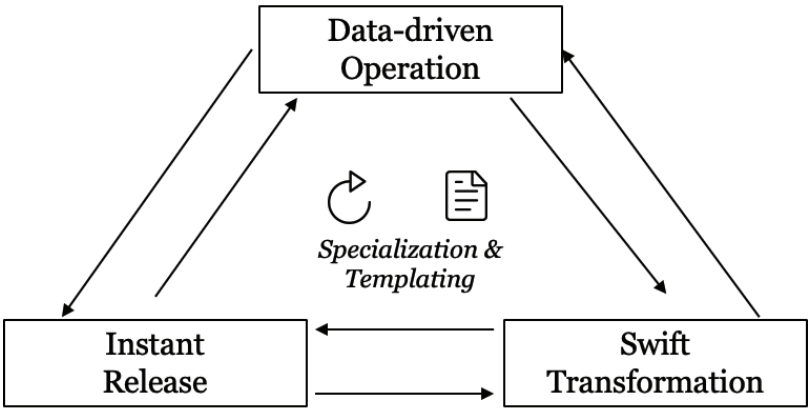


Figure 6 – Inner Workings of Digital Ventures
(adapted from Huang et al. 2017, Huang et al. 2022, Tumbas et al., 2017b)

To enable similar internal operations that serve as digital innovation determinants, industrial-age incumbent firms face gaps regarding

- an appropriate digital strategy, that builds on (Sia et al. 2016) and/or enables data-driven operations (Bharadwaj et al. 2013),
- the dynamic and digital capabilities needed to respond rapidly to a changing environment (Teece et al. 2016), enabling the instant release of novel outcomes to adjust to shifting environmental requirements (Ellström et al. 2021)
- and an appropriate and malleable organizational form (Hanelt et al. 2021a) and adaptive culture (Gurbaxani and Dunkle 2019) to enable swift transformations.

II.3.1 Strategizing in Digital Times

Digital innovation entails distinct strategic concerns and foundations (Berente 2020; Bharadwaj et al. 2013; El Sawy and Pereira 2013; Matt et al. 2015), notably the consideration of two distinct strategic dimensions: strategies *from* digital technologies and strategies *for* digital technologies. First, with the widespread adoption of digital technologies and significant growth of accessible and analyzable data, digital innovation strategies and strategic decisions should evaluate and build on digital insights (Sia et al. 2016), as with decisions based on big data or data-driven operations (Huang et al. 2017). This demands a shift from hierarchical decision making to the strategic consideration of internal and external knowledge (Henfridsson and Bygstad 2013; Vega and Chiasson

2019). Consequently, strategic decisions must embrace and consider digital data to capitalize on rapidly emerging digital opportunities while constantly minimizing the potential risks of executing these strategies (Sebastian et al. 2017). Second, this leads to strategies for digital technologies (Klopper et al. 2022), which are defined as "organizational strategies formulated and executed by leveraging digital resources to create differential value" (Bharadwaj et al. 2013, p. 472) and prepare organizations to consider novel forms of digital value creation (Chanias et al. 2019).

Consequently, strategies in the digital age must understand digital innovation (Yoo et al. 2010) and should simultaneously focus on digital innovation-related goals and objectives (El Sawy et al. 2010) to prioritize and capitalize on digitized solutions (Sebastian et al. 2017). Therefore, digital strategies must formulate pathways to transform the existing business model while considering insights from digital data (Matt et al. 2015). In addition, digital-centric strategies must account for the main characteristics of digital innovations and their inherent digital technologies (Nylén and Holmström 2015), such as blurring and converging boundaries (Hund et al. 2021) and generativity (Yoo et al. 2010).

Industrial-age incumbents have engaged in several strategies to enable and participate in digital innovation (Fabian et al. 2022; Jöhnk et al. 2022). The literature reports on a variety of strategic initiatives, such as investments in digital mergers and acquisitions (Hanelt et al. 2021b), forging external digital partnerships (Chanias et al. 2019) and recruiting digital talents (Ciriello and Richter 2015). Academia, like practice, has found the internal establishment of dedicated digital innovation units to be a viable, strategic digital innovation initiative (e.g., Jöhnk et al. 2022; Lau et al. 2021).

II.3.2 Organizational and Cultural Determinants for Digital Innovation

In addition to strategic considerations for digital innovation, research indicates the need for novel organizational structures (Lyytinen et al. 2016; Majchrzak and Griffith 2020; Wang 2021), such as "a new organizational form that departs dramatically from traditional industrial production" (Berente, 2020, p. 92) to account for the heterogeneous and decentralized aspects of digital innovation (Gawer and Cusumano 2014; Lyytinen et al. 2016). According to Huang et al. (2017), flexible, adaptable and agile organizational structures are preferable to facilitate swift transformation, which is essential to growth and success in digital innovation (Hanelt et al. 2021a). In considering digital innovation's distributed agencies (Lakhani and Panetta 2007), researchers have referred to the setup of more distributed and interorganizational structures such as

networks or ecosystems (Gawer and Cusumano 2014; Wang 2021). Examples include inviting external actors or customers (Eaton et al. 2015; Parmentier and Mangematin 2014) or crowds and networks (Boons and Stam 2019; Eiteneyer et al. 2019) to share knowledge and competencies, which opens organizational boundaries and necessitates decentralized internal structures (Lyytinen et al. 2016). Another, largely intraorganizational option is to establish separate and independent entities or business units that are distinct from the firm's headquarters to allow for experimentation and rapid learning while reducing the risk of cannibalization and intra-organizational conflicts (Verhoef et al. 2021). Given their bureaucracy, which hampers responsiveness and innovation, traditional and often hierarchical organizations with several administrative levels and a strong top-down orientation are no longer feasible in rapidly changing and turbulent digital environments (Verhoef et al. 2021). Consequently, incumbents in industrial-age contexts are under pressure to transform due to their generally hierarchical, centralized and homogeneous organizational setups (Hanelt et al. 2021b).

In addition, digital innovation necessitates a novel understanding and appreciation of organizational identity and culture; that is, the shared values, norms and beliefs inside an organization (Lokuge et al. 2019). Both are considered essential for the open and adaptable interaction with and use of digital technologies (Huang et al. 2017; Sandberg et al. 2020). When organizations evaluate digital potentials through the established lens of their traditional (pre-digital) identities, they may overlook critical digital opportunities (Tripsas 2009). Hence, an organization's identity has to change to enable and activate the use of digital technologies, but this process is typically associated with inertia (Haskamp et al. 2021c; Keller et al. 2022) and organizational resistance (Hylving and Schultze 2020). Organizational culture influences the boundaries and pace of knowledge diffusion (Ferlie et al. 2005) and decision making (Lucas and Goh 2009). A digital culture can therefore promote digital innovation (Magnusson et al. 2020) and is "characterized by lower risk adversity [*sic*], a stronger focus on experiments, and talent development to support digital initiatives" (Hund et al. 2021, p. 11). A traditional, pre-digital identity and bureaucratic culture can pose considerable obstacles and pitfalls in the path of digital innovation (Hylving and Schultze 2020; Piccinini et al. 2015; Svahn et al. 2017).

II.3.3 Dynamic and Digital Capabilities

To build and sustain competitive advantage in the digital era, a solid foundation of digital capabilities is necessary (Yoo et al. 2012), which must be compatible with the new logics underlying digital technologies (Hund et al. 2021). Organizations urgently need to find

ways to develop digital capabilities (Warner and Wäger 2019; Wiesböck and Hess 2020), because they play an important role in digital innovation (Holmström et al. 2021; Nambisan et al. 2017; Tumbas et al. 2017b). Digital capabilities "allow organizations to use digital resources for innovation purposes" (Wiesböck and Hess 2020, p. 80) and serve as a vital foundation to evolve and grow in challenging digital environments (Warner and Wäger 2019; Wiesböck and Hess 2020). Since they are deemed important for survival in a digital environment (Nguyen et al. 2019), their incorporation is influential and an advantageous building block for various digital innovation determinants and prerequisites (Keller et al. 2022), including creating digital knowledge (Dremel et al. 2017), facilitating adaptable organizational structures (Henfridsson et al. 2009) and enabling an agile and open mindset (Lucas and Goh 2009). Consequently, incorporating digital capabilities into an organization implicates its structure, procedures and overall culture and can pave the way for digital innovation (Svahn et al. 2017; Yoo et al. 2012). Hence, it is especially important for industrial-age incumbents to build digital capabilities (Warner and Wäger 2019; Wiesböck and Hess 2020) to enable a shift from their traditional innovation approaches to participating in digital innovation (Nambisan et al. 2017).

Karimi and Walter (2015) point out that building digital capabilities requires dynamic capabilities that foster the creation and modification of ordinary (daily-business) capabilities (Teece 2007). Dynamic capabilities are defined "as the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments" (Teece et al. 1997, p. 516); they are the fundamental criteria that determine whether a business can survive or thrive in an era of growing digital challenges, turbulence and pressure (Ellström et al. 2021) and incorporate the capacity to "innovate, adapt to change, and create change that is favorable to customers and unfavorable to competitors" (Teece et al. 2016, p. 18). The three key elements of sensing, seizing and transforming (Teece 2007) are used, respectively, to identify novel digital opportunities (Helfat and Raubitschek 2018), to select and execute them (Teece 2018) and to align and enhance existing business models and capabilities with new ones (Soluk and Kammerlander 2021; Teece 2018). Research outlines the need for organizational foundations to build and realize dynamic capabilities, which should be internally incorporated, not bought, to enable an intrinsic link to the firm's strategy and activities (Teece 2018).

Additionally, dynamic capabilities are said to be closely linked to the concepts of organizational ambidexterity (O'Reilly III and Tushman 2008) and agility (Lee et al. 2015; Sambamurthy et al. 2003). Prior research has defined ambidexterity as the organizational capacity to simultaneously pursue divergent goals (Gibson and

Birkinshaw 2004). According to separation-oriented ambidexterity research, structural, contextual or temporal distinctions and segregation are effective for achieving ambidexterity (O'Reilly and Tushman 2013). Further, recent studies have embraced a second perspective on ambidexterity, which goes beyond separation-based perspectives and focuses on transcendence and synthesis rather than segregation to simultaneously handle two opposing poles (Andriopoulos and Lewis 2009; Danneels and Viaene 2022; Papachroni et al. 2014). Agility, another organizational capability, "is the ability to detect opportunities for innovation and seize those competitive market opportunities by assembling requisite assets, knowledge, and relationships with speed and surprise" (Sambamurthy et al. 2003, p. 245). The emergence of both ambidexterity and agility is closely tied to dynamic capabilities (O'Reilly III and Tushman 2008; Teece 2014) and is advantageous for digital innovation (Chan et al. 2019; Magnusson et al. 2020). Although other capabilities have been associated with the framework of dynamic capabilities (Warner and Wäger 2019), they are not further considered here, since this dissertation focuses primarily on the concepts of the three key elements of dynamic capabilities, digital capabilities, ambidexterity, and, more indirectly, agility.

Summarizing, digital innovation necessitates multiple determinants: an adjustment of strategic considerations, an organizational structure and culture aligned with these new digital strategies, and the development of novel capabilities, including a basis for building them.

II.4 Synthesis: Digital Innovation Units as Strategic Initiative to Alter Organizing for Digital Innovation

Facing the need for digital innovation determinants, industrial-age incumbents establish strategic initiatives (Chanias et al. 2019; Jöhnk et al. 2022; Keller et al. 2022). One prominent example is the establishment of specialized organizational entities known as digital innovation units (e.g., Jöhnk et al. 2022; Svahn et al. 2017). In contrast to other digital innovation initiatives such as the formation of external digital alliances (Chanias et al. 2019), cooperation with external ventures (Islam et al. 2016) or investments in digital mergers and acquisition (Hanelt et al. 2021b), digital innovation units involve a firm's creation and development of idiosyncratic digital capabilities (Svahn et al. 2017). Internal capability sourcing is presumed to be advantageous since it can consider the existing (pre-digital) environment (Keller et al. 2022; Teece 2007). Additionally, in contrast to other initiatives, digital innovation units, as distinct organizational units, are structural alterations of the main organization and therefore direct manifestations of a firm's digital transformation endeavors (Hanelt et al. 2021a).

Digital innovation units are a timely topic in information systems research, but scholarly inquiry into them remains in its infancy (Holotiuk and Beimborn 2019; Raabe et al. 2021). They have been defined "as autonomous entities that aid their respective main organization in the development of digital capabilities and in the search for and creation of new digital products, services, and processes" (Schumm et al. 2022, p. 1). Digital innovation units are a vital initiative for digital innovation and digital transformation endeavors (e.g., Jöhnk et al. 2022; Raabe et al. 2020a; Svahn et al. 2017), since they are inherently built on digital capabilities (Hellmich et al. 2021), produce novel digital outcomes (Svahn et al. 2017) and can aid in the execution of digital transformation endeavors (Chanias et al. 2019).

Digital innovation units have been demonstrated to be important to carry out digital research and development (Dremel et al. 2017; Svahn et al. 2017), to enable the implementation of digital transformation strategies (Chanias et al. 2019), to overcome digital transformation inertia (Haskamp et al. 2021c) and to enable organizational hybridity (Schumm and Hanelt 2021). Their purpose includes the internal generation of digital services or products (Barthel et al. 2020; Fuchs et al. 2019) like automotive clouds and infotainment apps (Svahn et al. 2017). Their activities focus inherently on digital or digital-influenced objectives (e.g., Raabe et al. 2020a), which distinguishes this phenomenon from those discussed in other research streams, such as studies of new business incubators (e.g., Gassmann and Becker 2006). While different archetypes of digital innovation units may have distinct attributes, they all share an emphasis on digital technologies at their core (Fuchs et al. 2019; Raabe et al. 2020a). Digital innovation units are characterized as flexibly and creatively (Barthel et al. 2020), focused on the context of digital innovation and digital transformation (Raabe et al. 2020a) by using agile practices (Haskamp et al. 2021d) and adopting a close orientation toward customers (Holotiuk and Beimborn 2019).

By creating and providing novel digital products or services and acting as a potential foundation for novel capabilities (Hellmich et al. 2021), digital innovation units' outcomes offer beneficial ramifications for the main organization (Holotiuk and Beimborn 2019; Raabe et al. 2021). Research regards the creation and integration of novel digital offerings into an existing product landscape as advantageous for gaining new customers and market share (Gregory et al. 2018), which can lead to an improvement in financial performance (Hanelt et al. 2021b). Therefore, the beneficial impact of digital innovation units' outcomes appears to rise over time as they become more established, which accelerates their efficacy and internal acceptance (e.g., Chanias et al. 2019; Dremel et al. 2017; Svahn et al. 2017).

In sum, establishing digital innovation units as one vital digital innovation initiative (Jöhnk et al. 2022) enables incumbents to create an internal unit that a) focuses its efforts and resources expressly on the creation of digital innovations (Raabe et al. 2020a), b) incorporates and expands digital capabilities through its agile and post-bureaucratic form of organizing (Hellmich et al. 2021) and c) incorporates digital transformation by contributing to the structural alteration of an incumbent organization (Hanelt et al. 2021a; Schumm and Hanelt 2021) and acting as a blueprint for new methods of working, culture change and strategic enhancements (Chanias et al. 2019).

III. Methodological Background[3]

Chapter A.III lays the methodological foundation for this dissertation. Different types of RQs necessitate distinct research strategies that in turn predetermine the selected methods while taking the RQs into consideration (see RQs in A.I.3) (Venkatesh et al. 2013). Creswell and Creswell (2017) define strategies of inquiry as qualitative, quantitative and mixed methods, each of which involve distinct research processes and results. Qualitative research strategies are suitable for investigating and answering RQs that focus on experiential data that can best (or only) be expressed in words. They are focused on explaining a wider setting to investigate distinct phenomena in context (Recker 2021). Quantitative research strategies, meanwhile, are appropriate for investigating RQs that are based on a foundation of data that can be expressed in numbers. They generally apply the hypothetico-deductive research model, which means testing, measuring and validating hypotheses (Recker 2021). A mixed methods approach combines quantitative and qualitative research strategies and can adopt either sequential or concurrent practices (Creswell and Creswell 2017). Combining several research tactics and procedures is recommended to improve the reliability of research results (Mingers 2001). Following this pluralist approach (Mingers 2001), this dissertation and the four studies incorporated in it apply both qualitative and quantitative strategies. In Chapter B.I and Study 1, RQ1 is investigated using a systematic literature review approach, which is a vital first step for establishing a knowledge-promoting foundation in every research endeavor (Webster and Watson 2002) and can be conducted either quantitively or qualitatively (Pan 2016). To investigate RQ2, Chapter B.II.1 (Study 2) applies a qualitative research strategy in the form of a single case study, and Chapter B.II.2 (Study 3) applies a quantitative research strategy that is based on longitudinal panel data analysis (Ahuja and Katila 2001). To investigate RQ3, Chapter B.III (Study 4) applies a qualitative research strategy in the form of a Delphi study.

Chapter A.III.1–A.III.4 provide an overview of the research strategies and methodologies applied, which means outlining general research context and design (A.III.1), describing the literature review (A.III.2) and detailing qualitative (A.III.3) and quantitative (A.III.4) approaches. The literature review section is separated since literature reviews can be conducted either quantitively or qualitatively (Pan 2016), however, the present study consists solely of qualitative literature reviews. In addition

[3] Some sections are based on research papers that have been previously submitted by the author. Detailed information on the papers is summarized in Table 1.

to generalized methodological descriptions, Part B and the four studies cover the reasoning, data generation and distinct methods used in those studies. In addition to the methods employed, multiple others could be considered for conducting valuable empirical research (for a detailed overview, see Recker 2021).

III.1 Research Context and Design

Research on information systems aspires to investigate the interaction between information technologies and human organizations (Grover and Lyytinen 2015). Its purpose is to inform both scholars and practitioners "how to understand, interpret, adapt to, and effectively manage technologies that have been and currently are in use, as well as emerging technologies whose impact are just being felt" (Banker and Kaufman 2004, p. 294). Given this focus, the domain falls in the social sciences (Bhattacherjee 2012) and, given its emphasis on both technical and social components, can be described as a socio-technical field (Recker 2021). As a comparably young research area, information systems research builds on and has been influenced by an interdisciplinary foundation of multiple related disciplines, such as computer science, management science, organizational science, biology, sociology, philosophy and psychology (Gregor 2006). Against this background, it is thus essential to clarify the dissertation's general theoretical foundation, including the basis of paradigms (Hevner et al. 2004), epistemological stances (Orlikowski and Baroudi 1991), research streams (Banker and Kaufman 2004) and the methods and theory types applied (Gregor 2006).

As to research paradigms, two stances are commonly found in information systems research: design science and behavioral science (Hevner et al. 2004). The design science research paradigm is generally aimed at effectively and efficiently designing, creating and implementing technology-oriented artifacts to alleviate organizational issues and improve existing activities (Hevner et al. 2004; Wilde and Hess 2007). Being rooted in engineering science and the science of artificial (Simon 1996), the design science paradigm approaches subjects in their real-world contexts (Kuechler and Vaishnavi 2008). By contrast, the behavioral science paradigm aims to develop and advocate theories that explain or anticipate organizational and human phenomena regarding the interaction and use of information systems (Hevner et al. 2004); it originates in natural science research (March and Smith 1995). Since this dissertation examines organizing for digital innovation in incumbent firm contexts spurred by the pervasive use of digital technologies, it more closely relates to the stated objective of behavioral science and is therefore largely associated with this research paradigm.

In terms of epistemology – that is, "the assessment and justification of knowledge claims" (Wynn Jr and Williams 2012, p. 788) – three distinct positionings can be differentiated: positivism, interpretivism and critical realism (Gregor 2006). Positivism presumes an objective reality (Hudson and Ozanne 1988) consisting of phenomena with relationships that are determined a priori and are suitable for general theorization (Orlikowski and Baroudi 1991; Wynn Jr and Williams 2012); the positivist's view is that "while theories may be created via reasoning, they are only authentic if they can be verified through observations" (Bhattacherjee 2012, p. 8). Interpretivism asserts that reality is subjectively constructed by individuals and their social interactions (Walsham 1995); thus, an objective reality does not exist (Orlikowski and Baroudi 1991), and research on social interactions must consider the subjective realities, interpretations and behaviors of the individuals involved (Bhattacherjee 2012). Critical realism presumes an "independent reality that comprises the world, even though humans are usually unable to fully understand or observe this reality, and that our knowledge of reality is fallible" (Wynn Jr and Williams 2012, p. 789). Since this dissertation seeks to increase the knowledge and understanding of organizing for digital innovation in the context of incumbent firms, an independent and objective reality, it adopts a positivist position, signifying a neutral and observer-like research perspective in relation to the phenomena under investigation (Orlikowski and Baroudi 1991).

As to research streams, five distinct research directions have been identified in the information systems field (Banker and Kaufman 2004): (1) decision support and design science, which comprises research on the architecture of decision support and control systems and considers their human users and associated business principles; (2) value of information, including research on the interaction of technologies and information with decision makers based on economic considerations; (3) human-computer systems design, which encompasses research on the cognitive basis for effective user interaction and behavior with reference to technological artifacts; (4) information systems organization and strategy, which includes research on multilevel explanatory models of information systems-related organizational behavior and management; and (5) economics of IT and information systems, which encompasses research that uses theoretical perspectives and methodologies from both analytical and empirical economics to information systems-related managerial problems. Since this thesis investigates industrial-age incumbents' organizational and strategic responses to the emerging threats posed by digital technologies and digital innovation, it is closely related to the research stream of information systems organization and strategy.

Regarding methodology, the dissertation incorporates four distinct studies that investigate the topic of organizing for digital innovation in industrial-age contexts using

both qualitative and quantitative approaches, which is deemed particularly suitable for complex social phenomena (Bhattacherjee 2012). In chapters A.III.2–A.III.4, the relevant methodological techniques are detailed. Additionally, information systems research can be divided into five theoretical types: (1) analysis, (2) explanation, (3) prediction, (4) explanation and prediction and (5) design and action Gregor (2006). Chapters B.I and B.II.1 relate to theory for analysis because they "describe what is"; these notions are particularly effective "when little is known about some phenomena" (Gregor 2006, p. 624), which is applicable here. Analytical theories provide descriptive and analytic insights into the subject of investigation. This was attempted in this research by constructing classifications in Chapter B.I and outlining survival and growth mechanisms of digital innovation units in Chapter B.II.1. In addition, Chapters B.II.2 and B.III pertain to a theory for explaining and predicting, as they identify the performance implications of digital innovation units as a vital digital innovation initiative for incumbent firms and approaches to help overcome digital innovation-related challenges in physical product-based organizations (Gregor, 2006). The methodologies used in the chapters, such as case studies and statistical analysis, are suitable for this type of theory because they provide an "understanding of underlying causes and prediction, as well as description of theoretical constructs and the relationships among them" (Gregor 2006, p. 626). Table 4 provides an overview of the research contexts and designs applied to the four studies in Part B.

Table 4 – Applied Research Context and Design

No.	RQ	Episte-mology	Paradigm	Methodology (Seminal work)	Data Collection	Data Analysis
1	1	Positivistic	Behavioral science	Systematic Literature Review (Webster and Watson 2002)	Structured literature review	Coding
2	2a	Positivistic	Behavioral science	Single case study (Yin, 2003)	Interviews, firm documents, secondary data	Coding
3	2b	Positivistic	Behavioral science	Longitudinal panel data analysis (Ahuja and Katila, 2001)	Database retrieval, secondary data collection	Panel data regression
4	3	Positivistic	Behavioral science	Delphi method (Schmidt, 1997)	Delphi survey	Coding

III.2 Literature Review

"The reviewing of existing literature relating to a topic is an essential first step and foundation when undertaking a research project" (Baker 2000, p. 219). It is vital, especially for emergent research areas where profound theory is currently lacking, to summarize and synthesize prior research with a critical lens, to investigate and explain the current status quo and to build a scientific foundation for the descriptions of novel phenomena (Paré et al. 2015; Schwarz et al. 2007). Literature reviews help determine the research goal, assist in formulating hypotheses, explain relationships between components and can be used to analyze and interpret existing information to build on a cumulative tradition (Leavy 2017). A "literature review synthesizes past knowledge on a topic or domain of interest, identifies important biases and knowledge gaps in the literature, and purposes corresponding future research directions" (Rowe 2014, p. 243). A literature review can be either narrative or systematic and qualitative or quantitative (Collins and Fauser 2005; Kitchenham et al. 2009). While a narrative review reflects the experiences of the reviewers, a systematic review reflects an organized procedure for discovering, analyzing and summarizing knowledge (Vom Brocke et al. 2015). Three

different types of literature reviews have been identified (Okoli 2015). In addition to a standalone literature review, where all data and information stem from the review process, a literature review can serve as a chapter in a thesis or as an introduction or background section to provide theoretical foundations and insights for a research project (Okoli 2015). Webster and Watson (2002) define completeness and conceptual focus as relevant to pursuing a high-quality literature review. They further underline the relevance of including various viewpoints on a given topic by including a broad set of publications rather than focusing on one journal or conference (Webster and Watson 2002).

To derive distinct knowledge when conduct a literature review, especially a systematic and standalone review, a two-stage approach is widely applied (e.g., Nischak et al. 2017; Schumm and Hanelt 2021). First, after clarifying the research aims, objectives and questions (Vom Brocke et al. 2015), an appropriate literature sample needs to be generated. To do justice to the thematic orientation, a keyword search in the corresponding research field needs to be applied (Webster and Watson 2002). To reduce sample size, a focus on distinct qualitative indicators can be compiled; for example, a comparison of the VHB Jourqual 3 rankings can help reduce sample size while ensuring high quality (e.g., Koeffer 2015; Leonhardt and Kolbe 2016)[4]. A second possibility to limit the research focus is to concentrate on certain time spans (Rowe 2014). To enlarge a sample, the widely applied method of forward and backward loops described by Webster and Watson (2002) can be used. By reviewing the citations of identified articles (backward) and identifying research citing key papers (forward), the sample can be expanded to other literature strings (Webster and Watson 2002). Going forward and backward within the sample enables the creation of a web of science that incorporates multiple research streams and dimensions (Robey et al. 2000).

To derive systematic knowledge from the chosen articles and research prospects, the second step classifies the information obtained into a concept matrix (Webster and Watson 2002). In this regard, Mayring's (2014) approach to qualitative content analysis has been found to be especially suitable for a structured analysis of commonalities in the identified content. It enables a distillation of large amounts of data into its key meanings. Mayring's (2004) widely applied method of qualitive content analysis (e.g., Semmann and Böhmann 2015; Vogelsang and Hoppe 2013) divides the procedure to create a concept matrix into six separate steps (Mayring 2014): In the first step, the smallest unit

[4] For more information, see https://vhbonline.org/en/vhb4you/vhb-jourqual/vhb-jourqual-3.

to be analyzed is defined; this is typically a sentence. By reading all the articles and highlighting each relevant sentence, the papers in a sample can be analyzed at an initial, relatively superficial level. When reading all articles, each sentence with a direct reference to the RQ(s) should be coded. In a second step, a category system is created; the researcher draws on the preliminary analysis and on RQ(s) to create the category system. The categories refer to deductively developed theoretical assumptions from theories and repetitive text passages within the sample. Deductive derivations are formed from established and concise theories and scientific approaches, which are confirmed by references and citations. Inductive conclusions are drawn from recurring text passages that offer a contextual correlation. The derived attributes should be formed from the assignment of marked text passages to the corresponding categories. This results from step three, the assignment and coding of all relevant text units to categories. In this step, each identified text passage is assigned to one or more categories, thus creating a first classification. Each paper needs to be carefully classified in light of all categories. The assignments should be based more on explicit statements than on implicit interpretations, because that will create distinct attributes. These attributes should be supplemented or revised in the fourth step by the previously determined classifications. This step can lead to an extension and completion of the initial setup of categories and attributes. When carrying out classification, the category system should be further revised and adjusted to increase overall intelligibility. In doing so, the existing category system can be supplemented and expanded. To organize the final categories and their attributes into themes, clusters can be identified by aggregating the categories and their attributes. The findings of the classification should be discussed in the fifth step, and the results need to be interpreted in the sixth and final step (6). Figure 7 depicts the design process of a concept matrix.

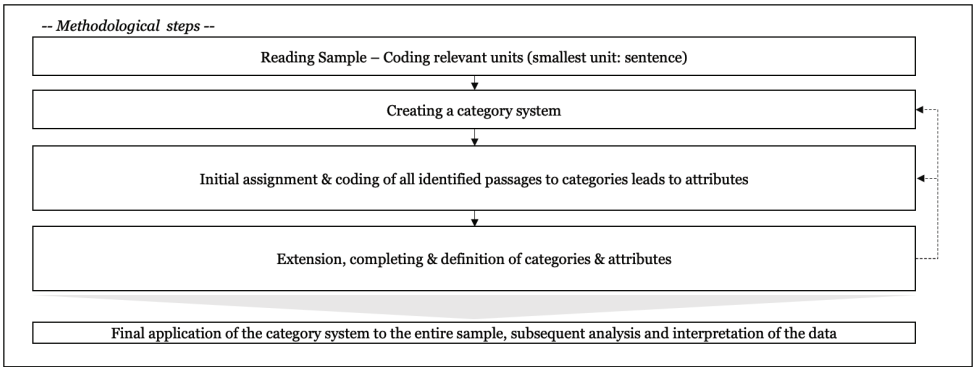


Figure 7 – Designing a Concept Matrix

III.3 Qualitative Research

"Qualitative methods are designed to assist researchers in understanding phenomena in context" (Recker 2021, p. 114) and are suitable when the object being investigated cannot readily be characterized by statistical or quantifiable data (Strauss and Corbin 1998). They also use multiple variables to gain information about a phenomenon by conducting long-term investigations in a real-life context (Gay et al. 2009). Building on these characterizations and the methodological literature, Yilmaz (2013, p. 312) defines qualitative research "as an emergent, inductive, interpretive and naturalistic approach to the study of people, cases, phenomena, social situations and processes in their natural settings in order to reveal in descriptive terms the meanings that people attach to their experiences of the world." Qualitative research is deemed sufficient when specific phenomena within a broad context of multiple real-life influences are under investigation (Recker 2021). These areas of application are further detailed by Sarker et al. (2018), who offer six stances in which qualitative studies are especially applicable: (1) investigating past events in detail and revealing underlying relations and activities (Van Maanen 2011); (2) generating comprehensive knowledge and understanding of a currently under-investigated phenomenon (Walsham and Sahay 1999); (3) abstracting and synthesizing novel theories and concepts from existing descriptions (Eisenhardt 1989); (4) developing an overarching explanation of a pervasive phenomenon while considering its generalizability and applicability (Yin 2009); (5) creating a representative characterization of a group's subjective meaning and opinion (Gubrium and Holstein 1999); and (6) summarizing the experiences of a distinct group of interests (Schweizer 1998). Recker (2021) defines certain basic principles that commonly characterize qualitative research:

- it is typically conducted in a natural environment that is the immediate context of a phenomenon (Creswell and Creswell 2017);
- the research instrument is often the researchers, as they acquire the necessary data on their own through interviews, observations and/or the analysis of existing data (Sarker et al. 2018);
- it is based on a variety of data sources, including interviews, organizational and governmental documents and press releases (Strauss and Corbin 1998);
- it focuses mostly on inductive, bottom-up analysis to derive unique patterns and ideas from empirical data (Eisenhardt 1989);
- it aims at uncovering the emergent meanings that lie underneath the behaviors and opinions of the research participants (Gubrium and Holstein 1999);

- it often evolves over the course of study and follows an evolutionary design that can change as the research progresses (Strauss and Corbin 1998);
- it is holistic and contextual to provide a thorough and comprehensive description of a complex setting (Van Maanen 2011).

III.3.1 Sampling and Data Collection

Conducting successful, impactful and reliable qualitative research depends heavily on obtaining suitable data (Sarker et al. 2018). Therefore, sampling plays a major role (Recker 2021). Sampling can be conducted either theoretically, randomly, purposefully or conveniently (Miles and Huberman 1994); Qualitative research generally employs theoretical sampling (Recker 2021), in which cases are selected based on the theoretical properties of interest in order to collect data directly related to the phenomenon under investigation (Tsang and Williams 2012). Different strategies are used to obtain the data within the sample (Yilmaz 2013). The most prevalent approach in the information systems field (and in numerous others) is to conduct interviews in which the researcher engages in conversations with one or more individuals (Schultze and Avital 2011). Interviews can reveal valuable insights and knowledge about people, processes, social interactions and events to investigate a distinct phenomenon (Schwandt 2001). Interviews can be conducted in person, via phone or video link or through textual exchange and can adopt an unstructured, structured or semi-structured interview format. They can be descriptive (to gain a comprehensive understanding on a subject), exploratory (to derive propositions and hypotheses) and explanatory (to detect relationships between subjects) (Recker 2021). In addition to interviews, qualitative research can be built on data collection techniques like real-life observations, which enable researchers to gather first-hand reports and disclose instances as they occur (Yin 2009), and archival data collection, which considers internal and external documents to enlarge knowledge (Eisenhardt 1989). Combining several data sources necessitates the triangulation of data, which is the process of correlating multiple sources of evidence regarding the research subject to gain a deeper understanding of the issue and improve the validity and reliability of the results (Recker 2021).

III.3.2 Data Analysis

Qualitative research usually involves large amounts of data to analyze (Recker 2021). The literature offers several techniques to structure and analyze data, all of which share three stages: *data reduction*, *data display*, and *conclusion drawing/verifying*. All three stages are interrelated and interwoven with the process of *data generation* (Miles and Huberman 1994). Data reduction aims to structure and organize a large amount of data,

partly by eliminating extraneous elements; data display seeks to synthesize data to present them in a readable and accessible form; and conclusion drawing or verifying enables researchers to develop generalized concepts that can be further tested (Miles and Huberman 1994). Figure 8 displays this generalized data analysis procedure.

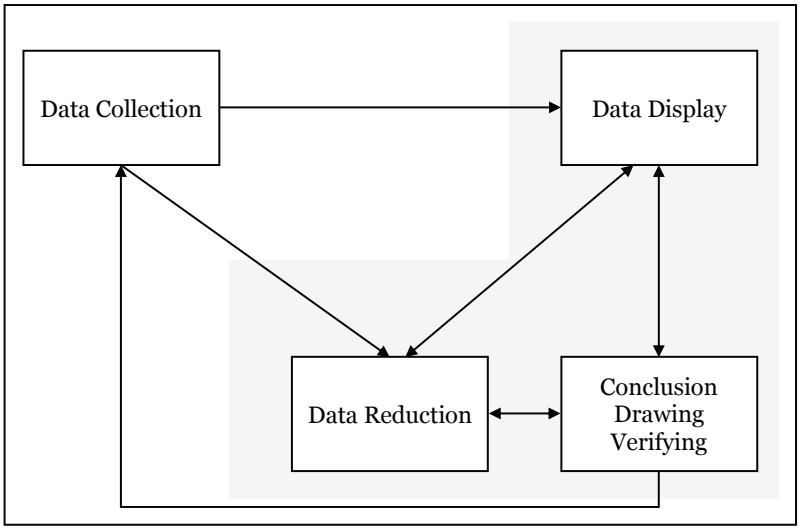


Figure 8 – Analyzing Data
(adapted from Recker 2021)

The most prominent technique to analyze and reduce qualitative data is *coding* (Recker 2021). The three-stage model introduced by Strauss and Corbin (1998) begins with *open coding* principles that seek to extract as many codes as feasible from the empirical data (Seidel and Urquhart 2013; Strauss and Corbin 1998). The second round employs the *axial coding* principle, which iterates the textual evidence generated and pertinent theory with the initial first conceptual assumptions (Strauss and Corbin 1998). By uncovering linkages between categories and subcategories, emergent theoretical ideas can be identified and abstracted to derive generic mechanisms (Strauss and Corbin 1998; Urquhart 2013). The third phase used *selective coding*, in which categories and subcategories around the core categories are recoded in order to further enhance the conceptual model and to investigate the interaction between its mechanisms (Strauss and Corbin 1998; Urquhart 2013). By comparing the conceptual model to the emergent case narrative and the theoretical underpinnings (Strauss and Corbin 1998), mechanisms can evolve.

III.3.3 Case Study

One of the two qualitative research methods applied in this dissertation is a case study, which is the most commonly applied qualitative method in information systems (Recker 2021). Case studies involve undertaking a thorough examination of a unique phenomenon, the case, in its actual context over time. Case studies are typically employed to comprehend complicated social phenomena involving individuals in groups or organizations, such as management or organizational procedures and strategies (Yin 2009). Case studies can consider numerous sources, such as interviews, observations and secondary data, to generate a coherent understanding of a complex phenomenon within its context and to help reveal the phenomenon's fundamental dynamics and interrelationships (Eisenhardt 1989; Recker 2021). Further, a foundation of multiple sources enables triangulation of data that enhances the credibility of the results (Recker 2021). It allows following a research process that iteratively switches between the empirical phenomenon and underlying theoretical assumptions (Wiklund et al. 2011). By concluding an open and inductive process of analysis while simultaneously and systematically analyzing theoretical underpinnings, this approach enables the development of novel theoretical insights based on an abundance of empirical evidence (Strauss and Corbin 1998; Urquhart 2013). While this method enables open and exploratory data analysis and novel theorizing, it cannot ignore existing research and theoretical assumptions (e.g., Huang et al. 2017; Tumbas et al. 2017b). Case studies are used for both confirmatory (theory-testing) and exploratory (theory-building) objectives. Confirmation-driven cases are based on existing theories that are applied to and tested in real-world scenarios (Eisenhardt 1989). The results of such studies might disclose gaps in current conceptions, stimulate future research and/or refine or complete existing theories (Siggelkow 2007). Exploratory cases are particularly useful when only minimal knowledge exists and there are no narrative concepts (Yin 2009). Case study designs can vary based on the unit of analysis and type of case. The case design differentiates between examining a single case or multiple cases, such as one or multiple companies operating in the same industry. The unit of analysis indicates whether the case focuses on one or several units of analysis, such as a single organization or several teams operating inside of an organization. This leads to four types of case study design (Yin 2009): single case holistic designs, single case embedded designs, multiple case holistic designs and multiple case embedded designs, as shown in Figure 9.

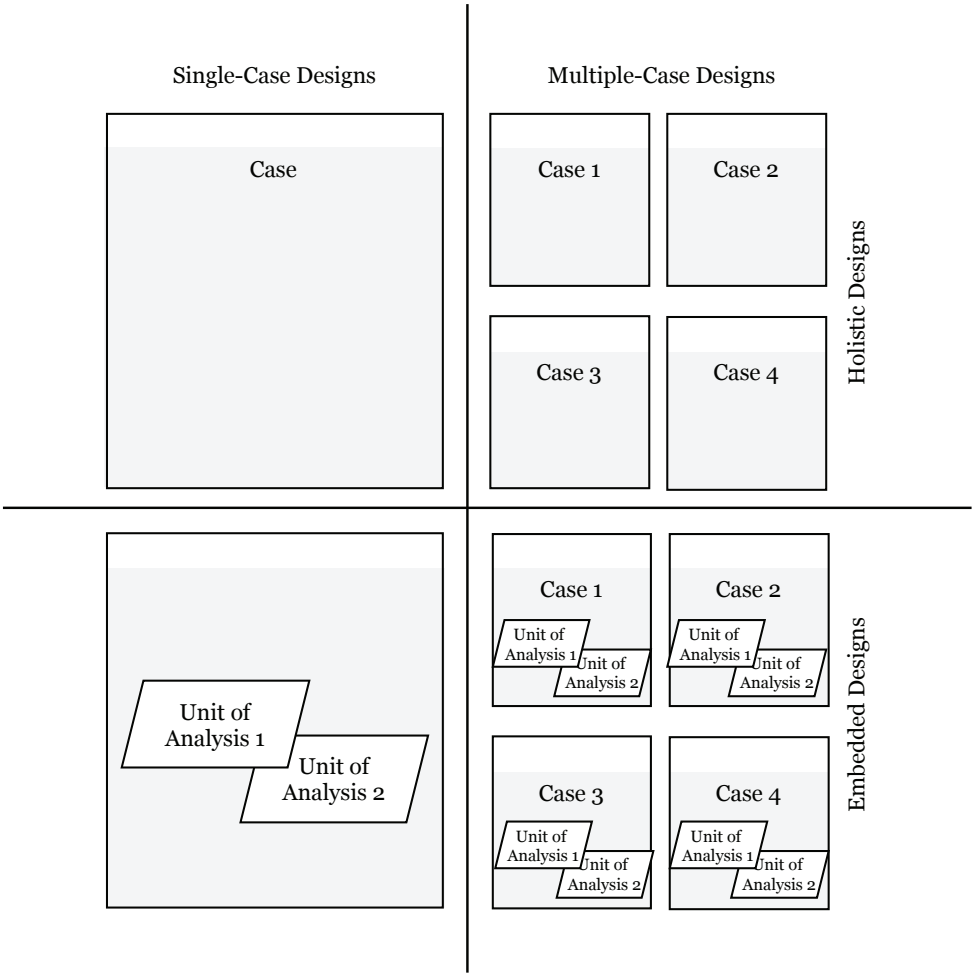


Figure 9 – Case Study Design
(adapted from Yin 2009)

In Chapter B.II.2, this dissertation uses a single case embedded design, meaning it observes multiple embedded entities (i.e., digital innovation units) in one organization (Yin 2009). Single case studies permit the exploration of a subject within its isolated setting, enabling scholars to comprehend a phenomenon (e.g., Chan et al. 2019; Svahn et al. 2017; Yeow et al. 2018b) and are appropriate when facing a new and unexplored subject of research (Yin 2009).

III.3.4 Delphi Method

The second qualitative research method used in this dissertation is the Delphi study. The application of an exploratory approach such as the Delphi study has several benefits in certain research situations and is suitable for seeking recommendations from specialists when approaching an information systems research topic (Skinner et al. 2015). The approach is particularly valuable when, first, the research field is relevant to practice and new theories or contexts need to be explored (Okoli and Pawlowski 2004; Singh et al. 2009), second, when "the problem does not lend itself to precise analytical techniques but can benefit from subjective judgments on a collective basis" (Linstone and Turoff 1975, p. 4) and, third, when little or no empirical research on the topic(s) or research problem(s) is accessible (Paré et al. 2013). In response to the scarcity of empirical evidence and a context-specific solution space, this method seeks to bring multiple expert perspectives into a single conversation (Schmidt et al. 2001; Skinner et al. 2015). The Delphi study is based on a collaborative discussion among experts and the aggregation of individual contributions on a specific topic related to their area of expertise (Singh et al. 2009; Skinner et al. 2015). The Delphi method enables a structured discussion between experts that takes place through controlled processes and enables them to provide constant feedback on an anonymous basis (Schmidt et al. 2001; Singh et al. 2009). Four basic conditions of empirical validation must be adhered to when conducting a Delphi study: the anonymity of individual participants, the iteration of different phases, the provision of controlled feedback, and a statistical treatment of the results (Singh et al. 2009). The Delphi method benefits from its modest panel size (Okoli and Pawlowski 2004), since it builds on experts with expertise and experience in the reviewed field (Skinner et al. 2015); it usually involves between 10 and 30 participants (Baldwin-Morgan 1993; Kasi et al. 2008; Keil et al. 2002). However, smaller sample sizes of 10 to 18 people can also provide robust findings (Okoli and Pawlowski 2004), since it is deemed unlikely that another, smaller group with the same level of expertise would provide drastically different outcomes (Skinner et al. 2015). The Delphi method requires suitable participants who have appropriate expertise (Okoli and Pawlowski 2004; Singh et al. 2009; Skinner et al. 2015). Selecting the appropriate sample group is critical to generating reliable and worthwhile findings (Singh et al. 2009). To successfully identify suitable experts, this dissertation follows the detailed guidelines of Okoli and Pawlowski (2004); see the case-related details in Chapter B.III.

Following Schmidt (1997), the data collection process consists of three phases: brainstorming, selection and rating. To minimize effort for participants, physical discussion rounds and meetings can be replaced by an online survey tool or e-mail

(Singh et al. 2009; Skinner et al. 2015). Each survey should be validated for comprehensibility and functionality with individuals who were not part of the survey to prevent misunderstandings and extra effort (Singh et al. 2009; Skinner et al. 2015). During the first phase of a Delphi study, experts are invited to identify factors related to the RQ. An appropriate context definition should be provided in advance to narrow the solution space as precisely as possible (Skinner et al. 2015). Singh et al. (2009) recommend that experts name between five and eight factors in the first round and be offered the opportunity to provide explanations for their responses (Skinner et al. 2015). This can contribute significantly to the comprehensibility of individual answers and their context (Okoli and Pawlowski 2004). To increase response clarity and avoid redundancy, duplicate responses should be removed and similar responses consolidated (Schmidt et al. 2001; Singh et al. 2009). The refined list should be classified into inductively formed categories. Aggregation, category development and assignment should occur iteratively between the involved authors (Schmidt 1997; Singh et al. 2009). To ensure that all replies have been allocated to the relevant categories and that all responses have been appropriately represented, a verification request should be issued to the panelists (Skinner et al. 2015). This helps the effect of noise; that is, misunderstanding due to misinterpretation (Paré et al. 2013; Singh et al. 2009). The consolidated list then undergoes a selection process in which the experts are asked to choose but not to rank the 10 most relevant factors (Schmidt 1997). Experts are supplied with a list of factors in a randomized order to avoid biases (Schmidt 1997). After an appropriate time and number of reminders, this phase should be closed. Singh et al. (2009) suggest that factors identified by at least 30% of experts should be retained to reduce the list of factors to a manageable 12 to 15 (Skinner et al. 2015). The final phase requires the experts to rank the surviving factors according to significance and relevance. Following Singh et al. (2009), controlled guidance in the form of the previous round's percentage of choices should be provided (Schmidt 1997). To obtain a robust result from a Delphi study, a certain level of consensus between the experts' answers is necessary (Schmidt 1997). To evaluate the consensus of non-parametric rankings, various metrics are available in the literature, among which Kendall's coefficient of concordance (W) is deemed by research as most suitable for Delphi studies (Okoli and Pawlowski 2004; Paré et al. 2013), since dissensus and consensus are immediately recognizable and the decision to proceed is unambiguous (Skinner et al. 2015).

Kendall's W can be determined as detailed below (Kendall and Babington Smith 1939, p. 276).

$$\text{(Eq. 1):}\ W = \frac{12 \times S}{m^2(n^3 - n)},$$

where m is the total number judges and n is the total number of factors. S is the sum of squared deviations and is defined as:

$$\text{(Eq. 2):}\ S = \sum_{i=1}^{n}(R_i - \bar{R})^2,$$

where $\bar{R}$ is the mean value of the total ranks and R_i is the total ranks given to object i.

Kendall's W ranges from 0 to 1, with 0 meaning the absence of any agreement and 1 meaning perfect consensus (Kendall and Babington Smith 1939). Different W-values can be narrowed down: those from 1 to 0.7 are strong consensus levels, those from 0.7 to 0.5 as moderate and those from 0.5 to 0 are weak (Schmidt 1997).

It is common practice to conduct further rounds in Delphi studies – as long as at least moderate consensus is reached – to increase the level of consensus through guided feedback (Paré et al. 2013; Singh et al. 2009). In this process, participants are asked to refine their rankings based on additional information, including rankings obtained in the previous round and participant comments (Schmidt 1997; Skinner et al. 2015). Schmidt (1997), however, argues that continuing a given study is a researcher decision, as other factors can signal its conclusion. These stopping rules are reaching a satisfactory consensus, observing no significant change in consensus between two successful rounds or jeopardizing the feasibility of another round by a high drop-off in participants (Schmidt 1997). In case of overload or excessive time and resource use due to further ranking rounds, even a low consensus can be considered valid (Paré et al. 2013).

III.4 Quantitative Research

"Quantitative methods describe a set of techniques for answering research questions with an emphasis on quantitative data [...] whose values are measured in numbers" (Recker 2021, p. 88). These methods are typically applied when numbers can be used to describe or present a phenomenon and to observe the relationship between different variables (Creswell and Creswell 2017). Quantitative research is deemed sufficient to build novel theories and to advance existing theories incrementally, meaning it can serve as a foundation for building cumulative knowledge or to enhance an existing tradition (Kaplan 2017). Yilmaz (2013, p. 312) defines qualitative research "as a type of empirical research into a social phenomenon or human problem, testing a theory consisting of variables which are measured with numbers and analyzed with statistics in order to determine if the theory explains or predicts phenomena of interest." Quantitative research is based on a foundation of a priori theories and hypotheses that are tested, validated or refined and interpreted in the hypothetico-deductive model of science (Recker 2021).

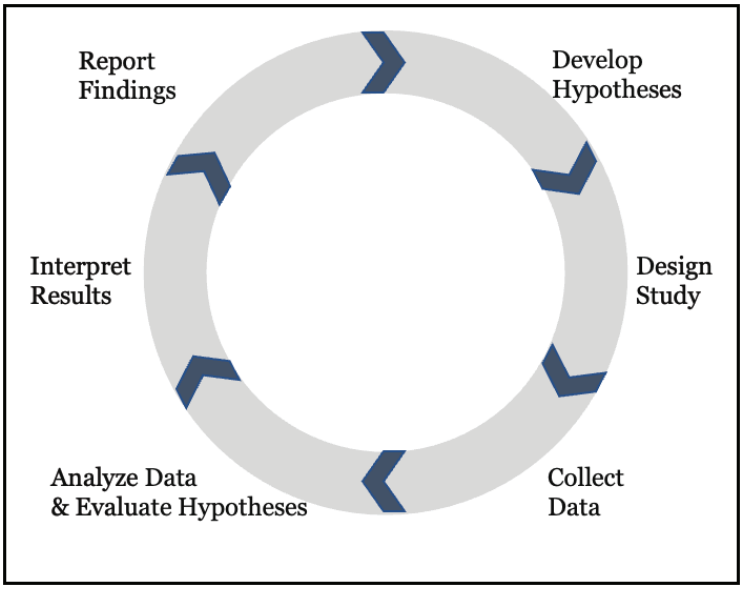


Figure 10 – Hypothetico-Deductive Research Process
(adapted from Recker 2021)

Building on Recker (2021) this process consists of six steps:

- generating theories and hypotheses that are to be tested and validated;

- developing and selecting appropriate instruments and measurements to obtain data;
- collecting empirical data from experiments or existing data;
- testing and validating empirical data to analyze the information and evaluate the hypotheses;
- interpreting the results based on statistical tests;
- reporting the study's results.

Empirical data in quantitative research can be collected in multiple ways, such as experiments, surveys or analyzing existing information like press releases (Yilmaz 2013). Quantitative research must meet the requirements of validity and reliability to ensure high quality (Burton-Jones and Lee 2017). While validity requires that the data must relate to the theoretical concept being investigated, reliability requires that the data provide consistent and precise measures (Recker 2021).

III.4.1 Analysis Methods – Regression Analysis

Quantitative research offers varying approaches to analyze empirical data (Yilmaz 2013). Since this dissertation applies a longitudinal data regression analysis, this approach is discussed in greater detail. Additionally, Chapter B.II.2 details the concrete research strategy, including the procedure, detailed measures and variables. Regression analyses are widely applied in information systems research (Recker 2021). They are used to investigate the ongoing relationship between dependent or predictive variables and independent variables (Saunders et al. 2009). Using survey instruments or archival databases that enable repeated measurements of the same variables at different times can be used to acquire longitudinal data (Ployhart and Vandenberg 2010). Considering multiple repeated observations in the same research context enables a broader view of the investigated phenomenon and accesses information on changes over time within one unit or between multiple units (Mertens et al. 2017). Analyzing a longitudinal set of data can have four general objectives. First, it can predict certain dependent or predictor variables. Second, a regression on a longitudinal data set can be applied to assess whether a set of independent variables influences a dependent variable. Third, applying a regression can determine whether independent variables are significant for a specific research issue. And fourth, a regression analysis can be used to establish the statistical significance of independent variables for a dependent variable (Mertens et al. 2017). Independent of the objective and kind of regression, each analysis follows the same structure (Bhattacherjee 2012):

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \cdots + \beta_n x_n + e,$$

where $ß_0$ and $ß_1$ (and all following beta values) are the regression coefficients and the x_i values characterize independent (or control) variables (Bhattacherjee 2012; Mertens et al. 2017).

When establishing a research model, moderators can be employed when the impacts of an endogenous or exogenous construct are dependent on the values of another variable (Hair Jr et al. 2014). A mediating variable in a research model can dilute the effects of an endogenous or exogenous construct (Hair Jr et al. 2014).

B Studies

Part B is comprised of four studies that address the three RQs. These studies are based on and related to four previously published papers that were written as part of the dissertation process. All chapters investigate novel ways of organizing for digital innovation, particularly in industrial-age contexts. To investigate the overall research goal and to enhance knowledge on how industrial-age incumbents are organizing for digital innovation through the strategic establishment of digital innovation units, this dissertation addresses three RQs (see Chapter A.I.2). While investigating the RQs, the respective studies narrow their research perspective from a broad focus on organizational forms (RQ1) to an investigation of the establishment of digital innovation units (RQ2) and to the distinct mechanisms used to manage the intersection within and between these entities (RQ 3). This results in three distinct perspective levels with a narrowing research focus, as depicted in Figure 11.

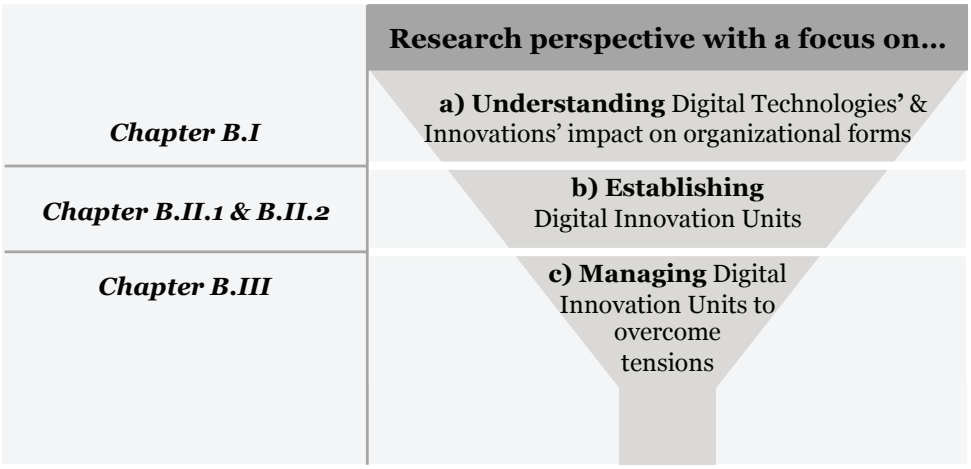


Figure 11 – Funnel of Research Perspectives

The first and broadest research perspective – understanding digital technologies' & innovations' impact on organizational forms – is addressed by the first study in Chapter B.I, which is based on the paper "Transformational Dynamics – Systemizing the Co-Evolution of Organizational Forms and Information Systems" (Schumm and Hanelt 2021). The second research perspective – establishing digital innovation units – is addressed by two studies in chapters B.II.1 and B.II.2, which are based on the papers "Survival and Growth of Digital Innovation Units: A Case Study Analysis" (Schumm and Hanelt Submitted) and "Digital Innovation Units: An Empirical Investigation of Performance Implications" (Schumm et al. 2022). The third and narrowest research

perspective – managing digital innovation units to overcome digital innovation tensions – is considered by one study in Chapter B.III, which is based on the paper "Digital Innovation Units in Industrial-Age Contexts – Paradoxes, Ambidexterity, and Symbiotic Collaboration" (Schumm and Hanelt Under Review). See Figure 12 for a representation of the research perspectives and related studies.

Research Perspective	Related Studies
I. Understanding Digital Technologies' and Innovations' impact on organizational forms.	*RQ: 1* **Study 1: Transformational Dynamics**
II. Establishing Digital Innovation Units.	*RQ: 2a* **Study 2: Survival and Growth of Digital Innovation Units** *RQ: 2b* **Study 3: Performance Implications of Digital Innovation Units**
III. Managing Digital Innovation Units to overcome Digital Innovation tensions.	*RQ: 3* **Study 4: Digital Innovation Units in Industrial-Age Contexts**

Figure 12 – Research Perspectives and Related Studies

I. Understanding Digital Technologies' & Innovations' impact on organizational forms

This section focuses on the first and broadest research perspective, understanding digital technologies' and innovations' impact on organizational forms, and is related to RQ1: "How do industrial-age incumbents adapt their organizational forms to emerging digital technologies and innovation?" To answer RQ1, this section builds on Study 1, which is based on and related to a previously published paper (i.e., Schumm and Hanelt 2021).

Study 1: Transformational Dynamics

I.1 Introduction

The ongoing and rapid surge in the utilization of digital technologies is profoundly impacting all industries and organizations (Vial 2019). Across contexts, firms are challenged to develop new digital products and services (Yoo 2010; Yoo et al. 2012), participate in digital platform ecosystems (Cennamo and Santaló 2019), find a strategic positioning adequate in a digital world (Hess et al. 2016), and redefine their business models (Piccinini et al. 2015). To cope with these enduring and evolving challenges, however, firms are not only called to develop novel digital capabilities (Nadkarni and Prügl 2021; Warner and Wäger 2019). Instead, recent research and contemporary business practice suggest that a change in organizational forms is at the heart of digital transformation (Hanelt et al. 2021a; Lyytinen et al. 2016).

Organizational forms can be defined as "agreed upon or contracted mixes of coordination mechanisms" (Grandori 1997, p. 900). Typical examples include bureaucracies (Weber 1947), post-bureaucratic organizations (Miles et al. 1978), networks (Lambert and Peppard 1993), or platform ecosystems (Parker et al. 2017; Saadatmand et al. 2019). Organizational forms are undergoing continuous alterations in response to changing contextual conditions (Hsu and Hannan 2005). For instance, critical humanism, a countermovement to the emerging Taylorism, has led to various adaptations of organizational forms (Horkheimer and Adorno 1972; Marcuse 1955). As an illustration, a change from mechanistic to organic forms was described early in the 1960s (Burns and Stalker 1961). One of the key influential factors in the evolution of organizational forms is technology in general and information technology and systems in particular (Sia et al. 2016; Wessel et al. 2021). Changing organizational forms due to information systems influences were already reported early in the 1950s due to simplified communication possibilities (Leavitt 1958; Miles et al. 1978; Thompson and Bates 1957). A further change was triggered by the advent of desktop computers and the resulting simplified way of exchanging information, which altered work processes and instruction cascades (Robey and Boudreau 1999). The introduction of the internet intensified organizational transformation and established more recent variants of organizational forms such as network organizations and virtual or boundaryless organizations (Robey and Boudreau 1999). These examples illustrate a co-evolution between information systems and organizational forms (Sia et al. 2016). However, a systematic and longitudinal investigation of these interactions to advance the

understanding and derive learnings for recent phenomena is currently lacking (Vial 2019).

Management literature has a long tradition of investigating organizational forms (Puranam et al. 2014). In doing so, management research generally considers the change of organizational forms without particularly examining the influence of information systems in detail. Management literature provides a comprehensive view of organizational change on a meta-view (e.g., Powell 1990; Puranam et al. 2014) and specific cases (e.g., Jansen et al. 2012; Powell 1990). Information systems artifacts are mentioned in these cases; however, they play mostly a subordinate role without particular consideration of their influence on organizational forms (Pedersen et al. 2019; Schilling and Steensma 2001). The Information Systems research, by contrast, typically focuses directly on the interconnections between specific information systems and organizational forms. Thereby, these interconnections are investigated mostly in a narrowly focused way and are usually described with regard to one specific organizational form, for example, bureaucracy (e.g., Stebbins et al. 1995), strategic alliances (e.g., Ravichandran and Giura 2019), networks (e.g., King 2013), or platform ecosystems (e.g., Cennamo and Santaló 2019).

Thus, while management literature informs about organizational forms and their development more generally on a meta-level and Information Systems literature reports on the interaction of specific information systems with particular organizational forms in a narrowly focused way, a systematic analysis on a holistic level over time with a focus on the intercorrelation between information systems and organizational forms is missing. Closing this gap is important as change in organizational forms is at the heart of the contemporary phenomenon of digital transformation (Hanelt et al. 2021a). A systematic analysis of the state of extant wisdom enables us to identify and utilize valuable established knowledge that can also be utilized in the era of digital transformation and also recognize where current knowledge falls short and needs further targeted additions. In other words, a systematic analysis of what is known prevents reinventing the wheel yet reveals promising learning opportunities, thereby allowing to provide informed guidance about pressing needs in contemporary managerial practice.

To close knowledge gaps, this study systematically selects and analyzes relevant literature (Webster and Watson 2002). Thereby, connections and dependencies between information systems and organizational forms are uncovered, analyzed, and described. For this purpose, the study systematically analyzed 42 papers from top journals. Based on the analysis, three meta-patterns were derived. First, an ongoing decentralization of

organizational forms in relation to the elaboration of information systems was identified (e.g., Ravichandran and Giura 2019). Second, a primacy of transition was diagnosed, focusing on a sharp transition between organizational archetypes (e.g., Brynjolfsson et al. 1994; Lambert and Peppard 1993). A clear influence of information systems on this transformation could be deduced (e.g., Fedorowicz and Konsynski 1992; Yoo et al. 2012). Thirdly, a change in the value of information systems technology from an instrumental to an inherent value was identified, resulting in a corresponding effect on organizational forms (Yoo 2010). As a synthesis of these meta-patterns, the study diagnoses a shift over several temporal phases toward a new narrative about the influence of information systems on organizational forms. From this synthesis, the study derived key research gaps and opportunities for future Information Systems research. Finally, the analysis offers implications for practitioners.

I.2 Research Strategy

Building a Literature Set

To better understand the relationship between information systems and organizational forms as well as their evolution over time, a two-stage literature review approach is applied (e.g., Burkhart and Loos 2011; Nischak et al. 2017). This method is described in depth in Section A.III.2; this section focuses on study-specific details. However, it provides a brief methodological foundation to contextualize these study-specific details.

First, an appropriate literature sample was generated. A keyword search in the corresponding research field was chosen to do fair justice to the thematic orientation. The initial keyword search focused on the term "Organizational Form*," including its derivatives "Organisational Form*" and "Organi*ational Form*" within Information Systems literature. To ensure a wide variety of results, this study conducts an initial search in the three most relevant databases - namely Journal Storage (JSTOR), EBSCO Host Business Source Complete, and Association for Information Systems Electronic Library (AISeL). Following various role models, a comparison with the "VHB Jourqual 3" ranking and a focus on A+ and A Information Systems journals enabled a reduction of the sample size while ensuring high quality (e.g., Koeffer 2015; Leonhardt and Kolbe 2016).

The "VHB Jourqual 3" ranking is a systematic and comprehensive ranking of outlets, which many Information Systems scholars have successfully applied (e.g., Koeffer 2015; Leonhardt and Kolbe 2016)[5]. In a full paper search, a total sample size of over 400 articles was obtained. By focusing on an abstract-, keyword-, and headline-based search, a sample size of 29 papers was achieved. To further enlarge the sample, the widely applied method of forward and backward loops by Webster and Watson (2002) was used. By reviewing the citations of identified articles (backward) and identifying articles citing these key papers (forward), the study expanded the sample to other literature strings (Webster and Watson 2002). This extends the sample to 59 papers, including additional research from the organizational science and management literature. Using Webster's and Watson's (2002) forward and backward loops, the study expanded the research focus to include the terms "Information Systems" and "Information Technology" to ensure an Information Systems reference in non-Information Systems literature. Based on this initial selection, the sample was examined in a detailed review process regarding its accuracy and fit in the topic of intercorrelation between organizational forms and information systems. Articles with a different scope were removed from the sample, resulting in a final sample size of 42 Information Systems and management literature papers.

Table 5 provides an overview of the outlets that published the selected articles. The distribution of relevant articles for the study is concentrated on the period from 1990 to 2020. The detailed distribution is presented in Figure 13. The study derived this period based on published papers relevant to the research topic. This period concludes a broad and representative period on the one hand and delimits the number of eligible papers on the other hand. The distribution of Information Systems papers, for instance, can be well traced in Abdel-Karim et al. (2020).

[5] For more information, see https://vhbonline.org/en/vhb4you/vhb-jourqual/vhb-jourqual-3.

Table 5 – Outlets (Number of Selected Articles)

Academy of Management Review	1	Accounting, Organizations and Society	1
Management Science	1	Hawaii International Conference on System Sciences	1
Journal of Management Information Systems	5	Journal of Information Technology	1
Information Systems Journal	6	MIS Quarterly Executive	2
Journal of Strategic Information Systems	2	Information Systems Management	1
European Journal of Information Systems	3	Journal of Economics & Management Strategy	1
Journal of Information Technology	1	Organization Science	2
Information Systems Research	10	Research Policy	1
Information and Organization	1	MIS Quarterly	1
The Journal of Strategic Information Systems	1		

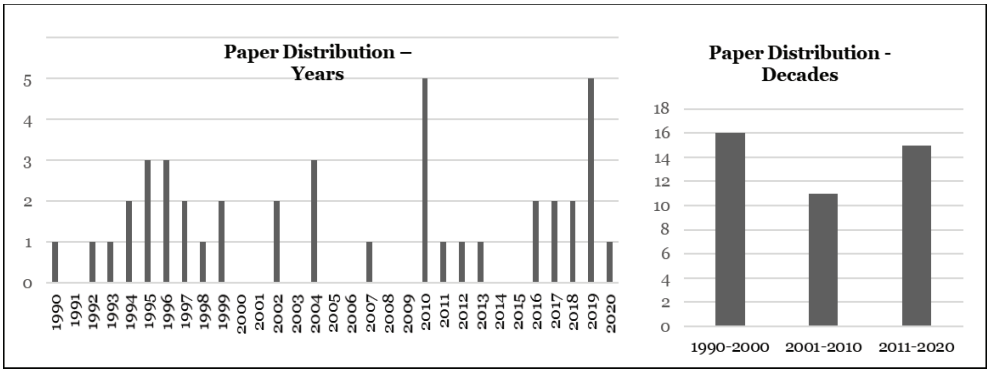


Figure 13 – Temporal Distribution of Selected Papers

Designing a Concept Matrix

To find answers to the posted research objective, the next step is the creation of a concept matrix to classify the existing literature (Webster and Watson 2002). The procedure of a qualitative content analysis was chosen, according to Mayring (2014), for a structured analysis of the commonalities in content and the respective derivable patterns. It enables the reduction of a large database to its key meanings. Mayring's (2014) widely applied method of qualitative content analysis (e.g., Semmann and Böhmann 2015; Vogelsang and Hoppe 2013) divides the procedure into six separate steps (Mayring 2014). Based on the sample, a category system using the logic proposed by Mayring (2014) was designed (see chapter A.III.2 for a detailed description). To organize the final categories and their attributes in a thematic sense, five clusters from the 19 categories with their 72 attributes were derived. The clusters result from an aggregation of each individual

category. Three meta-patterns emerged from the discussion of the results, the last step of this procedure. The meta-patterns emerged through overarching key themes that were evident across categories throughout the sample. For instance, the decentralization aspect repeatedly emerges in different categories and on different subjects, such as in the categories *Organizational Forms Archetypes, Organizational Boundaries, Interaction Boundaries, Application Reason (of information systems), Type of Products, Phenomenon Description / Research Focus*. This led to the establishment of a meta-pattern regarding decentralization. Figure 14 describes the design process of the concept matrix and presents a detailed example for a particular category.

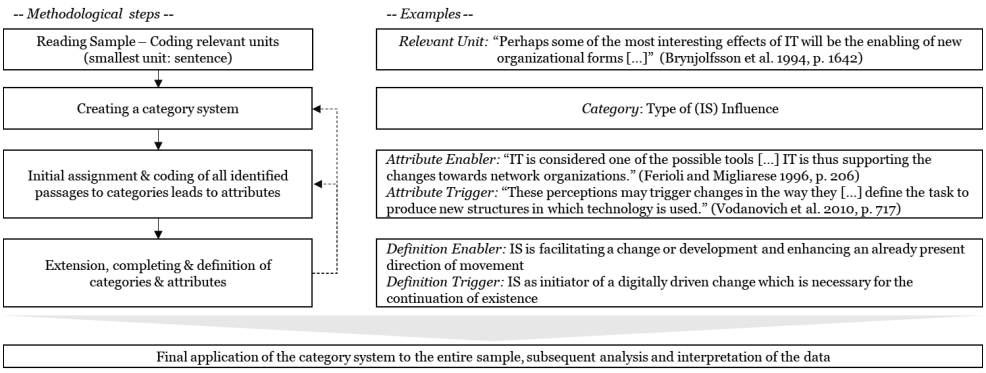


Figure 14 – Designing a Concept Matrix - Study 1

I.3 Findings

The classification of literature is carried out in five clusters, each containing several categories. Those clusters are presented briefly in the following, focusing on the most relevant categories.

The first cluster Classification of Selected Literature shows a focus on empirical research (72%), which mostly investigates the effects of specific information systems artifacts on organizations (e.g., Fiedler et al. 1996; Finnegan and Longaigh 2002; Whitaker and Krishnan 2010), while literature-driven research (28%), focuses more on conceptual work and theory building in relation to organizational forms (e.g., Huber 1990; Vodanovich et al. 2010).

The second cluster Comprehension of Organizational Forms presents the allocation of the category Organizational Forms Archetypes in which bureaucracy is the most common attribute (45%) (e.g., Brynjolfsson et al. 1994; Fedorowicz and Konsynski 1992;

Huber 1990), with assignments occurring predominantly in the first half of the sample. The bureaucracy serves as the only organizational form from which a transition to other organizational forms is described (e.g., Arunachalam 2004; Brynjolfsson et al. 1994; Lambert and Peppard 1993). Further results from cluster two present a focus on closed boundaries (60%) and inward focus (55%) rather than open (21%) or boundaryless (19%) and interorganizational focused (45%) organizational forms. Here a development toward more open and interorganizational focused organizational forms can be observed over time, as summarized by Parker et al. (2017).

The third cluster, Comprehension of Information Systems, introduces an overall focus on network and internet technologies (37%) within the category Type of Information Systems, while the last temporal quarter of the sample focuses on the still-young but highly relevant (Yoo et al. 2012) platform technologies (14%). Yoo (2010) introduces a distinction in considering the value of information systems technology, which is the basis for two deductively built categories. He differentiates instrumental value—perceiving information system technology as a supporting tool in creating value—from inherent value—perceiving information system technology as delivering user-valuable experiences by itself (Yoo 2010). Referring to Yoo (2010), the categories Value of Technology and Role of Information Systems describe the view on technologies and their contribution to organizational value creation. While the value of technology is described as instrumental for a lengthy period (84%), the description of an inherent value of technology increases in more recent papers (16%). Concerning this, the view of the role of technology is changing over time as well, from a tool to a capability.

The fourth cluster Relationship between Information Systems and Organizational Forms, differentiates the impulse for change by the categories Change Driver and Type of Influence, as characterized by Nambisan (2013). Two streams are considered. First, information systems are significantly more frequent (65%) drivers of change than organizational factors (45%). Thereby, over the second stage of the temporal development of the sample, the assignment of information systems-driven changes increases. Similarly, the influence of information systems points to a change over time, distinguishing between enablers and triggers (Nambisan 2013). It results in the peculiarity that the role of a trigger is only described if the change driver has been identified as information systems. In the role of an enabler, however, both the information systems and the organization can act as the change drivers. Organizations tend to experience an influence as a trigger less frequently (29%), occurring mostly in the most recent quarter of the sample (e.g., Saadatmand et al. 2019; Tan et al. 2019). In comparison, the role of an enabler is a broader (71%) and already broader-described phenomenon in relation to organizational forms (Huber 1990; Kambil and Short 1994).

The noticeable predominant effect when using information systems is a simplification in communication (37%) (e.g., Fedorowicz and Konsynski 1992) and an increase in networking within an organization (26%) (e.g., Whitaker and Krishnan 2010).

The final cluster Context presents a changing focus of the environment, from a rather pre-digital (Brynjolfsson et al. 1994) (73%) to a more digital (Tan et al. 2020) form of value creation. Relatedly, the study observed a change from physical products (26%) and (non-digitized) services (30%), mostly within manufacturing industries (24%), to more smart and digitized services (21%), smart products (12%), or purely digital products (12%), within high tech (11%), and entertainment industries (8%). Table 6 presents the classification of the clusters as well as the evaluation of the sample.

Table 6 – Classification Matrix

Cluster	Categories	Attributes	Huber (1990)	Bryan Hilson, Malone et al. (1994)	Radonowicz, Konsynski (1992)	Sauer, Lau (1997)	Jansen, Benson et al. (1997)	Willcocks, Smith (1995)	Hart, Saunders (1998)	Lee, Grover (1999)	Lambert, Peppard (1993)	Baskerville, Smithson (1995)	Stobbins, Sena et al. (1995)	Kambil, Short (1994)	Fersoli, Migliarese (1996)	Fiedler, Grover et al. (1996)	Winter, Taylor (1996)	Schwarz (2002)	Chiweles, Ramirez et al. (2010)	Selnick et al. (1999)	Doolin (2004)	Wagner, Newell (2004)	Arunachalam (2004)	Whitaker, Mithas, Krishnan (2010)	Sankaranarayanan, Sundaram (2010)	Finnegan, Longgigh (2002)	Tamrowski, Kosnas et al. (2007)	Bajwa, Rana et al. (2010)	Aljafari, Adler-Milstein et al. (2018)	King (2013)	Yeow, Sia et al. (2018)	Dremel et al. (2017)	Vodanovich, Sundaram et al. (2010)	Erik, Sukenik (2011)	Shieh, Wechsler (2019)	Gennamo, Santoli (2019)	Yoo et al., (2012)	Matt, Hess et al. (2016)	Staudaruud, Lindgren et al. (2019)	Tan, Pan et al. (2019)	Parker, van Alstyne et al. (2017)	Chen, Horton (2016)	Ravichandran, Omen (2019)	Tan, Ouzrus et al. (2020)
1. Literature	Research Methodology	Literature Driven	x		x						x	(x)	x		x		x			x				x		x			x				x					x				
		Empirical Driven - Quantitativ		x					x	x						x			x				x	x		x	x		x				x	x	x			(x)		x	
		Empirical Driven - Case Study				x	x	x							x					x	x	x								x	x	x				x	x	x		x	x	x
	Research Design	Process Perspective		x	(x)	x	x	x							x			x	x	x	x	x		x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x
		Snapshot Perspective	x						x	x		x	x			x	x						x		x	x	x	x	x	x			x	x			x				
2. Comprehension of Organizational Forms	Organizational Forms Archetypes	Bureaucracy	x	x	x	x		x			x	x	x	x	x	x	x	x		x		x	x	x			x						x	x	x						
		Post Bureaucracy		z			x	z				z			z		z																	x		x						
		Network		z								z			z		z						z											x								
		Plattform Ecosystem																							x				x								x	x	x	x	x	x	x
		Strategic Alliances							x						z									x		z	x	x		x												x
		Hybrid Form																								(x)			x													x
	Organizational Boundaries	Firmly Closed - Inward view (I)	x	x	(x)	x	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x								x	x	x	x	x		x			
		Mostly Closed - Relationship view (I-I/ I-n)							x																x	x	x	x			x							x				
		(Nearly) Boundaryless - Open View (n-n)																												x	x							x	x	x		x
	Interaction boundaries	Intraorganisational	x	(x)	x	x	x	x			x	x	x	x		x	x	x	x		x	x	x	x		x	x	x	x	x	x			x	x	x	x	x	x	x	x
		Interorganisational							x						x					x					x	x	x	x	x	x	x						x	x	x	x	x	x
	Decision premises	Power	x				x		x		x			x							x						x						x		x		x	x	x	x	x
		Governance		x	x	x		x		x		x	x		x	x	x	x	x	x		x	x	x	x	x		x	x	x	x		x	x	x	x	x			
3. Comprehension of Information Systems	Typ of IS	IT Architecture / System Architecture		x	x	x		x								x	x			x														x							
		Communication Systems	x				x		x	x	x	x	x		x		x		x		x			x		x							x		x						
		ERP System / EDI					(x)	(x)											x		(x)	x	x	(x)		x								x								
		Internet / Networks	x	x			(x)		x	x	(x)	(x)	x	x					x					(x)	x	x	x	x	x	x	x						x	x	x	x	x	x
		Online Plattforms																																									x
	Role of IS	Capability	x								x	x	x			x			(x)					x									x	x		x	x		x	x	
		Tool		x	x	x	x	x	x	x				x	x		x	x	x	x	x	x	x		x	x	x	x	x	x	x			x		x				x	x
	Value of Technology	Instrumental	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
		Inherent																																			x	x	(x)	x		x	(x)	x
	Application Reason	Decision Making	x		x							x		x	x	x	x																x		x							
		Linkage Usage		x					(x)		x				x							x		x	x		x		x	x	x	x						x		(x)		x
		Innovation																		(x)													(x)				x	x			(x)	
		Linkage Creation				x	x			x	x	x	x	x		(x)			(x)	x	x		x		x	x							x	x				x	x	x	
		Sales & Transactions						x	x											x							x		x													
		Performance & Efficiency Increasements		x	x			x											x		x	x													x							
4. Relationship between Organizational Forms & IS	Change Driver	Organizational Factors				x	x	x		x	x					x		x		x		x		x	x				x					x	(x)						
		IS Factors	x	x	x				x			x	(x)	x	x		x		x		x	x	x				x	x	x		x	x	x	x			x	x	x	x	x	x
	Type of Influence	Enabler	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x				x	x	x	x	x	x	x		x
		Trigger																					x	x							x	x				x	x	x	x	x	x		x
	Organizational Effects	Cost Reduction		x				x										x	x	x	x			x		x		x							(x)						
		Innovation / New Business Models																																x		x	x	x	x	x	x	x	x
		Simplification of Communication	x		x	x	x		x	x	x	(x)	x	(x)	x	x	x	x		x		x		x		x			x		x	(x)		x							
		Networking			x			(x)	x		x		x		x				x				x		x	x			x	x	x					x						
		Control Mechanisms															x					x																					
		Stabilizing					x		x		x			x				x		(x)		(x)		(x)	(x)				(x)	x	x				x			x				x
		Destabilizing	x	x	x	x			(x)		x	x	x	x	x	x	x	(x)		x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	IS Impact	Comprehensive			x		x		x	x			x	x	x	x	x	(x)	x	x	x	x	x		x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
		Partial	x	x		(x)		x			x	(x)							x		x		x		x	x		x														
		Compelling			x		x		(x)				x	x		x	(x)	x	x	x	x	x	(x)		(x)	x			x	x	x	x	x	x	x	x	x		x	x	x	x
		Complementary	x	(x)		(x)		x		x	(x)	(x)			x										x		x															
5. Context	Value Creation Focus	Digital																(x)																		x	x		x	x	x	x	x
		Pre-Digital		x	(x)	x	x	x	x	x		(x)	x		x		x	x	x	x	x	x	x		(x)	x			x	x	x	x		x			x				
	Industries	Retail					x		x														(x)		x														x			
		Health Care						x														x								x	x											
		High tech																x		x																			x	x		
		Entertainment																																			x		x				x
		Manufacturing		x				x	x	x									x				x			x						x		x							
		Public Sector				x												x					x																			
		Logistics																													x										
		Diverse											x		x				x																x		x					
	Type of Products	Physical (e.g. Cars)		x				x	x	x						(x)			x	x			x			x						x		x							
		Services (e.g. Health Care)				x	x	x	x				x		(x)				x		x	x		x		x				x	x											
		Digital (e.g. Software)																	x																	x			x	x		
		Smart Producrts (e.g. Smartwatch)																																x			x	x		x		
		Smarte Services (e.g. e-commerce)																		z					x					x							x	x	x	x	x	x
	Observation period	*1990-1980*	x																																							
		2000-1990		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x																		
		2020-2000																							x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
		2020-2019																																								
	Phenomenon description / Research focus	Communication across Hierarchies	x		x		x			x	x	x	x	x		x	x	x	x				x							x	x	x	x							
		Outcourcing / Partnerships							x		(x)				x				x						x	x		x														
		Downsizing/Cost Cutting /Efficiency Improvements		x		x		x		x		(x)								x	x	x	(x)			x																
		Networked Collaboration																												x	x	x									x	
		Plattforms/Digital Ecosystems																																			x	x	(x)	x	x	x	x

x = fully applies / (x) = partly or implicitly applies / y = changes over time | Papers ordered according to the order of the category "*Observation Period*"

I.4 Discussion and Implications

Three meta-patterns emerge from the classification analysis and reveal important insights with regard to the research objective. Furthermore, these meta-patterns represent signposts for the future development of organizational forms. In what follows, the meta-patterns are discussed in detail. An overview of all three meta-patterns is presented in Table 7.

Table 7 – Meta-Patterns Study 1

Continuous Decentralization	***Primacy of Transition***	***Towards Inherent Technology Value***	
An ongoing decentralization of organizational forms toward boundaryless organizations, networks or platform ecosystems, enabled and triggered by IS.	Sharp and planned transitions in co-evolution with IS, from one archetype of organizational forms to another without taking hybrid forms into account.	Changing technological value from instrumental to inherent which requires a combinatorial and distributed form of organizing (Yoo et al. 2010).	***Observation***
▪ Opening of organizational boundaries (Ravichandran and Giura 2019) ▪ From intra- to interorganizational focus (Tan et al. 2019) ▪ Decentral decision making (Ferioli and Migliarese 1996) ▪ From centralized to decentralized organizational forms (Chwelos et al. 2010; Fiedler et al. 1996)	▪ Transition from bureaucratic to post bureaucratic (Fedorowicz and Konsynski 1992), alliances (Stebbins et al. 1995) network (Brynjolfsson et al. 1994) and platform (Yoo et al. 2012) organizational forms ▪ Transition from governance (Brynjolfsson et al. 1994) to power decision premises (Chen and Horton 2016)	▪ New technological value creation triggers other ways of coordination and collaboration between organizational actors (Tan et al. 2020) ▪ Inherent technological value requires digital value creation and thus call for novel forms of organizing (Yoo et al. 2012)	***Indicators:*** **Organizational Forms Perspective**
▪ Decentralized computing enables simplified networking & communication (Baskerville and Smithson 1995) ▪ Networks & platforms trigger interconnection across organizational borders, temporal and geographic boundaries (Ravichandran and Giura 2019)	▪ Increase of complexity through an increase of IS enabled networking and communication (Brynjolfsson et al. 1994) ▪ Online platforms and continuous real time exchange triggered an increase of transparency, communication and interaction of information and goods (Saadatmand et al. 2019)	▪ New embedded digital technologies in consumer goods or digital apps and services have a value within itself, rather than enhancing an existing value (Yoo 2010) ▪ Inherent technological value creation triggers new opportunities to interact with customers or users and thus opens new business models (Tan et al. 2020; Yoo 2010)	***Indicators:*** **IS Perspective**

Continuous Decentralization

Decentralization of organizational forms represents the first meta-pattern. In accordance with Grandori's (1997) definition of organizational forms, this meta-pattern refers to whether organizational mechanisms are designed to permit centralized or decentralized coordination. The first clear indication of an increased decentralization is a shift in the boundary characteristics of organizational forms, which becomes obvious when analyzing the category Organizational Boundaries. Ravichandran and Giura (2019) describe this as a change from "internal focus to external value creation" (Ravichandran and Giura 2019, p. 2), which also becomes visible in the sample over time. In the first stage, the boundaries of an organization are perceived as being rather closed. Contacts and cooperation with the environment are reported rarely (e.g., Lambert and Peppard 1993; Stebbins et al. 1995). This is followed by descriptions of contacts between one organization and several external entities (1:n) (e.g., Bapna et al. 2010; Whitaker and Krishnan 2010), in which the borders are liberalized through communication, partnerships, and cooperation. This development finally converges on nearly borderless corporations across organizational boundaries (n:n) (e.g., Cennamo and Santaló 2019; Saadatmand et al. 2019). Accordingly, there is a change from the "traditional inward focus to [an] external view" (Tan et al. 2019, p. 4). The category Interaction Boundaries endorses this trend. At the beginning of the sample's time frame, observations focus is strongly on the inner of the organizational forms, i.e., on central and intra-organizational activities (e.g., Fedorowicz and Konsynski 1992; Janson et al. 1997; Sauer and Lau 1997). One example could be enterprise-wide information management and its influence on organizational forms, as presented by Seltsikas (1999). Currently, mainly interorganizational and decentralized activities are in focus (e.g., Adjerid et al. 2018; Cennamo and Santaló 2019; Tan et al. 2019). Cennamo and Santaló (2019) provide a representative description of the interaction between different actors in a platform ecosystem. A further indicator of increasing decentralization lies in allocating decision rights within an organization. The study derived this indicator from the category Decision Premises. For instance, Ferioli and Migliarese (1996) discuss the distinction between centrally made governance decisions and a more autonomous decision-making process in local organizational units with the associated degree of decentralization. In more decentralized organizational forms, decision-making focuses more on power than governance (Fiedler et al. 1996). Thereby, the allocation of decision rights depends more on the skills and knowledge of actors, i.e., their power, rather than on their respective hierarchical governance positions (Fiedler et al. 1996). This enables ideas to transcend the traditional, centralized boundaries of an organization and to

influence external actors (Vodanovich et al. 2010). This development increases the speed and flexibility of decision-making (Ferioli and Migliarese 1996). A further example within the sample is the study by Fink and Sukenik (2011), who describe the centralized mechanistic organization as "tightly controlled and more hierarchical" (Fink and Sukenik 2011, p. 307) and the decentralized organic organization as "more consensual [and] more loosely controlled" (Fink and Sukenik 2011, p. 307). As the focus of the sample shifts from predominantly governance-driven decisions to power-driven premises, an increase in decentralized management and decision-making can be assumed. An increase in decentralization is also indicated by the category Type of Products outlined in the sample. The classification shows a decrease in physical products and classic services (e.g., Hart and Saunders 1998; Willcocks and Smith 1995) and a strong increase in digital products as well as smart products and services (e.g., Dremel et al. 2017; Yoo et al. 2012). The production of physical products is much more centralized than the production of digital goods (Dremel et al. 2017). Parker et al. (2017) observe that the role of a manager within a digital platform context is changing from creating a partial, centrally-focused business optimum to an overall, decentralized-focused business optimum. A final and concise indicator of the increasing decentralization lies in the assignment of the aforementioned organizational forms within the sample. This becomes evident when evaluating the category Organizational Forms Archetypes. The centralistic bureaucracy (Huber 1990) is followed by strategic alliances (Ravichandran and Giura 2019), post-bureaucratic organizations (Castells 1996), networks (Raab and Kenis 2009), and platform ecosystems (Yoo et al. 2012), which are becoming increasingly decentralized in this particular manner. In addition, throughout this sample, various publications point out the continuing decentralization, which initially takes place through the transformation within one organization (Baskerville and Smithson 1995; Seltsikas 1999), followed by a decentralization across organizational boundaries (Vodanovich et al. 2010), within alliances (Tanriverdi et al. 2007), and finally across organizations within networks (King 2013) and platform ecosystems (Tan et al. 2020).

The ongoing decentralization outlined above is also associated with the utilization of information systems as well as the reasons behind their application. To be more precise, these interactions are derived from the categories Type of Information Systems and Application Reason. Here, decentralization becomes visible in the sample with the rise of networks and platforms (Schwarz 2002; Stebbins et al. 1995). To be specific, the decentralization of computer applications by means of networks leads to a decentralization of the organization (Baskerville and Smithson 1995). This is supported by the reasons for information systems adoption, in which more than 50% of the sample

refers to the creation or use of interconnections (e.g., Kambil and Short 1994; Whitaker and Krishnan 2010). This facilitates collaboration across organizational, temporal, and geographic boundaries (Ravichandran and Giura 2019). In addition, this argument is further supported by the positive effects of information systems on organizations. Over 60% of the papers consider information systems to enable networking - 25% - (e.g., Bapna et al. 2010) or easier communication - 37% - (e.g., Winter and Taylor 1996). Both indicate the contribution of information systems to decentralization, made possible by connections and simplified communication (Lambert and Peppard 1993; Stucki and Wochner 2019). Comparable effects of information systems are illustrated in the sample by Chwelos et al. (2010), who state that "the evolution of organizations toward more decentralized forms (via decentralization of decision authority, self-management teams, work cells, etc.), enabled by new types of decentralized technologies (e.g., PCs, servers, networking, etc.)" (Chwelos et al. 2010, p. 404) is a key factor in the transformation of organizations.

Primacy of Transition

The second meta-pattern derived from the analysis describes the strong research emphasis on the change of organizational forms (Puranam et al. 2014). Changes from one organizational form to another are key indicators of sharp and planned transitions. The first main category relevant to this meta-pattern is Organizational Forms Archetypes. Examples from the sample are usually characterized by a sharp transition without any intermediate state, e.g., from mechanistic to organic organizational forms (Fink and Sukenik 2011), from a hierarchical form to a postmodern form (Fedorowicz and Konsynski 1992), or from centralized to decentralized organizational forms (Chwelos et al. 2010; Fiedler et al. 1996). Interestingly, hybridity, i.e., the parallel existence of different archetypes, is only mentioned in five papers. Thus, the focus lies strongly on the transition from one mostly bureaucratic form to another organizational form. A comparable absence of hybrid forms is also illustrated in the category Decision Premises. Here, a clear mixed hybrid form is only recognized in two examples (Cennamo and Santaló 2019; Fink and Sukenik 2011). The process of a sharp transition is also evident in the category Value Creation Focus. While organizations were described in a pre-digital context for a long time (e.g., Brynjolfsson et al. 1994; Sauer and Lau 1997), an almost abrupt change to digitally influenced organizations takes place in the last timely quarter of the sample (e.g., Saadatmand et al. 2019; Tan et al. 2019). Adjerid et al. (2018), for example, see traditional organizations "thriving" and raise the question of whether those organizations will endure in future times. Comparable transitions are also evident regarding the produced goods, as can be derived from the category Type of Products. Whereas in the early stages, primarily physical products (e.g., Brynjolfsson et

al. 1994; Willcocks and Smith 1995) and services (Janson et al. 1997; Sauer and Lau 1997) were specified, digital products (Chen and Horton 2016) or smart products (Hess et al. 2020), as well as digital services (Saadatmand et al. 2019; Tan et al. 2019), are currently in the focus of research. It is striking that mixed forms, in other words, hybridity (Seibel 2015), are under scarce research in the sample. It focuses on ideal archetypes without considering hybrids, combinations, intermediate stages or other similar issues. Furthermore, it is noticeable while evaluating the sample that a transition among organizational forms is usually seen as planned or occurs abruptly and without a precisely described intermediate stage. This development was derived from the category Organizational Forms Archetypes. Astonishingly, this hybrid form of organizing receives only little attention since, as already described in Kolbjørnsrud (2018), it has a practice-relevant place, especially when change occurs (Hennart 1993; Kolbjørnsrud 2018). One of the few exceptions in the sample is Dremel et al. (2017), who analyze the transformation within the automotive industry. They point out that decentralized "networks complement the traditional organizational structure" (Dremel et al. 2017, p. 94). They refer to digital innovation units as the linkage between bureaucratic and post-bureaucratic forms of organizing. Referring to the research question, the categories Change Driver and Type of Influence offer an answer to the interaction between information systems and the change of organizational forms. Understanding the reason for change is investigated in the category Change Driver. It shows that information systems are the driving factor of change in about two-thirds of all papers. Early on, Brynjolfsson et al. (1994) already stated that using information systems could lead to a transition in organizational forms to cope with the upcoming rise of complexity through increased networking. Possible transition goals are described in the sample, for example, as "networks, ad-hocracies or more complex forms" (Brynjolfsson et al. 1994, p. 1642). In the papers where organizational development determines the change, information systems are considered as enabler as well, i.e., to establish better connections between individual units using information systems and thus build a network organization (Ferioli and Migliarese 1996). One example from the sample is Ferioli and Migliarese (1996), who point out that "IT is considered one of the possible tools" (Ferioli and Migliarese 1996, p. 206) to enable a change of organizational forms, and "IT is thus supporting the changes toward network organizations" (Ferioli and Migliarese 1996, p. 206). Since information systems served for a considerable time as an enabler for new organizational forms, they are now increasingly assuming the role of a trigger, as stated by Vodanovich et al. (2010). They illustrate that "these perceptions may trigger changes in the way they [...] define the task to produce new structures in which technology is used." (Vodanovich et al. 2010, p. 717). This development can be

further derived from the category Type of Influence. Here, increased pressure for change can be identified, in particular, initiated by information systems artifacts. Examples derived from the sample are the creation of platform ecosystem initiatives within the transportation industry caused by increased information transparency through networks (Saadatmand et al. 2019) or the transformation of the Korean pop industry compelled by technological advancements (Tan et al. 2020). This movement is driven primarily by the usage of new and broader digital technologies and digital innovations, as well as their current widespread availability (Yoo et al. 2012; Yoo et al. 2010). This broader influence of information systems triggers a different organizational response to cope with rising needs and complexity (Yoo et al. 2012). The role played by information systems in interacting with a change in organizational forms is thus made visible. The increased pressure to transform may be an indicator, explaining why the studies describe change as plannable and sharp. To do fair justice to this pressure, it seems necessary to implement the change directly without taking time for an intermediate and hybrid step. This study remarks upon the fact that as the influences of information systems become more dynamic, there is still little or no focus on hybrid organizational intermediaries in the most recent studies of the sample (Saadatmand et al. 2019; Tan et al. 2020).

Towards Inherent Technology Value

Yoo (2010) introduced the distinction between an inherent and an instrumental value of technology. He differentiates instrumental value, perceiving information systems technology as a supporting tool in creating value by facilitating information and communication, from inherent value, perceiving information systems technology as delivering valuable user experiences by itself via digital products, services, and platforms (Yoo 2010). The study implemented the category Value of Technology to investigate this development. While the value of technology is described as instrumental for a lengthy period (84%), the description of an inherent value of technology increases in more recent papers (16%). The sample shows the establishment of an inherent value of technologies in recent times (e.g., Cennamo and Santaló 2019; Parker et al. 2017; Saadatmand et al. 2019). Practical examples presented within the sample are, for instance, building an entire ecosystem around the Korean pop scene, which offers value in itself. Without the increased availability of social networks or streaming services, it would not be possible to build this ecosystem, which as a whole, offers greater value than its parts (Tan et al. 2020). Another example drawn from the sample is the development of digital apps and digital games by Ravensburger AG, a mid-sized German game publisher. In addition to the core business, consisting of analog games, the offering is supplemented and extended by the inherent value of digital experiences (Hess et al. 2016). It supports the thesis that an inherent value could only be created by increasing technological

possibilities (Yoo 2010). Increasing technological possibilities and their usage are also reflected in the classification of the category Type of Information Systems, e.g., in the increase in networking or platform ecosystems. A relevant instance of this change, presented in the sample, is the introduction of digital services into the automotive world, which changes the value from a tool - instrumental - to a value in itself - inherent - (Dremel et al. 2017).

The shift toward an inherent value of technology has strong effects on the corresponding organizational forms. While an instrumental value leads rather to optimizations within organizations, such as simplified communication (e.g., Janson et al. 1997; Sauer and Lau 1997) or cost reduction (e.g., Willcocks and Smith 1995), all papers that ascribe an inherent value, identify the use of technology for innovations. This development can be derived from the category Application Reason. Moreover, a link between the way an organization creates value and its attribution of technological value is identified. Six out of seven papers that describe an inherent value simultaneously pursue organization-wide digital value creation, which can be deduced from the category Value Creation Focus. Technology is not used as a tool to simplify or control non-digital value creation but as a capability that can create its own value. This observation is connected to the category Role of Information Systems. While technology has long been seen as a tool for solving problems - in other words, as having an instrumental value –(e.g., Adjerid et al. 2018; Brynjolfsson et al. 1994; Winter and Taylor 1996), it is nowadays increasingly assigned to the role of a capability (Cennamo and Santaló 2019; Stucki and Wochner 2019). Information systems contribute no longer as process enablers for producing non-digital goods and services but become themselves the center of value creation, e.g., with digital and smart products and services (e.g., Cennamo and Santaló 2019; Saadatmand et al. 2019). Within the sample, Parker et al. (2017) point out that the boundaries of digital products are more loosely defined as compared to physical products, which leads to more cooperation within organizational forms. This entails a new product architecture that can no longer be built on linear and plannable supply chain mechanisms but rather seeks for networks and platform ecosystems (Yoo et al. 2010). In addition, the production and innovation of digital goods and products follow no longer a linear process but require more dynamic forms of problem-solving (Nambisan et al. 2017). A practical example, drawn from the sample, is presented by Parker et al. (2017), who represent a decentralized and dynamic software production with widely distributed actors within an ecosystem. As information systems evolve from instrumental to inherent value, which affects their interrelationship with organizational forms. Another example, derived from the sample, is the study by Tan et al. (2019), who argue that digitalization and the value of technology "play a significant role in shaping agility for

many firms, [...] and cultivate emergent organizational forms" (Tan et al. 2019, p. 2). While information systems have long served as an enabler to facilitate organizations' change, they are now the reason for change and the center of developing for new organizational forms (derived from category: Type of Influence). Platform ecosystems provide the perfect example (Saadatmand et al. 2019; Yoo et al. 2012). Thus, a new narrative is emerging that places information systems in the leading role within a co-evolutionary development.

I.5 Synthesis

The meta-patterns reveal an evolution and shift in the narrative of organizational forms and information systems (see Figure 15). As described in pattern one, the organizational form changes by becoming more decentralized (Ravichandran and Giura 2019), as well as presented in pattern two, by showing a primacy of transition of respective archetypes (e.g., Brynjolfsson et al. 1994). The third pattern describes a shift from an instrumental to an inherent technological value (Yoo et al. 2010). Taking together all three meta-patterns, another observation becomes evident: There is a shift in the narrative surrounding the co-evolution of organizational forms and information systems. Accordingly, three temporal phases are derived from the sample. In the first phase, information systems are predominantly used to optimize processes and communication. In doing so, it supports organizational transformation as a tool. In the second phase, information systems enable the development of existing organizational forms and facilitate the change of existing organizations. In the last and current phase, however, information systems are the driving factor that triggers transformation. The development reverses, and information systems serve, on the one hand, as a prevailing trigger for transformational dynamics and, on the other hand, as the nucleus around which new organizational forms evolve, as exemplified by networks and platform ecosystems. The crucial factor is the focus on value creation. Since digital products and services have become the center of value creation, the dynamic of co-evolution is shifting. The new narrative of organizational forms and information systems results from highly dynamic digital innovations and products and thus demands highly dynamic organizational solutions (Nambisan et al. 2017). To conclude, the co-evolution between organizational forms and information systems changes from enabling dynamics to inherent dynamics.

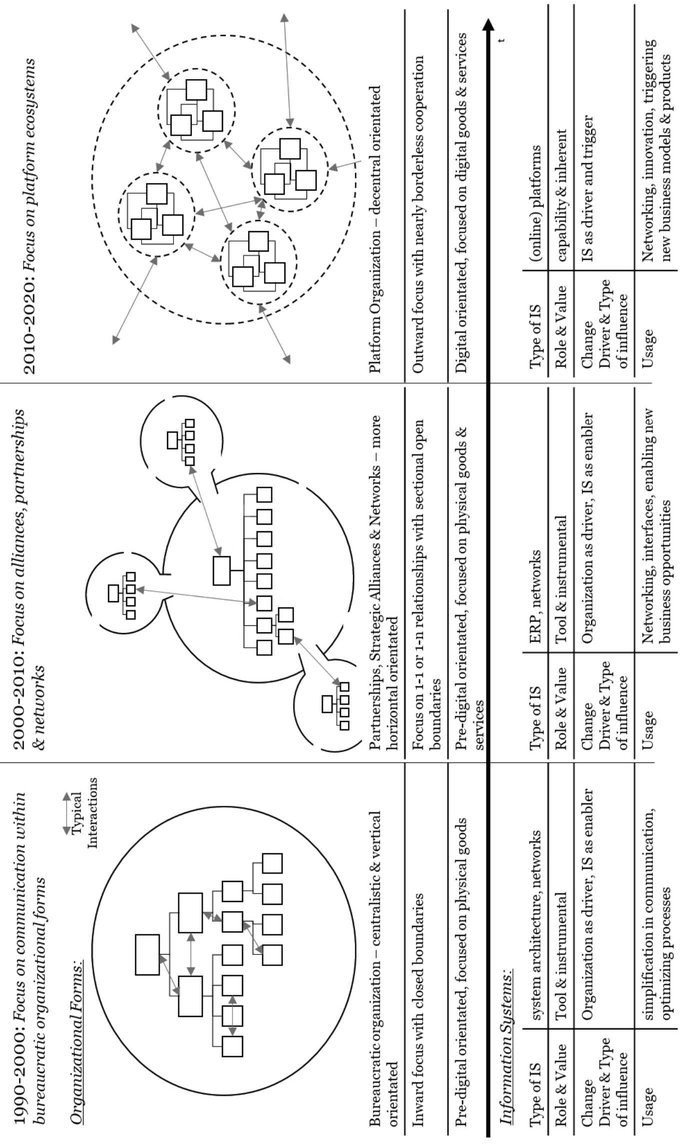


Figure 15 – Co-Evolution of Organizational Forms and Information System

I.6 Managerial Implications

As the meta-patterns demonstrate, organizational forms change over time and under the influence of information systems (e.g., Brynjolfsson et al. 1994; Chwelos et al. 2010). Regarding these transformational dynamics, the analysis provides considerations of relevance for practical application in the context of contemporary digital transformation. On the one hand, it is possible to look back into the past to be inspired by earlier transformation concepts and cultivate a more mindful perspective. In this regard, it should be questioned whether the current fashions and the excitement surrounding the "new" digital technologies are actually that new. Many concepts and ideas today are surprisingly similar to those of past periods. A suitable example is the current trend of holocratic organizational forms, with their long history into the 1980s (Mintzberg 1983). The difference between then and now is based on the evolution of information systems and their effects on organizations (Hanelt et al. 2021a). While technologies historically have facilitated changes as an enabler (Brynjolfsson et al. 1994; Ferioli and Migliarese 1996), technology today tends to act as a driver and reason for transformations in the form of a trigger (e.g., Chen and Horton 2016; Yoo et al. 2012). The value assigned to technology within an organization has also evolved over time (Yoo 2010). Thus, a simple copy of past transformation projects is unlikely to be viable in practical use and implementation. The usage of managerial best practices and success stories should be questioned due to the unique context of every transformation. Today's change pressure extends beyond the changes of previous information systems implementations, both in IT-related and non-IT-related organizations (Vial 2019). Moreover, the digital transformation requires a change in perspective from an episodic to a continuous change approach - triggered by digital technology (Hanelt et al. 2021a).

In conclusion, however, it is recommendable in all the current fashions of digital transformation to take a look at previous developments as inspiration and set them in the current technological context and current dynamics, like platforms. In line with Puranam et al. (2015), a (re-) combination of existing ideas and methods can create a new organizational form. The following steps would be recommended to implement the findings in practical use: Organizations need to be aware of information systems' contemporary influence within a co-evolutionary development. While information systems have long served as the enabler of planned (organizational) transformation, they are now the driving factor of change. Accepting these dynamics will make it, second, highly relevant to be able to constantly learn, adapt, and change as an organization.

The managerial implication concludes that while the change of bureaucratic organizations by information systems has already been investigated intensively and for

a considerable period, the current environment is quite different in character, which is why the changes nowadays should not be dismissed as a recurring fashion. However, it cannot be denied that similar problems have already been described. It is now up to future managers to put existing concepts into the current context and thereby not lose the incumbent organizations on their way to a digital future.

I.7 Theoretical Implications

Although a broad view of the relationship between information systems and organizational forms already exists, the current development of digital technologies and the resulting digital innovations generates a new need to address this issue. Through the analysis of the existing literature, the study contributes to scholarship by demonstrating that current technological developments have an unprecedented impact on organizational forms. The study contributes to the idea of a joint co-evolution of information systems and organizational forms and is confident that the research may improve the theoretical knowledge through conducting a longitudinal meta-analysis. The findings are valuable as a starting point for further investigations on the joint co-evolution of information systems and organizational forms, considering technological development. The three meta-patterns will help to enhance the understanding of the present transformational dynamics. The first meta-pattern contributes to the issue of how organizational forms will evolve in terms of boundaries and interorganizational connections (e.g., Ravichandran and Giura 2019). The study presents an overview of past and current progress in the ongoing process of decentralization. The research has implications for academia, providing a base for future research possibilities. One interesting question is whether the observed states already represent a climax of decentralization or whether a reversal to centralization will occur soon, as described in the sample by Fink and Sukenik (2011). Another question arising is how manufacturers of physical goods can react to this decentralization, given that the core of their value creation currently takes place and is controlled centrally. Similarly, within the production of smart products, the combination of physical layers and digital layers (Yoo 2010) raises the issue of how cooperation between very centralized (hardware) and, in the future, even more decentralized (digital) organizational forms will be shaped. This issue needs to be solved through a form of ambidexterity (Tushman and O'Reilly 1996); for example, enabled by the contemporary phenomenon of digital innovation units (Raabe et al. 2020a). Yet, firms must consider previously studied tensions and hurdles while integrating those post-bureaucratic forms of organizing into the established bureaucratic context (Svahn et al. 2017).

Concerning the second meta-pattern, the primacy of transition, the study contributes to the current literature by providing a base for discussing further research avenues. It will be interesting to observe whether and how new organizational forms of self-organized platform ecosystems will prevail and in which areas these forms will be less appropriate. It should also be questioned why the sample often and early on (e.g., Brynjolfsson et al. 1994; Lambert and Peppard 1993) describes a change toward more self-organization, but self-organized organizational forms outside the platform ecosystem context are only studied in very few cases (e.g., Janson et al. 1997). The findings could serve as an encouragement to further investigate the development of self-organized forms. In addition, it will be interesting to see how organizations, especially those that are currently based on the old narrative, are striving for a transition to the new narrative. This process, currently connoted with the term *digital transformation* (e.g., Hanelt et al. 2021a; Wessel et al. 2021), is often identified as a lengthy one that almost inevitably leads to hybrid forms (Kolbjørnsrud 2018). This study contributes to academia by suggesting that there is no common ground regarding whether these hybrid states are intermediate or permanent. The constant need for physical products, often manufactured in the old narrative (Parker et al. 2017), suggests the latter. For this state, compatible forms of collaboration between both worlds urgently need to be explored and developed. Building on these findings as a starting point, further research should investigate the role of hybrid organizational forms within a firms' digital transformation. Furthermore, the study contributes to the literature stream on organizational ambidexterity by suggesting that the findings can open a further relevant research area in this context (Nadkarni and Prügl 2021; Vial 2019). To consider a two-handed organizational approach between exploration and exploitation (Tushman and O'Reilly 1996) could be an appropriate link to the findings. A current orientation is the introduction of digital innovation units within incumbent organizations to gain ambidexterity (e.g., Fuchs et al. 2019; Holotiuk 2020). Although it gains multiple attention in practice (e.g., Capgemini and MIT 2021; Lau et al. 2021), this field of research is currently scarce in various domains, like its real impact, evolutionary perspectives, and integration approaches (Trischler et al. 2022). Lastly, the observed primacy of transition is an ongoing process and, in line with the lens of co-evolution, seems to lead to continuous and ongoing adaptation (e.g., Breslin 2016; Montealegre et al. 2014).

Thirdly, the study confirms the findings of Yoo et al. (2012) by elaborating on the change in technological value and setting it into the context of organizational transformation. Building on these findings, the study could further help to examine whether this inherent

value will continue to increase in the future and whether it can also be created outside of digitally-built companies. Future studies should target investigating organizational forms' influence on creating digital technologies' inherent value. In line with Dremel et al. (2017), the study offers a valuable indication that more self-organization and post-bureaucratic forms of organizing are required for areas working on this issue. One of the theoretical implications is to provide a starting point for further work that focuses on the new role of information systems, standing at the center of new organizational forms and serving as the key value driver. This could be a vital issue for future research.

In detail, first, research indicates digital innovation units as a vital organizational alteration to enable the alteration of traditional bureaucratic organizational forms (Svahn et al. 2017). Those should be investigated in greater detail. Further, the synthesis of the three meta-patterns provides a signpost for the future development of co-evolution between organizational forms and IS. This could provide a solid foundation for further investigations in this regard, focusing on the pace, continuation, and level of observation (Hanelt et al. 2021a). Furthermore, the study contributes to the existing literature on digital transformation by elaborating on different phases of organizational change over a long period as well as presenting an overview of a current narrative of contemporary organizational forms (e.g., Hanelt et al. 2021a; Vial 2019; Wessel et al. 2021). Overall, the findings contribute to the idea of co-evolution, complementing a comprehensive view from a meta- and long-term perspective. The meta-patterns, as well as the managerial implications, represent signposts for the future development of organizational forms. To implement the findings in scholarship, this study offers future research opportunities to further deepen the investigation of digital transformation. The study derived a shift from enabling dynamics to triggering dynamics. Hence, research will serve as a base for future studies on this development.

I.8 Limitations

The study is not without limitations. First, the selection of the sample has to be mentioned. Although a certain qualitative evaluation was introduced by the selection with reference to the "VHB Jourqual Ranking", nevertheless, a biased view of contents and research streams cannot be excluded. Second, this also bears the risk of excluding relevant papers that were not considered by this distinction. While the research relies on a non-biased and general investigation of the interaction of information systems and organizational forms, the sampling was designed accordingly open, focusing on the term "Organizational Form*". A further valuable and relevant research stream could focus on terms like "Transformation" or "Organizational Change" as a preliminary part of the sampling process to start with a more focused view on transformational dynamics.

Furthermore, using a concept matrix entails a trade-off between a certain level of detail and a general comparison. To obtain a more detailed perspective on the interactions between information systems and organizational forms, the degree of granularity has been reduced. However, this also provides the potential for future research projects conducting deep dives into specific clusters or categories. Lastly, the study has focused on a more theoretical view, while investigating the interaction of information systems and organizational forms. As to this focus, the study deemphasized contextual aspects like the influence of different regional or organizational cultures. Another interesting aspect could be an examination of how different sizes of organizations lead to different transformational paths. This could lead to a valuable future research stream.

I.9 Concluding Remarks

In sum, Study 1 derives valuable insights for understanding digital technologies' and digital innovations' impact on organizational forms. By evaluating the influence of information systems on organizational forms over recent decades, this study looks back on previous information technology-enabled organizational transformations to explore possible similarities to learn from and build on and to investigate peculiarities and novelties in contemporary digital times. It answers RQ1 - "How do industrial-age incumbents adapt their organizational forms to emerging digital technologies and innovation?" - and derives numerous findings with regard to organizational adaptations as a response to emerging digital technologies and innovation:

1) an ongoing decentralization that transcends organizational and industrial boundaries;
2) an archetypal transformation in organizational form from bureaucratic to post-bureaucratic;
3) a constant need for change and adaptation and the primacy of transition, which is manifest in more adaptable and malleable organizational forms;
4) a shifting role for technologies in the process of transformation and in the establishment of new organizational forms;
5) a co-evolutionary development between digital technologies and organizational forms, in which digital technologies' role changes from enabling dynamics to triggering dynamics.

Since this study identifies hybrid organizational forms within industrial-age incumbents as a way to incorporate post-bureaucratic organizational forms into an existing bureaucratic context, initiatives that facilitate these assumptions should be the focus of further investigation. Previous research has identified digital innovation units as a vital strategic initiative for embedding post-bureaucratic forms of organizing to cope with digital innovation and technologies (Brauer et al. 2021; Jöhnk et al. 2022). Digital innovation units are a timely topic in information systems research, but scholarly inquiry remains in its infancy (Holotiuk and Beimborn 2019; Raabe et al. 2021). Digital innovation units have been defined "as autonomous entities that aid their respective main organization in the development of digital capabilities and in the search for and creation of new digital products, services, and processes" (Schumm et al. 2022, p. 1). They are vital to digital innovation and digital transformation endeavors (e.g., Jöhnk et al. 2022; Raabe et al. 2020a; Svahn et al. 2017), since they are inherently built on digital capabilities (Hellmich et al. 2021), produce novel digital outcomes (Svahn et al. 2017) and can aid in the execution of digital transformation endeavors (Chanias et al. 2019).

However, contemporary research leaves open how they can be incorporated into an industrial-age incumbent to develop valuable and applicable digital innovation, what their real implications are, and how they evolve to increase their implications. While previous research on digital innovation units has provided initial qualitative insights into their activities and objectives (Raabe et al. 2021) as well as their purposes (Barthel et al. 2020; Fuchs et al. 2019), there is little long-term empirical evidence – whether qualitative or quantitative – on how they enable digital innovation and how that can lead to performance impacts and implications for building competitive advantage (Mayer et al. 2021). In addition, previous research provides only general details on how digital innovation units are established and positioned and how they evolve over time within an existing framework (Trischler et al. 2022). These gaps lead to RQ2.

II. Establishing Digital Innovation Units

This section focuses on the second research perspective, establishing digital innovation units, and is related to RQ2: "How can the establishment of digital innovation units a) facilitate the development of digital innovation within industrial-age incumbents, and b) how do they co-evolve over time?"

To answer this two-part question, this section builds on two studies that are related to previously submitted and (partly) published papers. While the first study in this section (Study 2) describes the establishment of digital innovation units and the mechanisms that enable their evolution and growth (Schumm and Hanelt Submitted), the second study in this section (Study 3) investigates the implications of digital innovation units on firm performance and their ability to serve as a foundation for dynamic capabilities (Schumm et al. 2022).

Study 2: Survival and Growth of Digital Innovation Units

II.1 Introduction

Inaction on digital innovation exposes industrial-age incumbents to the risk of client, market share, and reputation loss to upcoming born-digital competitors (Gregory et al. 2018). While born-digital firms seem to effortlessly grasp digital innovation (Huang et al. 2017), incumbents are confronted with tremendous challenges (Chanias et al. 2019; Yoo et al. 2012) and specific hurdles and pitfalls (Piccinini et al. 2015). In addition, digital innovation follows an evolving and reprogrammable architecture (Yoo 2010) and remains flexible during and beyond the process of innovation (Henfridsson et al. 2014), whereas traditional physical innovation requires a solid pre-specification of product attributes and linearly executed innovation processes (Baldwin et al. 2000; Hylving et al. 2012). Since industrial-age incumbents are built on a rich tradition of incremental innovation inside a physical product environment (Hylving and Schultze 2020), they often lack important digital capabilities to engage in digital innovation (Sambamurthy et al. 2003; Yoo et al. 2012). Digital capabilities "allow organizations to use digital resources for innovation purposes" (Wiesböck and Hess 2020, p. 80) and are seen as a vital foundation to evolve and grow in a challenging digital environment (Warner and Wäger 2019; Wiesböck and Hess 2020). Consequently, industrial-age incumbents are increasingly required to build digital capabilities (Warner and Wäger 2019; Wiesböck and Hess 2020) to enable a shift in their traditional innovation and participate in digital innovation (Nambisan et al. 2017).

Facing this need for digital capabilities to engage in digital innovation, industrial-age incumbents establish multiple yet often competing initiatives (Chanias et al. 2019; Jöhnk et al. 2022; Keller et al. 2022). One prominent example is the establishment of specialized organizational entities known as digital innovation units (e.g., Jöhnk et al. 2022; Svahn et al. 2017). They are "autonomous entities that aid their respective main organization in the development of digital capabilities and in the search for and creation of new digital products, services, and processes" (Schumm et al. 2022, p. 1). In contrast to other digital innovation initiatives, such as the formation of external digital alliances (Chanias et al. 2019), the cooperation with external ventures (Islam et al. 2016), or investment in digital mergers and acquisitions (M&As) (Hanelt et al. 2021b), digital innovation units initiate the creation and development of idiosyncratic digital capabilities internally (Schumm et al. 2022; Svahn et al. 2017). Novel capabilities should be built and supplied internally, not bought, to enable an intrinsic link to the firm's strategy and activities (Teece 2018) and to integrate them into the established

organizational context (Keller et al. 2022; Teece 2007). Additionally, in contrast to other initiatives, digital innovation units, as distinct organizational units, can be characterized as structural alterations of the main organization and, therefore, as direct manifestations of a firm's digital transformation endeavor (Hanelt et al. 2021a). Digital innovation units' impact increases as they become more established and grow in size, speeding their effectiveness and obtaining internal acceptance (Chanias et al. 2019; Dremel et al. 2017; Svahn et al. 2017).

However, digital innovation units' survival and growth are aggravated due to two specific challenges. First, to deliver novel capabilities and digital innovation outcomes to their main organizations, digital innovation units must assure a minimum level of applicability and integration (Svahn et al. 2017). On the one hand, they must take into account the pre-digital environment and organizational characteristics of industrial-age incumbents (Sandberg et al. 2014) —that is, an established information-technology infrastructure (e.g., Tumbas et al. 2017a), bureaucratic organizational structures and processes (e.g., Lyytinen et al. 2016), and a traditional, pre-digital work culture (e.g., Lucas and Goh 2009). On the other hand, digital innovation units are also responsible for inspiring and triggering change and adaptations in these dimensions (Raabe et al. 2020a). These contradictory forces can lead to conflicts concerning technical and product aspects, as well as organizational prerequisites (e.g., Hylving and Schultze 2020; Svahn et al. 2017). Although digital innovation in industrial-age contexts is about "the carrying out of new combinations of digital and physical components to produce novel products" (Yoo et al. 2010, p. 2) and is based on the introduction of a modular-layered product architecture, both digital and physical product components and organizational prerequisites must be combinable (Yoo 2010). Thus, while being deliberately geared toward digital innovativeness, digital innovation units need to be sensitive to integration requirements in a pre-digital environment (e.g., Hylving and Schultze 2020; Svahn et al. 2017), which can lead to distinct physical–digital tensions (Piccinini et al. 2015). Second, digital innovation units compete with multiple concurrent internal and external digital innovation initiatives (Chanias et al. 2019; Jöhnk et al. 2022; Nadkarni and Prügl 2021), such as digital M&As (Hanelt et al. 2021b), or the incorporation of digital top management (Firk et al. 2022), all of which demand finite organizational resources—such as attention and funding—to increase their impact (Jöhnk et al. 2022). Faced with these internal competitors, digital innovation units must find ways to deliver quantifiable value for their main organizations (Schumm et al. 2022) and integrate themselves into the existing organizational context (Lorson et al. 2022) to secure their survival and growth (Chanias et al. 2019; Raabe et al. 2021).

Although some studies depict digital innovation units as vital initiatives to overcome capability gaps (Schumm et al. 2022) with the impact increasing as these units grow and expand (Chanias et al. 2019; Svahn et al. 2017), prior research falls short in explaining how digital innovation units survive and grow while facing integration hurdles (Svahn et al. 2017) and internal competitiveness (Chanias et al. 2019; Jöhnk et al. 2022; Nadkarni and Prügl 2021). The research attempts to address the following research objective to understand digital innovation units' evolution:

How and why do digital innovation units inside industrial-age incumbents achieve survival and growth?

Drawing on an exploratory case study, this study investigated 16 digital innovation units inside the CarOrg (anonymized) group, one of the world's leading automotive OEMs, including numerous diverse and international brands. CarOrg represents an appropriate example since automotive OEMs are confronted by tremendous pressure to create novel digital offerings (Hanelt et al. 2021b; Svahn et al. 2017), while they are traditionally built on "a strong hardware legacy, where development processes and organizational structures are typically adjusted and reflected in the physical product, i.e., the car" (Hylving and Selander 2012, p. 2). In addition, prior research has acknowledged that automotive OEMs intend to accelerate digital innovation efforts by establishing digital innovation units (e.g., Dremel et al. 2017; Svahn et al. 2017; Wulf et al. 2017). By studying the development of CarOrg's digital innovation units, this research observed their ongoing evolution and derived three mechanisms driving digital innovation units' survival and growth: *directed innovation, rapid value focusing,* and *participatory enablement*. Utilizing the lens of general Darwinism (GD), this study defines the mechanisms and their evolution over time. Since this lens is commonly employed to portray evolutionary survival and growth in organizational development (Hodgson 2013; Van de Ven and Poole 1995), it enables the researcher to investigate and characterize the ongoing process of change and adaptation within a competitive environment.

The study contributes to the literature on digital innovation in multiple ways. First, it deepens the knowledge about overcoming the central tensions arising from integrating physical and digital components in the course of digital innovation (Piccinini et al. 2015). Second, while much is known about external digital ventures, their inner workings, such as their mechanisms for growth (Huang et al. 2017), and the concepts for gaining acceptance and legitimacy in competitive environments (Fisher et al. 2017; Überbacher 2014), very little is known about their internal counterparts (i.e., digital innovation units), which struggle for survival and growth in a challenging internal environment.

The study examines survival and growth mechanisms in a competitive context and compares its findings to those of the external digital venture literature (e.g., Huang et al. 2022; Tumbas et al. 2017a). Third, it contributes to the literature on digital innovation by pointing out that the digital innovation unit's establishment as a structural alteration of the main organization changes the existing organizational form in response to the diffusion of digital technologies (Schumm and Hanelt 2021), which leads to the assumption that digital innovation units may serve as a linkage between digital innovation and digital transformation and lead to more hybrid and malleable organizational forms (Hanelt et al. 2021a).

II.2 Background

Digital Innovation Units – Objectives, Growth, and Evolution

Digital innovation in industrial-age incumbents means changing the way of innovating (Nambisan et al. 2017; Yoo et al. 2012). Whereas born-digital organizations build their growth on digital innovation (Huang et al. 2017), incumbents are challenged to alter their innovation processes for the digital age (Yoo et al. 2012), since digital and physical innovation differ significantly in terms of flexibility, pre-specification, and speed (e.g., Henfridsson et al. 2014; Yoo et al. 2012). Industrial-age incumbents frequently lack the required capabilities to quickly adapt to the fast-changing and iterative requirements of digital innovation (Svahn et al. 2017; Yoo et al. 2012). Therefore, they are urgently required to find a way to develop or source digital capabilities (Warner and Wäger 2019; Wiesböck and Hess 2020) to enable a change in their traditional innovation and engage in digital innovation (Nambisan et al. 2017).

Since digital innovation units are deemed to serve as the organizational foundation to build and supply novel (digital) capabilities for their main organizations (e.g., Hellmich et al. 2021; Schumm et al. 2022), while their digital innovation objectives are tightly linked to their main organizations (Raabe et al. 2020a), these units may lead to mechanisms that incorporate and supply new capabilities and digital outcomes that consider both digital and physical components and conditions (Svahn et al. 2017).

Digital Innovation units represent unique organizational units established to purposefully explore and develop digital products and services (Barthel et al. 2020; Raabe et al. 2021). The beneficial impact of digital innovation units' outcomes appears to rise over time as they become more established and grow, thus accelerating their efficacy and gaining internal acceptance (e.g., Chanias et al. 2019; Dremel et al. 2017; Svahn et al. 2017). Digital innovation units are being built on the premise of post-bureaucratic organizational forms (Barthel et al. 2020), including an open and agile

culture (Hellmich et al. 2021), no or flat hierarchies (Raabe et al. 2020a), and a focus on and broad expertise in agile work principles, such as Design Thinking, Kanban, and Scrum (Haskamp et al. 2021b; Holsten et al. 2021). Additionally, digital innovation units have objectives and aim for outcomes with a digital focus (Schumm et al. 2022) within a non-digital context (Barthel et al. 2020; Haskamp et al. 2021b; Raabe et al. 2021). This digital focus distinguishes digital innovation units from other internal ventures or independent organizational innovation entities (e.g., Gassmann and Becker 2006).

Notable instances in the automotive industry describe how digital innovation units can facilitate the integration of digital knowledge in the realm of big data analytics to develop novel digital services (Dremel et al. 2017) and how they supply main organizations with digital components to enable connected vehicle functions (Svahn et al. 2017; Wulf et al. 2017). Despite a spatial, procedural, and cultural separation from the main organization to enable and secure an innovative environment (Holsten et al. 2021), digital innovation units' activities and outcomes are inextricably bound to the strategic priorities of their main organizations (Chanias et al. 2019). This dependency appears to be stronger in physical product–based industries (e.g., automotive) (Svahn et al. 2017), in which physical and digital components must be combined to generate a multilayered product architecture (Yoo et al. 2010). This can lead to distinct organizational tensions (Piccinini et al. 2015) in addition to those over the combination of digital and physical product components (Yoo et al. 2010), as the organizational governance of manufacturing physical items is fairly hierarchical and sequential, while digital products impose more networked and loosely coupled organizational structures (Hanelt et al. 2021a). Tensions can emerge on several levels, such as roles, boundary openness, knowledge sharing, and responsibilities (Hylving and Schultze 2020; Svahn et al. 2017). Concrete automotive industry examples that lead to distinct tensions are different development cycles between digital and physical components, which, however, must be combined, or divergent organizational cultures and strategical visions, which yet must serve the same customer (McKinsey 2020; Porsche-Consulting 2020). These conflicts and tensions hamper the growth ambitions of digital innovation units and affect their focus on disruptive digital innovation outcomes, since they must constantly examine their main organizations' pre-digital constraints (Svahn et al. 2017). Additionally, digital innovation units encounter a second hurdle for growth, as they must compete with other initiatives aimed at developing and supplying novel digital capabilities for the main organization (Jöhnk et al. 2020; Nadkarni and Prügl 2021). Besides sourcing digital capabilities externally—for example, through external digital alliances and collaborations (Chanias et al. 2019; Islam et al. 2016) or digital M&As (Hanelt et al. 2021b)—the main organization could seek to build those capabilities internally through

the incorporation of digitally focused top managers, such as Chief Digital Officers (CDOs) (Tumbas et al. 2018), the sourcing of digital talents (Singh and Hess 2020), or digital education (Fernandez-Vidal et al. 2022). Since all initiatives compete for finite resources (e.g., attention and funding) to gain and increase their impact (Jöhnk et al. 2020; Nadkarni and Prügl 2021), digital innovation units need to gain awareness and approval for themselves and their outcomes to survive and grow (Jöhnk et al. 2022).

In this regard, research on external digital ventures and start-ups has focused on rapid growth mechanisms, awareness from the direct environment (e.g., Huang et al. 2017; Tumbas et al. 2017b), and the vital relevance of acceptance and legitimacy (Fisher et al. 2017; Überbacher 2014). In the stream of digital ventures, rapid growth is accompanied by a close connection to customer requirements (Huang et al. 2022; Huang et al. 2017) and by a strong influence from the immediate environment, resulting in a (more or less noticeable) adoption of this environment's business principles, product concepts, and organizational structures (Tumbas et al. 2017a; Tumbas et al. 2017b). Despite this profound understanding of (rapid) growth mechanisms in external digital innovation units (i.e., digital ventures), research has provided relatively little information about their internal counterparts (Raabe et al. 2020a). It may be conceivable to foresee a co-evolution between digital innovation units and main organizations akin to that of digital businesses and their immediate surroundings, although digital venture and start-up research insights cannot be translated automatically. Digital innovation units are distinguished from external digital ventures through their inextricable link to their main organizations in terms of their inability to act freely and make decisions on their own, their association with existing products and business models (i.e., those of the main organization), and their need to consider and adapt to the main organization's pre-digital and physical-product restrictions, processes, and structures. Additionally, research describes a crucial need for a certain adaptation in comparable contexts, such as internal digital innovation initiatives (i.e., the incorporation of a CDO) (Tumbas et al. 2018) or digital ventures (Tumbas et al. 2017a; Überbacher 2014). Digital innovation units may be able to become integrated by main organizations when they are identified as "desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions" (Suchman 1995, p. 574)—thus, when their culture, outcomes, and mechanisms are aligned with those of the traditional incumbents. Consequently, adoption and integration can help entities overcome the "liability of newness" and gain access to inputs that boost their otherwise slim odds of survival and evolution (Keller et al. 2022; Singh et al. 1986). Finally, the current literature provides scarce insights into how digital innovation units evolve over time and overcome the hurdle of adaptation during growth phases (Lorson et al. 2022). Although the extant

literature characterizes the notions of change within internal digital innovation units as evolutionary (Raabe et al. 2020a), a general Darwinian interpretation of their evolution is insufficient. General Darwinism has demonstrated its efficacy in explaining organizational survival and growth (Abatecola et al. 2016; Hodgson 2013) in several comparable research fields, such as digital ventures (Feldman et al. 2021) and technological acceptance (Benbya and McKelvey 2006). This (co-)evolutionary perspective is commonly employed to portray change, survival, and growth in organizational development (Hodgson 2013; Van de Ven and Poole 1995) because it enables the investigation of ongoing processes of change and transformation within a competitive environment. Although the characteristics of change within internal digital innovation units are classified as evolutionary according to preliminary studies (Raabe et al., 2020), a Darwinian explanation of their development is currently lacking.

II.3 Research Strategy

To derive novel concepts from empirical observations while simultaneously considering a sufficient theoretical foundation, the research design was inspired by relevant studies in related research domains (e.g., Huang et al. 2017; Keller et al. 2022; Tumbas et al. 2017b). A case study with a single-case embedded design was conducted, meaning that multiple embedded entities (i.e., digital innovation units) in one organization (i.e., CarOrg) were observed (Yin 2009). Single-case studies permit the exploration of a subject within its isolated setting, enabling scholars to comprehend a phenomenon (e.g., Chan et al. 2019; Svahn et al. 2017; Yeow et al. 2018b). A single case study seems appropriate, since this is an unexplored research subject (Yin 2009). The study followed a research process that iteratively switches between the empirical phenomenon and the underlying theoretical assumptions (Wiklund et al. 2011). By conducting an open and inductive process of analysis while simultaneously and systematically analyzing the theoretical underpinnings, the approach enables one to develop novel theoretical insights based on an abundance of empirical evidence (Strauss and Corbin 1998; Urquhart 2013). The study aimed to maintain an open mind while adopting existing theories, which "demands that we include of the repertoire of vocabularies and theories that can be mobilized for us to consider more or less evident aspects" (Alvesson and Karreman 2011, p. 37). While this method allows for open and exploratory data analysis and novel theorizing, it cannot ignore existing research and theoretical assumptions (e.g., Huang et al. 2017; Tumbas et al. 2017b).

Data Collection

The study focused on incumbents within the automotive industry. To collect the necessary information, the digital innovation unit activities of one of the world's largest automotive OEMs were investigated. Through an established connection with the case organization, it was able to facilitate and secure access to pertinent data from CarOrg (Yin 2009). It enabled an analysis of the formation, growth, and digital innovation processes of 16 digital innovation units established in five global-acting CarOrg brands and within the group itself (see a detailed overview in Table 8). In total 24 interviews, with a total duration of about 20 hours and an average of approximately 57 minutes each were conducted. A semi-structured approach was used to gather information about the case organization (Myers and Newman 2007). The interviews started with a brief introduction of the interviewee, the researcher, and the research topic. To prevent misconceptions during the interview's main section, the underlying definitions of the core themes were clarified. The interview guidelines included questions pertaining to the growth of the digital innovation units, digital innovation units' organizational, procedural, and cultural characterizations over time, the distinct descriptions of cooperation and collaboration practices with the main organization, the mechanisms on how to create digital innovation, the challenges and obstacles encountered during the development and incorporation into CarOrg, and approaches to overcome them. As the study endeavored to appreciate the survival and development of digital innovation units, a section of the queries focused on the evolutionary principles and theoretical foundations behind their evolution (Charmaz 2006; Urquhart 2013). Consequently, the study inquired about digital innovation unit activities that could be related to the Darwinian triplet. Hence the interview questions were constantly adjusted to modify the focus of the interview based on the experience and skills of the interviewees (Myers and Newman 2007).

Table 8 – DIU Sample

DIU	MO	Established	Interviews	Interviewed Experts
DIU A-1	Brand A	2015	4	Head of DIU; DIU team lead; DIU team lead; DIU team lead
DIU A-2	Brand A	2017	1	Head of DIU
DIU A-3	Brand A	2021	1	Founder and head of DIU
DIU A-4	Brand A	2019	2	Founder and head of DIU; project lead
DIU A-5	Brand A	2017	2	Founder and head of DIU; DIU team lead
DIU A-6	Brand A	2018	2	DIU team lead; DIU team lead
DIU B-1	Brand B	2016	2	CDO brand, former DIU lead and lead of all DIUs; head of DIU
DIU C-1	Brand C	2017	1	Head of the Digital Services & Products brand and former DIU founder
DIU D-1	Brand D	2018	1	DIU team lead
DIU D-2	Brand D	2016	2	Founder and head of DIU; DIU team lead
DIU D-3	Brand D	2017	1	DIU team lead
DIU E-1	Brand E	2017	1	Brand CDO, former DIU lead and lead of all CarOrg DIUs
DIU Group-1	CarOrg	2018	1	Head of DIU
DIU Group-2	CarOrg	2018	1	Founder and head of DIU
DIU Group-3	CarOrg	2017	1	DIU team lead
DIU Group-4	CarOrg	2017	1	Head of DIU

To obtain a broad perspective on the development through time, first two brand CDOs who were both formerly responsible for all CarOrg digital innovation units and the founder of the first internal CarOrg digital innovation unit were interviewed. Although it was unable to examine all CarOrg digital innovation units to acquire a comprehensive understanding of their overall evolution, it was possible to focus the investigation on relevant and expressive examples. Consequently, based on the advice of the first three experts to delve deeper into certain digital innovation units, the study searched for examples that present typical characteristics and have undergone an observable evolution. The research focused on both successful and unsuccessful digital innovation units. Guided by concepts from the literature and the empirical data, more experts were systematically sampled, which is termed "theoretical sampling" (Recker 2013; Urquhart 2013). By including the interview partners in the recruitment of more experts who met the selection criteria, the study utilized the so-called snowball technique to increase the sample size (Singh et al. 2009) while carefully targeting the sample activities in certain directions, enabling the researcher to specify early-stage hypotheses (Urquhart 2013). To gather insightful and comprehensive data, all experts interviewed were expected to hold or have held a position of leadership and responsibility within a CarOrg digital innovation unit. The interviews were conducted in both English and German. Every interview was taped, anonymized, and transcribed. The MAXQDA software package was used to code the data.

Although the interviews served as the primary source of data, the analysis also included a number of informal (de-)briefings with digital innovation unit experts and CarOrg employees, a substantial amount of archival data—such as reporting slides, strategic and operational guidelines, organizational charts, and project reports—and information from the open press. Although nearly all of the data is confidential and could only be utilized indirectly for the research endeavor, it allowed the validation and re-evaluation of the hypotheses throughout the analytical process and further provided a timely overview of the digital innovation units' development over the last 7 years before starting the interviews (e.g., Huang et al. 2017). Finally, one of the authors had the opportunity to visit CarOrg digital innovation units in Europe, China, and the United States.

Coding and Analysis

The analysis approach can be considered to be a variation of the phases of grounded theory methodology (Charmaz 2006; Suddaby 2006), as described by Gioia et al. (2013 and comparably utilized by a number of well-known examples (e.g., Henfridsson and Yoo 2014; Huang et al. 2022; Tumbas et al. 2017b). For conceptualizing and theorizing the raw empirical data, a recursive and iterative coding and analysis strategy is

recommended (Eisenhardt 1989; Glaser and Strauss 1967; Urquhart 2013). After acquiring a basic overview of the research subjects' contextual conditions and history utilizing internal and publicly available data and gaining a deep understanding of the theoretical underpinnings of the research subject (e.g., Henfridsson and Yoo 2014; Huang et al. 2017; Tumbas et al. 2017b), the study followed a three-round coding and analysis approach (Charmaz 2006; Suddaby 2006) containing open, axial, and selective coding (Strauss and Corbin 1998). This permits the formulation (not the testing) of change, process, and growth-related theories in organizational settings (Glaser and Strauss 1967; Urquhart 2001). In line with previous studies, the study employed theoretical concepts and ideas from the literature as analytical filters during the empirical investigations (e.g., Henfridsson and Yoo 2014; Huang et al. 2022).

The first round of analysis was based on open-coding principles and sought to extract as many codes as feasible from the empirical data (Seidel and Urquhart 2013; Strauss and Corbin 1998). By emphasizing the digital innovation units' evolution, the process of digital innovation development and integration, and the theoretical concepts of GD, the data were carefully filtered (e.g., Huang et al. 2017; Tumbas et al. 2017b). Using this filter while simultaneously coding line by line with an open mind for further emerging theories (Charmaz 2006) enabled the researcher to construct a preliminary understanding of the cases' narrative (Strauss and Corbin 1998).

In the second round of analysis, based on axial coding, the generated textual evidence and a pertinent theory based on the initial assumptions and conceptions were iterated (Strauss and Corbin 1998). By uncovering linkages between categories and subcategories, the study refined early emerging theoretical ideas and abstracted them to derive the generic mechanisms applicable to the case in a cohesive whole (Strauss and Corbin 1998; Urquhart 2013). This round led to a preliminary formulation of the three empirically derived mechanisms: directed innovation, rapid value focusing, and participatory enablement.

During the third phase, based on the principle of selective coding, the categories and subcategories were recoded around the core categories to further improve the conceptual model and investigate the interaction between its underlying mechanisms (Strauss and Corbin 1998; Urquhart 2013). By comparing the conceptual model to a) the emergent case narrative and b) the theoretical underpinnings (Strauss and Corbin 1998), the study examined how the mechanisms have evolved and operated through time (e.g., Huang et al. 2017). The outcome of this final round enabled the construction of a unified concept and narrative for the conceptual model and its evolution over time. The conceptual ideas were verified with the assistance of numerous

experts who confirmed the narrative's and conceptual model's compatibility with the practical realities of CarOrg (e.g., Huang et al. 2022).

II.4 Findings

Three Evolutionary Stages of Digital Innovation Unit Development

Since 2015, CarOrg has launched more than 25 digital innovation units in its group. As an internal digital innovation engine, they are supposed to concentrate, on the one hand, on the research, development, and integration of new digital products and services and, on the other hand, on digitally enabled process improvements inside their main organization. Additionally, digital innovation units are aimed at developing and transferring digital capabilities to the main organization. To set the stage for digital innovation inside CarOrg, all digital innovation units are subject to analogous requirements and limitations, resulting in comparable designs, aims, and working methods. Nevertheless, setting up digital innovation units, seeking digital innovations, and integrating them into the main organization are not plannable or linear processes.

From the interviews and secondary data, it could be found that almost all established digital innovation units survived over time, yet some have been merged with others to gain synergies; however, at least one digital innovation unit has been closed because it failed to produce and supply valuable and applicable outcomes. Although not all of CarOrg's digital innovation units could be examined, the study could investigate both successful and unsuccessful examples. By applying the theory of ongoing evolution to describe how entities continuously adapt to a competitive environment, the study focused on successful cases to deduce the elements that contribute to survival and growth (Hodgson 2013). It can be noticed that CarOrg's digital innovation units underwent a continual evolutionary process that resulted in three distinct stages with individual characteristics (see Table 9). While all investigated digital innovation units experienced the characteristics of the first stage and, with one exception, transitioned to a second stage, not all digital innovation units evolved into the third stage. In addition, not all digital innovation units could evolve at the same speed, resulting in digital innovation units at varying stages throughout the research period. Nevertheless, the study could observe and abstract three general evolutionary stages, which can be set into a distinct sequence. This evolution was expressed accurately by one digital innovation unit leader: *"We have actually always experienced a transformation and have always been in a constant state of change. […] from a very small organization; to larger data labs, where one can build prototypes internally; to building products end-to-end.*"

The digital innovation units in the three evolutionary stages can be characterized as (1) the innovation playground and lighthouse, (2) the creation and prototyping unit, and (3) the product center. The study observed a certain internal alignment regarding changes within the digital innovation units, which seems to be caused by two reasons. First, distinct development paths were observed, which several digital innovation unit leaders termed "*digital innovation unit cookbooks*" or "*blueprints for digital innovation unit development*." Second, being set up with comparable aims and objectives in the same immediate environment (i.e., CarOrg) can lead to a comparable evolution, since all digital innovation units are compelled to comply with similar goals, restrictions, and frames. This led to generalizable observations and allowed the formulation of the proposed evolutionary stages. The investigation identified inductive criteria that served as the basis for characterizing the distinct stages comprehensively and comparably (see Table 9). During all three stages, the digital innovation units sought to expand their digital innovation efforts and improve how their outcomes were integrated and accepted within the main organization.

Innovation Playground & Lighthouse

CarOrg launched multiple digital innovation units inside its conglomerate between late 2015 and early 2018 to build digital capabilities and start participating in digital innovation. This time was described by one digital innovation unit leader as "*the boom phase, […] with all these digital innovation unit ideas*." At this time, digital innovation units were associated with the objective of organizationally and culturally distancing themselves from the existing main organization to serve as the vanguard of digital innovation. One interviewee stated that the digital innovation units were "*founded on the principle of doing things differently*." In stage 1, digital innovation units were characterized by their modest size (less than 10 employees), no hierarchical constraints, methodological and processual autonomy, and a full emphasis on open (digital) innovation. Delighted to secure funding, they intended to develop disruptive digital offerings without (almost) any thematic constraints.

The purpose of establishing digital innovation units was twofold. First, digital innovation units were set up "*with the objective to provide a lot of new digital business models and to enhance the core business,*" as one digital innovation unit founder explained. Despite the contextual connection to the automotive sector, the innovation emphasis was broad and geared toward an unspecified "*disruptive approach*" facilitated by a substantial financial ramp-up without any defined commitments to expected outputs.

Besides providing digital innovation and building novel digital capabilities, the establishment of digital innovation units served a second, more subtle purpose. The digital innovation units should externally portray a certain level of modernism to the media and internally irritate, yet excite, with their disruptive atmosphere. On one occasion, a lab manager portrayed her digital innovation unit as "*the favorite tourist island of all the board members [because] there are such crazy people to look at*."

Nonetheless, the digital innovation unit managers and employees encountered several obstacles during the first stage. The initial cooperation and collaboration between digital innovation units and their main organizations caused "*various tensions as a result of the disruptive method. Since, obviously, a significant gap has developed between the main organization and our unit*," as described by one of the specialists. Digital innovation unit managers had to take the lead in sustaining negotiations between digital innovation units and main organizations. Even though digital innovation units were intentionally established and funded by their main organizations, one digital innovation unit founder explained, "*It seems to be quite expensive to launch a brand-new venture that is absolutely unrelated to the present firm. The existing organization first evaluates it critically*."

In stage 1, digital innovation units provided inspiration and vision for their main organizations. They freely engaged in digital research and development activities and provided capabilities for future digital innovation. Early digital outcomes and insights into the digital innovation units' new work practices were imparted, since their outputs differed significantly from those of the main organizations, and their culture and organizational structure aggravated the main organizations.

Creation & Prototyping Unit

In the second stage of evolution, which occurred from 2018 to 2020 in most cases, the digital innovation units within the CarOrg conglomerate experienced an initial growth period accompanied by intraorganizational changes and the first wave of thematic specialization. The digital innovation units in question were medium-sized units of 10–30 employees, structured and grouped into several sub-units. They were responsible for their own funding and concentrated their daily efforts on developing and evaluating new digital technologies in joint projects with the main organizations.

Two parameters triggered the transition to the second evolutionary stage. First, on a structural level, organizational adjustments were required to accommodate growth demands while meeting the main organizations' process requirements. As one digital innovation unit manager noted, "*the digital innovation unit continued to grow, so it necessitated the introduction of hierarchies, as we would not have been able to*

manage all the requirements otherwise." Yet, as another digital innovation unit leader pointed out, "*the [hierarchical] pillars are required solely to serve CarOrgs procedures. Whether it's job interviews, sick leave, or disciplinary concerns, these pillars aim to facilitate the process*."

The second trigger for change was the altered financial situation, since the digital innovation units no longer received unrestricted base funding from their main organizations, and future projects were no longer financially pre-secured. One lab leader summarized the situation as follows: "*The nature of our job is still relatively flexible regarding the themes we explore. We just need to determine whether and how we can afford it*."

As a consequence of the financial strain, everyday tasks were becoming more precise and organized. The emphasis of the intended digital innovation outcomes was narrowed to specialized technical areas of the main organization or distinct technologies in which the digital innovation units were specialized. Dedicated creative techniques, such as an "*agile module construction kit*," various post-bureaucratic methods, such as "*Lean Start-up, agile things in general, Kanban, and SCRUM*," and "*other rituals, which are known from agile working*," were mentioned by the experts. One digital innovation unit leader accurately characterized digital innovation units at this stage as "*a component of the conventional hierarchy, but with an agile mentality. The external boundary conditions are CarOrg-typical, everything else is CarOrg-atypical*."

In stage 2, the digital innovation units provided the first applicable outputs to enable new digital innovations, including three key areas: a) creativity and ideation techniques for specific clients, b) idea and technology scouting for the main organization, and c) the development and testing of digital prototypes in consultation with clients and project partners.

Product Center

In the third stage, which began around 2020, most observed digital innovation units inside the CarOrg conglomerate experienced a second wave of expansion and a second shift in their internal structure and thematic emphasis. The digital innovation units in stage 3 could be characterized by a simultaneously increasing degree of formalization and professionalization in terms of organizational structures, internal workflows, and procedures. Their focus shifted to the sustainable operation and maintenance of their previously developed digital products and services. The digital innovation units continued to grow by attracting digital specialists from the external market, resulting in a 60–120 employee size. The desire for long-term financial security further triggered and accelerated the change toward a higher degree of specialization. An

additional driver of change was the ambition to build long-term products that resulted in more applicable innovations, which was, as explained by one expert, "*also a need from the team [...] to generate a certain level of sustainability in the job*."

According to another digital innovation unit leader, this adjustment of tasks demonstrated that the "*traditional digital innovation unit function has already evolved to [...] industrialize products even more*." This was highlighted in CarOrg's new digital innovation unit strategy, "*from digital innovation unit to product center*," as termed by one digital innovation unit leader. To enable a consistent emphasis on the long-term operations of their digital offerings, the digital innovation units implemented an organizational matrix structure that permitted a concentration on internal clients and already established products. However, as practically all digital innovation unit managers agreed, such formalization comes with numerous pitfalls and impedes the original intent of the digital innovation units. According to one digital innovation unit leader, "*the new structure actually killed creativity since the digital innovation units are working product-driven, project-driven, and executing tasks rather than focusing freely on ideas*."

The development had several serious ramifications for the digital innovation unit leaders. They noticed a decline in creative digital output while receiving negative feedback from their staff, who felt they were losing the original digital innovation unit atmosphere. As one digital innovation unit leader stated, "*they missed the old lab environment when you were [...] more flexible, free, and able to concentrate on what inspired you. That is unquestionably a dilemma*."

This led to a stage in which digital innovation units attempted to maintain their innovation focus while being charged with standardized operating duties to secure their financing. This specialization and formalization resulted in a substantial improvement in collaboration with and acceptance of the main organization—"*You really grind yourself back into this corporate parent cosmos very quickly*"(as stated by one digital innovation unit leader)—enabling higher sustainability and integrability. Nevertheless, some digital innovation unit leaders provided a glimpse into the future and warned not to lose focus on innovation, as this may result in the end of growth (and maybe survival).

In stage 3, the digital innovation units provided full-service products, services, and internal tools. They developed, implemented, and maintained their outcomes to secure their sustainable integration and utilization in the main organizations.

Table 9 – Lifecycle Stages

	Size	Organizational Structure	Process/ Methods	Funding Financials	Focus of Work	Outcome	MO Acceptance	Trigger (for Change)
Stage 1 **Innovation Playground & Lighthouse**	3–10	Completely self-organized	No defined processes or methods	MO funding	Open innovation/ disruption	Digital inspiration and visioning	Irritation and defensive contact	The MO's need for digital innovation
Stage 2 **Creation & Prototyping Unit**	10–30	Small teams, flat hierarchy	Best practices	Project-based	Focused ideation and prototyping	Software prototypes and first digital artifacts	Acceptance within established projects	The DIU's internal funding and the MO's process requirements
Stage 3 **Product Center**	60–120	Matrix structure	Standardized agile work-book	Service/ maintenance-based	Software development & operation	Applicable digital products and tools	Broad acceptance–partnership	Sustainable development and legitimacy

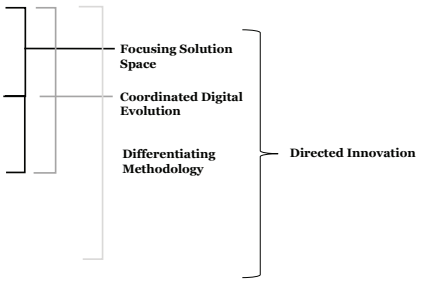
The analysis revealed several recursive patterns in how developing, selecting, and implementing digital innovations that were closely related to the main organization was accomplished. The study observed that these patterns enabled the continued survival and growth of digital innovation units in all three stages, whose legitimacy and integration increased as they continued to adapt to the requirements of the main organization. In what follows, these patterns are elaborated in the form of three generative mechanisms to ensure survival and growth in a competitive environment. Figure 16 provides representative examples of each mechanism and its components (e.g., Henfridsson and Yoo 2014; Huang et al. 2017; Tumbas et al. 2017b).

So, if we are successful, like one of our **products is a multi-model application** (...). And, the idea was, **how can the customer benefit from having all the different mobility services integrated into one platform**. What are the main pain points of the customer in the big city? It is parking. So, we need to have the parking. So, there is the priority of the parking which is available here. **So, it is about having the customer at the forefront before we even start designing the service**.

Others can create an app faster than an automaker, but we can create an app that adds value to the vehicle more effectively than others. That is our moment of realization.

Our domain-specific orientation is one unique aspect (...) that I have now incorporated. **So, we have clearly stated that we are digitizing production and logistics and place a high value on it**; this is the foundation that was built, that we **accomplish this in a sustainable manner.**

However, I believe that a DIU always has the personality of "**we are somehow different from the rest, we are a new beginning, and we are also a counter-proposal to conservative or traditional understandings of labor."** That is also what distinguishes a DIU - **we are the satellite, we are unique.**

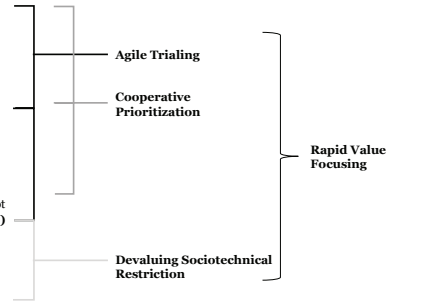


(...) The majority of them have also recognized that **our iterative process is also a successful model for the quality that goes live, because they can always adjust very quickly, because they are very directly involved in decisions**, and also because the whole thing doesn't somehow run in the wrong direction for half a year, **as you can always make adjustments and also have something that you can try out and then make new decisions.**

(...) **We need to check (...) in three or six months to see how good the outcomes are and if they are heading in the correct path.** Then we make changes, (...) then **we refine till we have a usable product.** And, **even throughout the evaluation, there is always a feedback loop with the CarOrg department**. So we say, "Look, we have a new result, and it's heading in that direction." **And, if that's okay with you, should we change something?**

(...) to then realize, "**Could this be useful and interesting for CarOrg Yes / No?"** And there was another thing that was crucial to us. Of course, with the existing structure, it is often difficult to dismiss issues that have been started quickly enough when we recognize they will not be effective. **In accordance with the maxim "start fast - fail fast," we stated in the (...) DIU: "If we identify that we really can't make a sustained profitable service out of it (...), based on certain Group criteria (...), then we must also cease it as soon as feasible."**

Number one, **it is about focus on strategic priorities of the mother company.** So, of course, mother company does not focus on cryptocurrency priorities, for example.



But sometimes it takes a long time, and by the moment I can legally utilize the technology, it's already outdated, which is simply not conceivable in our field. **So we formed our own group and run our own servers since we simply need to be faster and act outside of the CarOrg's processes.**

Our company does not have a cloud. There is no cloud knowledge at all. T**he first thing we did was set up Amazon Web Service and Cloud Foundry**. **All of this to run a platform** in four locations across the world where we can say, "Deploy your product in the cloud, and we'll take care of everything."

(...) **This means things that add value. And with that, you receive the DIUs' approval. They were viewed critically for a long time, and I know that some people still do. However, if you can suddenly generate products with actual added value in a relatively short period of time**, all of the concerns with internal hurdles and processes become relative. (…) **You suddenly have encouragement from everywhere.**

In general, it works fairly well **since most people now understand what Scrum is, how it works, and how to work in software development.**

There's no getting around the fact that we need to industrialize and formalize ourselves more. If I want to have and take responsibility for sustainable products, I simply need to employ particular working practices that also assure that the firm doesn't fail because my product is somehow poorly designed.

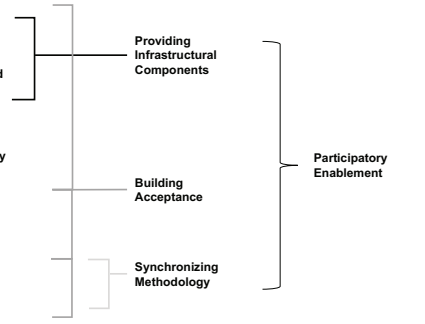


Figure 16 – Evolutionary Mechanisms

Directed Innovation

The main objective of a digital innovation unit is to incorporate and supply digital capabilities and generate digital innovations that are disruptive yet applicable in the main organization's pre-digital environment. Directed innovation describes the mechanism by which digital innovation units (purposefully) explore novel innovation opportunities. This mechanism comprises three components.

The first component, titled "Focusing the solution space," encompasses the activities that confine innovative exploration to known customers and their requirements. These requirement-related guardrails become more stringent over time. As noted by a digital innovation unit leader, "*the early innovation activities were only vaguely connected to the automotive or transportation environment*" to disrupt the main organization's pre-digital heritage and broaden the traditional perspectives. The solution space in stage 2 focused on particular business areas and "*contract work*", as termed by one specialist, to gain more outcome integrability. In the third stage, the solution space was further specified and narrowed, focusing on well-established client domains with well-defined and applicable digital functions, tools, and systems, which were developed in close relation to the main organization.

The second component, "Differentiating methodology," refers to the utilization of post-bureaucratic working styles and project forms that deviate from those utilized in the main organization. During the first evolutionary stage, digital innovation units' working habits were diametrically opposed to those of the main organizations, with one digital innovation unit leader describing them as a complete "*counter-narrative to the conservative or conventional understandings of labor*" to enable an unrestricted focus on innovation. In stage 2, the digital innovation units' entirely autonomous and diverse array of labor was reduced to particular frameworks and modular method kits to reduce irritation within the main organization and accelerate the innovation process through efficiency. During the third evolutional stage, organizational practices underwent a significant transformation toward more formalization, since the digital innovation units' aims shifted to operative work—aligned with the traditional main organization processes. However, the digital innovation units' work continued to be designed "*in accordance with post-bureaucratic work practices, using specified and set best practice solutions*," as one digital innovation unit leader stated.

The third component, "Coordinated digital evolution," specifies the activities by which digital innovation units tune in on a future trajectory enabled by digital capabilities and products. The extent to which this occurs across evolutionary stages differs. Initially, the digital innovation units adopted an open-minded stance toward different sorts of digital

innovation to broadly inspire the main organization, as evidenced by one digital innovation unit leader: "*impulses come pretty strongly from the digital innovation unit, with a lot of showcases involving autonomous vehicles that have a significant media effect*." In the second stage, particular technologies that allowed digital breakthroughs were extracted. Stage-two digital innovation units provided a variety of specializations to create applicable digital components. In the third stage, digital innovation was orchestrated even more judiciously as described by one digital innovation unit leader: "*The emphasis is placed directly on the systems or tools offered to the main organization, which may be applied, for instance, to all manufacturing lines where one specific robot is positioned*." However, innovation remains based on digital technologies and is built on digital capabilities.

Rapid Value Focusing

The second mechanism entails the validation and selection process in collaboration with internal customers and stakeholders. Rapid value focusing can be characterized as the mechanism by which digital innovation units hedge innovation opportunities concerning the existing main organization to ensure customer benefits. This mechanism consists of three generalizable components.

The first component, "Agile trailing," refers to the utilization of short and recurring cycles of prototyping and evaluation to enable rapid decision-making. In the first evolutionary stage, the component is defined by periodic *scoping* during the construction of *prototypes* without a deeper methodological emphasis. In the second stage, project-related and systematic validation workshops were organized to align with the main organization, whereby, according to one manager, "*iteration [was] performed repeatedly*." The third evolutionary stage is characterized by planned, frequent, and systematic prototyping in repeated iterations and the early participation of all stakeholders to standardize and professionalize interactions and minimize frictions and delays provoked by unapplicable outcomes.

The second component, "Cooperative prioritization," focuses on the activities of evaluation, reflection, and choice of innovations in close alignment with the main organization. It seeks to guarantee the sustained applicability of digital innovation units' outcomes by integrating the customer's viewpoint at an early stage. This approach evolved over the course of the three stages. In the first stage, cooperative prioritization was viewed as particularly challenging, since the digital innovation units' expected contributions were positioned between digital disruption and applicability. A digital innovation unit leader explained that the way of cooperating shifted to integrate the main organization perspective more thoroughly "*when the digital innovation units*

have rather followed the road of becoming service providers, i.e., have transitioned from a push to pull strategy and start to work more challenge-based." In the third stage, the collaboration turned into a partnership, which one expert defined as "*a good community of interest [...] that occurs consistently*" with nearly equal participation within the innovation process to include and consider the main organization's product requirements and constraints.

The third component, "Devaluing sociotechnical restrictions," describes the activities by which organizational, strategic, and information technology related constraints are negotiated as an external boundary condition to gain attention and innovation speed. Initially, digital innovation units intentionally and provocatively operated beyond the main organization's organizational confines. This caused friction in joint digital innovation initiatives, which one digital innovation unit leader described as "*the challenge of integrating ideas produced in a digital innovation unit setting with numerous degrees of freedom into the tighter corset of manufacturing, engineering, or even the IT landscape of the main organization.*" digital innovation units tended to examine these boundary conditions in the second stage more thoroughly. They deliberately increased their field of action—for example, by concentrating on incorporating new technologies into the main organization's *Book of Standards* soon after introducing them to bend and recreate the main organization's restrictions. Digital innovation units in the third evolutionary stage frequently operated within predetermined technical, strategic, and structural limitations and restrictions to minimize friction and produce mutually sustainable solutions aligned with the main organization's objectives. As noted by a digital innovation unit manager, "*the number one objective is to concentrate on the strategic targets of the main organization.*"

Participatory Enablement

In addition to variation and selection, the process of participatory enablement provides a third mechanism by which digital innovation units underscore their right to exist and grow in the main organization. This mechanism consists of three generalizable components.

The first component, "Building acceptance," highlights the activities by which digital innovation units increase internal recognition based on innovation transfer. This process gains momentum over time. In the first stage, the digital innovation units were "*at first scrutinized rigorously by the existing organization,*" as one digital innovation unit founder described the early years. Deviant methods of labor and disruptive appearances enraged the main organization and triggered their defensive systems. By contributing value and delivering potent digital outcomes, acceptance was created in the

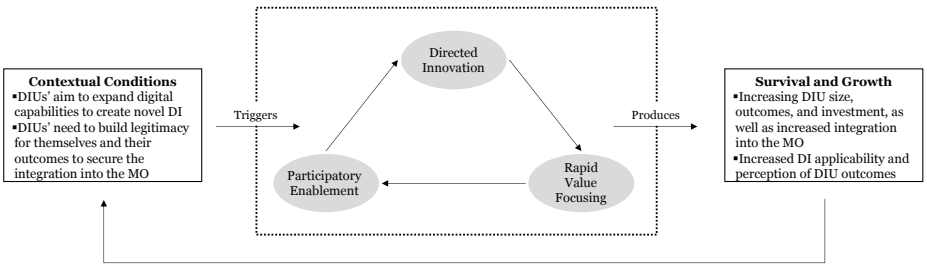
second stage. The project and interface partners inside the main organization learned to value the digital innovation units' efficient working styles. One digital innovation unit executive summarized it: "*With the colleagues with whom we have acquired valuable knowledge by collaborating on projects [...] we have a very strong reputation and network. Other departments that are a bit farther distant nonetheless examine us with great scrutiny*." As digital innovation units pursued successful initiatives and contributed digital value while incorporating digital capabilities into their main organizations, their legitimacy grew over time. In the third stage, the digital innovation units gained widespread recognition as their products and services became more established and integrated into the main organizations.

The second component, "Converging methodology," describes the activities by which collaborative delivery leads to a reciprocal adaptation of the digital innovation units' and main organizations' ways of working. It became evident that collaborative cooperation led, on the one hand, to decreased irritation and frictional losses and, on the other hand, to adopting the counterparts' most effective work practices. There are three distinct degrees of this component. During the first stage, digital innovation units acted primarily as irritants and displays of disruptive change, which made numerous post-bureaucratic work styles observable. After a period of irritation for the main organization, in the second stage, "*specific working attitudes or beliefs [...] [were] carried over to the main organization*." By using post-bureaucratic operating modes in collaborative projects, digital innovation units' methodologies, cultural characteristics, and digital capabilities permeated the main organizations, leading to mutual understanding and cooperation. Intriguingly, the third step indicated an inversive adaptation. To eliminate frictional losses in several administrative issues and to transfer products and capabilities sustainably to the main organization, according to one digital innovation unit founder, "*the digital innovation units must [...] industrialize and formalize extensively to meet the main organization's standards*." This entailed adopting administrative concepts, structures, and procedures from the bureaucratic main organization to gain internal efficiency and legitimacy.

The third component, "Providing infrastructural components," describes the activities of implementing and operating new infrastructures to enable, launch, and support digital innovation. The observations reveal that, at first, digital outcomes (e.g., big data solutions) typically operated in a "*technical vacuum*", as termed by on digital innovation unit leader, inside the main organization. Technically, or in terms of capabilities, no existing infrastructure provided a foundation for operation. To overcome this gap, one digital innovation unit manager noted, "*the digital innovation units developed their own hosting teams since [they] needed to be faster and operate somewhat*

independently of the corporate procedures." In the second stage, the digital innovation units supplied new digital infrastructures to the main organization, including components such as digital clouds, digital platforms, and communication infrastructures, to deploy their digital innovation into the existing context more sustainably. This facilitation of infrastructure continued in the third stage. CarOrg's brand-spanning infrastructure was installed and maintained. In addition, the digital innovation units provided coaching and training sessions to facilitate a shared understanding of new digital products and services within CarOrg. The digital innovation units used digital and analog services to guarantee the main organization's sustainable usage and to create acceptance for their outcomes.

Overall, the observations indicate that the application of all three mechanisms grew more effective as the digital innovation units evolved. The work routines became simplified, the processes were accelerated, cooperation with the main organization was strengthened, and the innovation focus was sharpened and became more aligned with the main organization's requirements. The observed digital innovation units sought to overcome the digital–physical tensions (Piccinini et al. 2015) by gaining legitimacy through constant negotiation between disruption and outcome applicability (Fisher et al. 2017; Überbacher 2014). During a phase of ongoing survival and growth, they strengthened this capability by approximating more and more the main organization.



Mechanisms	Components
Variation: Directed innovation *The mechanism by which DIUs (purposefully) explore innovation opportunities in relation to the existing main organization.*	1. **Focusing Solution Space:** The activities that confine innovative exploration to known customers and their requirements. 2. **Differentiating Methodology:** The utilization of post-bureaucratic working styles and project forms that deviate from styles and forms utilized in the MO. 3. **Coordinated Digital Evolution:** The activities by which DL tune in on a future trajectory enabled by digital capabilities and products.
Selection: Rapid value focusing *The mechanism by which DIUs hedge innovation opportunities in relation to the existing main organization to ensure customer benefits.*	1. **Agile Trialing:** The utilization of short and recurring cycles of prototyping and evaluation to enable rapid decision making. 2. **Cooperative Prioritization:** The activities of evaluation, reflection and choice of innovations in close alignment with main organization. 3. **Devaluing Sociotechnical Restrictions:** The activities by which organizational, strategic and IS constraints are negotiated as an external boundary condition.
Retention: Participatory enablement *The mechanism by which DIUs underscore their right to exist and grow in the main organization.*	1. **Building Acceptance:** The activities by which DL increase internal recognition based on Innovation transfer. 2. **Converging Methodology:** The activities by which collaborative delivery leads to a reciprocal adaptation of Lab's and MO's ways of working. 3. **Providing Infrastructural Components:** The activities of implementing and operating new infrastructures to enable, launch and support digital innovation.

Figure 17 – Survival and Growth

II.5 Discussion

Survival and Growth of Digital Innovation Units

The study derived an evolutionary process model (see Figure 17) that focuses on a) *contextual triggers* that drive digital innovation units to incorporate mechanisms to develop, b) *evolutionary mechanisms* that allow digital innovation units to survive and grow inside the main organizations while in a constant state of negotiation and ambiguity, and c) digital innovation units' *survival*, *growth*, and applicable *outcomes* (e.g., Henfridsson and Yoo 2014; Huang et al. 2017).

Contextual triggers

In 2015–2018, numerous digital innovation units inside the CarOrg conglomerate were established. This development was triggered by the rapid penetration of digital technologies into well-established industrial-age industries (Lucas and Goh 2009; Yoo et al. 2012). The launch of Apple's iOS and Google's Android in the car industry, as well as technological breakthroughs, such as connected vehicles, acquired digital momentum

and prompted traditional automotive OEMs to reassess their innovation processes (Hylving et al. 2012; Svahn et al. 2017). Missing the required digital capabilities, traditional automotive OEMs must incorporate specialized digital innovation initiatives, for instance, by setting up digital innovation units (Svahn et al. 2017). Digital innovation units are aimed at building and supplying digital capabilities and hence paving the way for digital innovation (Hellmich et al. 2021), which is favored by a certain growth to bear fruit (e.g., Dremel et al. 2017; Svahn et al. 2017). To enable a combination of digital and physical value creation, they must overcome contradictory demands as they seek to build and supply new and valuable digital capabilities and products while ensuring applicability and integration for their outcomes (Svahn et al. 2017). To survive in a competitive (internal) environment, digital innovation units must incorporate mechanisms to generate acceptance and legitimacy for themselves and their outcomes (Fisher et al. 2017; Überbacher 2014). They need to compete for scarce resources (e.g., attention and funding) with other digital innovation initiatives internally (Jöhnk et al. 2020; Nadkarni and Prügl 2021) to secure their survival and growth. This pressure of adaptation creates a central impetus for the incorporation of evolutionary mechanisms, since, on the one hand, a free and disruptive innovation emphasis must be inhibited, while on the other hand, a degree of consecutiveness between digital innovation units and main organizations, as well as legitimacy for digital innovation units and their outcomes, must be secured. The observed mechanisms appear capable of overcoming these tensions and permitting survival and growth.

Mechanisms

The investigation uncovered contextual causal patterns in how the digital innovation units dealt with the central tension between innovativeness and adaptation. The observed digital innovation units acted and developed comparably in responding to triggering environmental demands and restrictions to achieve survival and growth. The study conceptualized these demands and restrictions, organizational and procedural responses, and the respective outcomes as three primary mechanisms (Figure 17): (1) directed innovation, (2) rapid value focusing, and (3) participatory enablement. These three mechanisms serve as the driving engine for the constant development of the applicable digital innovation and the evolution of digital innovation units. Building on Darwin's triplet of variation, selection, and retention (Breslin 2010; Hodgson 2013), these mechanisms do not follow a deterministic and causal template but rather an ongoing, iterative, and inherently self-evolving framework in which the digital innovation units evolve in a constant state of negotiation and ambiguity (Henfridsson and Yoo 2014). Since evolution is predicated on continual adaptation to the direct environment (Breslin 2010; Hodgson 2013), the study proposes that these mechanisms

are ongoing and not limited or triggered by their outcomes. However, it can be acknowledged that as intraorganizational complexity increases with each adaptation, variation, selection, and retention become more challenging over time (Hodgson 2013; Hodgson and Knudsen 2010). Consequently, as observed in the case and aligned with evolutionary theory (Hodgson 2013), this leads to increased specification and adjustment to environmental requirements.

Directed innovation is defined as the mechanism by which digital innovation units (purposefully) explore innovation opportunities in the existing main organization. In doing so, it reflects the intentional alteration of current routines and habits to generate variations (Hodgson 2013; Winter and Nelson 1982). As a result, digital innovation units *focus their solution space* on creating legitimacy within their direct environment (i.e., their main organizations) (DiMaggio and Powell 1983), which determines the design of their outcomes (Aldrich and Fiol 1994; Fisher et al. 2017). A comparable alignment with the direct environment was observed within the start-up context (Tumbas et al. 2017a; Weiblen and Chesbrough 2015); however, this context is less restricted, and start-ups are able to reach out to a significantly broader audience, which lowers the pressure of adaptation. In this process, digital innovation units purposefully utilize *differentiating methodologies* compared to their main organizations, since their objectives and aims inherently diverge from traditional physical innovation within the incumbents (Dremel et al. 2017; Raabe et al. 2020a). Digital innovation units aim for a *coordinated digital evolution*, which implies that, as in the case of born-digital ventures and start-ups, digital technologies serve as the core and inspiration for the production of new innovative products and services (Huang et al. 2017; Tumbas et al. 2017b). Thus, variation is inextricably linked to the incorporation of digital technologies, which presents an example of the generativity of digital technologies (Henfridsson and Bygstad 2013).

Rapid value focusing is defined as the mechanism by which digital innovation units hedge innovation opportunities concerning the existing main organization to ensure customer benefits. Hence, it can be related to the biological process of selecting variants that fit best in interaction with the environment (Hannan and Freeman 1977; Van de Ven and Poole 1995). Digital innovation units follow the necessity to enable rapid reaction and decision-making, which can be related to iterative and agile working approaches, which are deemed essential to survive in fast-changing digital settings (Chan et al. 2019; Sambamurthy et al. 2003). Therefore, digital innovation units adopt an *agile trailing* technique to interact repeatedly with their main organizations. Furthermore, they pursue this through a *cooperative prioritization* aligned with the main organization to alleviate frictions caused by tensions and misconceptions between

the "old" world (the main organization) and the "new" world (the digital innovation unit) (Piccinini et al. 2015). Digital innovation units achieve this by constantly acknowledging and adapting to the peculiarities and characteristics of multilayered digital innovation, as previously described in the literature (Hylving and Schultze 2020; Svahn et al. 2017). This results in a collaborative and mutual product vision that enables a rapid focus on value, which scholars deem essential when novel digital components are introduced in a non-digital context (Dremel et al. 2017; Raabe et al. 2020a). Furthermore, digital innovation units consistently *devalue sociotechnical restrictions*. Although they face less technical and organizational debt than their main organizations (Sandberg et al. 2014; Svahn et al. 2017), digital innovation units must consider several IT-security and processual constraints when evaluating their outcomes. Research has demonstrated that ignoring environmental constraints can lead to a lack of legitimacy and a decrease in impact and expansion, as previously found in the start-up context (Tumbas et al. 2017a).

Participatory enablement is defined as the mechanism by which digital innovation units underscore their right to exist and gain legitimacy in the main organizations. The observed notions can be related to the biological retention of previously selected variants (Van de Ven and Poole 1995) and, in the IS context, to the adoption of new digital innovation processes and digital capabilities (Huang et al. 2017; Tumbas et al. 2017b). Digital innovation units gain legitimacy by *building acceptance* within the main organizations—that is, by successfully transferring their outcomes. To achieve a continuous flow of digital innovation, it has been shown that gaining legitimacy within the direct environment is an essential factor (Fisher et al. 2017; Tumbas et al. 2017a). However, it is considered especially difficult to build legitimacy in the context of new technologies and unfamiliar settings (Drori et al. 2009). Nevertheless, to achieve this goal, "demonstrating the technical superiority of the innovative practice, characteristic or form over existing alternatives" (Suddaby et al. 2017, p. 458) is identified as an appropriate attempt (Tumbas et al. 2017a). The study witnessed this through the digital innovation units' successful transfer of digital innovation and digital capabilities to the main organizations, thereby acquiring legitimacy by demonstrating technological supremacy. *Converging methodologies*, implying the reciprocal adaptation of work practices, can be related to the field of institutional isomorphism (DiMaggio and Powell 1983). It is deemed to result in a better perception of outcomes and the retention of digital innovation (processes) to overcome cultural clashes (Weiblen and Chesbrough 2015). It can be observed through the reciprocal adoption of certain methodologies between digital innovation units and main organizations. Finally, by *providing infrastructural components*, digital innovation units begin to incorporate digital innovations and lay the groundwork for the continued dissemination of digital

capabilities and outcomes through the development and management of a (digital) infrastructure. This development can be related to digital innovations' generativity, an "overall capacity to produce unprompted change driven by large, varied, and uncoordinated audiences" (Zittrain 2006, p. 1980).

Outcomes

digital innovation units build legitimacy for themselves to secure their ongoing survival and growth through continuous and evolutionary adaptation to the main organizations' constraints (e.g., Fisher et al. 2017; Überbacher 2014), which enables an ongoing supply of novel capabilities and digital outcomes. In this way, their formalization and professionalization lead to an improvement in how they are perceived and an increase in their ability to enhance and accelerate innovation processes and outcomes. By building and supplying new digital capabilities and gaining legitimacy, DUIs enable their main organizations to build their value creation on digital technologies; yet, the use of these digital technologies simultaneously trigger the evolution of digital innovation units. More generally, a state of joint co-evolution is enabled through digital innovation while also triggering the creation of digital innovation.

II.6 Implications

The research contributes to the field of digital innovation in several ways. First, the study deepened the knowledge about overcoming the central tensions caused by integrating physical and digital components in the course of digital innovation (Piccinini et al. 2015), tensions that arise from the fact that the two are diametrically opposed yet interrelated (Hylving and Schultze 2020; Yoo et al. 2010). The work provides insights into how incumbents establish digital innovation units to build and supply novel digital capabilities, yet align them with the existing pre-digital context to pave the way for digital innovation (Svahn et al. 2017). The investigation found that existing capabilities can supply the building blocks for the emergence of novel digital capabilities (Keller et al. 2022; Warner and Wäger 2019). Another contribution of the work is identifying the mechanisms that enable the applicability and integration of digital products and services inside a physical product environment (Hylving and Schultze 2020) by defining a continuous cycle of negotiation and adoption (Henfridsson and Yoo 2014).

Second, as a contribution to the digital innovation unit research field, which can be considered a sub-stream of digital innovation (e.g., Barthel et al. 2020; Ciriello and Richter 2015), the study identified novel and previously uninvestigated survival and growth mechanisms. While the literature already provides significant insights into the internal survival and growth mechanisms of external digital ventures (e.g., Huang et al.

2022; Huang et al. 2017), distinct knowledge of their internal counterparts falls short. The research fills this research gap by highlighting the parallels and discrepancies between the two streams. First, digital ventures are constructed and evolve around a digital core as their foundation, enabling their growth and expansion (Huang et al. 2022; von Briel et al. 2018). The observed CarOrg digital innovation units revealed a comparable focus on digital technologies as their impetus for growth; however, in contrast to external digital ventures, they needed to constantly consider the non-digital core of their main organizations, which impacted their innovation and growth activities; this provided novel insights into the evolution of digital innovation-focused organizational entities. Second, within external digital ventures, organizational changes appear to co-evolve with both applied and specialized (digital) technologies (Huang et al. 2022), which is termed "the mirroring hypothesis" (Colfer and Baldwin 2016), as well as with their direct digital environment (Tumbas et al. 2017a). Similar phenomena can be observed within digital innovation units regarding their digital outcomes and the main organizations' environmental restrictions; however, in these contexts, the co-evolution is not based on purely digital products but on the modular layered product architecture, which consists of both digital and physical components. This is reflected in digital innovation units' inclusion of procedures and structures from the main organizations' physical-product environment and provides novel insights into the effects of the modular-layered architecture characteristics on organizational forms (Hylving and Schultze 2020). Third, the digital venture literature states that organizational growth is accompanied by a continual professionalization and formalization of structures, procedures, and value creation, since "when the organization doubles in size (revenues, production volume, annual budget, or the number of employees), it requires a different infrastructure" (Flamholtz and Randle 2015, p. 94) to transition into a more established institution (Hellmann and Puri 2002; Tumbas et al. 2017b). Furthermore, research on start-up lifecycles describes a thematical focus and specialization within external digital ventures (e.g., digital templating) (Huang et al. 2022; Tumbas et al. 2017b). When digital innovation units surpass the product-center stage, comparable changes can be observed, as they aim toward more professionalized and formalized structures and procedures, as well as toward a thematic specification within their objectives and outcomes, which is—in contrast to external ventures—strictly guided by their main organizations' existing physical-product landscape and established framework of processes and structures. This provides a novel and currently uninvestigated structured and predetermined pathway of organizational evolution. Overall—despite a completely different and much more restricting environment and a strong relation to physical-product constraints—by identifying distinct commonalities

between internal and external digital innovation units, the study attempts to bridge the gap between the two research streams in terms of collaboration and reciprocal learning to guide future studies in this field.

Third, the study establishes a link between digital innovation and digital transformation. While aiming to create new digital capabilities and innovations, the study observed that digital innovation units—as distinct organizational units—encourage change and alter the organizational form by spreading post-bureaucratic and agile work techniques, such as Design Thinking, Scrum, or Kanban (Ciriello and Richter 2015; Fuchs et al. 2019). This change in the organizational structure represents a substantial and broad appearance of an organization's digital transformation, defined as "organizational change that is triggered and shaped by the widespread diffusion of digital technologies" (Hanelt et al. 2021a, p. 1160). Hence, this research contributes to the literature by characterizing digital innovation units as an organizational linkage between digital innovation and digital transformation and their ongoing evolution as a distinct process of an incumbent's transformation toward more malleable (Hanelt et al. 2021a) and hybrid organizational forms (Schumm and Hanelt 2021). Additionally, the study describes in detail an example of how this hybridity between digital and pre-digital organizational entities can be reached, as it illustrates how to establish and integrate post-bureaucratic islands into existing contexts while simultaneously maintaining a bureaucratic and centralized core of value creation (Kolbjørnsrud 2018). As digital innovation units are post-bureaucratic entities embedded within incumbent bureaucratic firms, they are suitable for investigating this hybrid organizational form (Fuchs et al. 2019; Holotiuk 2020).

For practitioners, the study presents managerial implications. First, it provides suggestions on how industrial-age incumbents can stay competitive and modify their innovation endeavors by launching specific digital innovation initiatives. Digital innovation units appear to be an especially appropriate initiative to establish. Second, the investigation proposes a roadmap for establishing a digital innovation unit by providing a full overview of their three evolutionary stages and proposing distinct strategies to alter and update the main organization's existing innovation processes. Finally, the results should also serve as a warning sign: Changing the course of innovation is not like turning on a light switch. It necessitates a lengthy and evolutionary process characterized by negotiation and ambiguity that is neither predictable nor linear. Managers should begin as soon as feasible to develop additional digital innovation paths and build a resilient organizational environment to survive the evolutionary process of negotiations while simultaneously enabling a continuous flow of innovation within the digital innovation units.

II.7 Limitations and Future Research

The study is not without limitations. Despite concentrating on multiple digital innovation units in various brands, the study focused the research only on one incumbent conglomerate in one specific industry. Although a certain degree of generalization can be advocated in the theoretical framework, this must be tested and validated under different conditions. The study also lacks evidence of the competitive advantages provided by the investigated digital innovation units, although their ongoing expansion and development may speak to their beneficial impact. Nonetheless, these shortcomings may open up new research opportunities in the future. First, future studies should investigate similar digital innovation endeavors within diverse industrial-age contexts to strengthen and expand the theory and evaluate and apply the proposed evolutionary mechanisms. Second, the study wants to encourage the utilization of these mechanisms in practice through empirical research. Finally, since a steady decrease in open innovation practices and an ongoing formalization within digital innovation units were observed, future studies should investigate digital innovation units' development toward greater formalization and establish the mechanisms by which these entities remain innovative and creative. This endeavor could benefit from the theoretical model.

Study 3: Digital Innovation Units: An Empirical Investigation of Performance Implications

II.8 Introduction

Competitive advantage without embracing digital innovation, defined „as the creation of [and consequent change in] market offerings, business processes, or models that result from the use of digital technology" (Nambisan et al. 2017, p. 224), appears to be unattainable in recent times (Nambisan et al. 2017; Yoo et al. 2012). Inactivity regarding digital innovation exposes firms to the risk of losing customers, market shares, and reputation to emerging digital players in their industry (Gregory et al. 2018). Yet, digital innovation comes with specific hurdles as firms must build the capabilities to engage in the development of new digital market offerings (Piccinini et al. 2015; Yoo et al. 2012). One popular initiative to overcome these hurdles is the establishment of digital innovation units. Digital innovation units can be defined as autonomous entities that aid their respective main organization in the development of digital capabilities and the search for and creation of new digital products, services, and processes (e.g., Raabe et al. 2020a; Svahn et al. 2017). Although this initiative is popular in business practice (e.g., Lau et al. 2021) and has recently garnered some attention in Information Systems research (e.g., Jöhnk et al. 2022; Raabe et al. 2020a; Svahn et al. 2017), there is no large-scale empirical evidence to verify its presumed beneficial impact.

Information Systems research documents a variety of initiatives aimed at building capabilities for digital innovation (e.g., Jöhnk et al. 2022). Among other initiatives, including the installment of digital institutional entrepreneurs (e.g., Firk et al. 2021), investment in digital mergers and acquisitions (Hanelt et al. 2021b), and the formation of external partnerships (Chanias et al. 2019), digital innovation units are of special interest for research and practice (e.g., Barthel et al. 2020; Svahn et al. 2017). Compared to other initiatives, digital innovation units are unique since they can, as organizational entities, internally enhance and aid the development of novel, idiosyncratic capabilities via research, production, and integration of digital products (Barthel et al. 2020; Raabe et al. 2021). Sourcing novel capabilities internally is considered a competitive advantage (Teece 2007), as it enables an intrinsic link to the firm's strategy and activities (Teece 2018). Further, in contrast to other initiatives, digital innovation units can be characterized as structural alterations, which represent manifestations of a firm's digital transformation, as it is characterized "as organizational change that is triggered and shaped by the widespread diffusion of digital technologies" (Hanelt et al. 2021a, p. 1160). However, research frequently leaves unexplained if digital innovation units are more

than a media phenomenon or signaling effort by the respective firms and whether they achieve substantial and quantifiable benefits (e.g., Mayer et al. 2021; Raabe et al. 2020b). Further, research reveals significant challenges and tensions when it comes to integrating digital innovation units' digital outputs in a pre-digital context (Svahn et al. 2017). Relatedly, a practitioner study, for instance, describes a significant number of closures (10%) on over 250 monitored European digital innovation units (Lau et al. 2021). Thus, while previous research on digital innovation units provides valuable qualitative insights into their areas of activities, objectives (Raabe et al. 2021), and purpose (Barthel et al. 2020; Fuchs et al. 2019), less empirical evidence on their performance impacts, their ramifications for building competitive advantage and associated driving forces exists (Mayer et al. 2021).

To build and sustain a competitive advantage in the digital era, a solid foundation of digital capabilities is necessary (Yoo et al. 2012), which must be compatible with the new logic underlying digital technologies (Hund et al. 2021). Karimi and Walter (2015) point out that building digital capabilities requires so-called dynamic capabilities, which foster the creation and modification of ordinary (daily business) capabilities (Teece 2007). Dynamic capabilities are " the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments" (Teece et al. 1997, p. 516) and are associated with three key elements of *sensing*, *seizing,* and *transforming* (Teece 2007). They are described as the fundamental criteria that determine whether a business can survive or thrive in an era of growing digital challenges, turbulence, and pressure (Ellström et al. 2021). In line with prominent examples of Information Systems research on the subjects of digital innovation and digital transformation, this study applies the established perspective of dynamic capabilities to understand the influence of digital innovation units (Karimi and Walter 2015; Steininger et al. 2022; Warner and Wäger 2019).

An organizational foundation consisting of "distinct skills, processes, procedures, organizational structures, decision rules, and disciplines" is required to enable the emergence and advancement of dynamic capabilities (Steininger et al. 2022). Initial research associates the establishment of digital innovation units with the emergence of dynamic capabilities since digital innovation units' desired objectives, entrepreneurial setup, and post-bureaucratic organizational setting can be related to the required characteristics to build dynamic capabilities (Hellmich et al. 2021; Warner and Wäger 2019). Further, digital innovation units may be used to modernize firms' ordinary capabilities for the digital era (Hellmich et al. 2021; Warner and Wäger 2019), as indicated by prior digital innovation unit research (Fuchs et al. 2019; Hellmich et al. 2021). Even though some research suggests that digital innovation units can build and

increase their main organization's dynamic capabilities (Hellmich et al. 2021), other studies highlight challenges and hurdles with regard to their integration (Svahn et al. 2017). In the absence of large-scale empirical investigations regarding these assertions, the study aims to clarify this pertinent instance. Further, there is a dearth of empirical data demonstrating the dynamic capability framework's favorable impacts in digital innovation contexts when built and realized in a distinct organizational entity (Ellström et al. 2021; Karimi and Walter 2015; Teece 2018; Warner and Wäger 2019). Additionally, recent research on digital innovation units is mostly based on the distilled expertise of employees directly associated with digital innovation units (e.g., Holotiuk and Beimborn 2019; Raabe et al. 2020a). This may result in an exaggerated and glossed-over - thus maybe biased – positive impression of digital innovation units' advantages, which is currently not validated nor confirmed by quantifiable empirical investigations. By leveraging independent and quantifiable empirical data, the study seeks to overcome this research gap on the true impacts of digital innovation units. Aiming to close these gaps, the investigation focuses on the following research objective:

How does establishing Digital Innovation Units influence firm performance?

To address this question, the study employs panel data regressions to a longitudinal dataset of Standard & Poor's 500 (S&P 500) firms in the years 2011 and 2019. The study observed that establishing a digital innovation unit is associated with higher future firm performance on average. Further, the findings suggest that the degree of tangible assets and the presence of digital ventures in the industry environment positively moderate the influence of digital innovation units on firm performance. Finally, additional tests reveal that the influence on firm performance may stem from three developments, each of which is intimately linked to the dynamic capability perspective. Specifically, the study discovered a beneficial effect (1) of digital innovation units on the number of produced digital patents (*sensing* capability), (2) of digital innovation units on the number of digital market offerings (*seizing* capability), and (3) of digital innovation units on the firm's digital transformation (*transforming* capability), showing that the establishment of digital innovation units can serve as a valuable foundation to build and realize dynamic capabilities.

This research contributes to the increasing body of knowledge on digital innovation units by presenting the first large-scale empirical investigation on their performance implications (Mayer et al. 2021; Raabe et al. 2020a). The study further provides insights about moderating contextual factors that positively influence digital innovation units' performance implications. In addition, the study contributes to the framework of dynamic capabilities by providing an indicator of how they are built and realized within

an organizational entity (i.e., a digital innovation unit) (Ellström et al. 2021; Karimi and Walter 2015; Teece 2007). By providing applicable metrics to assess the advantages of digital innovation units and dynamic capabilities, the additional analysis contributes to both streams of literature. Additionally, the results contribute to both digital innovation and digital transformation research by demonstrating and examining the impact of one initiative in depth (Hanelt et al. 2021a; Vial 2019). Finally, this study has significant implications for management practice.

II.9 Background

Digital Innovation and Transformation

Given the pervasiveness of digital technology in practically every product and service, being at the forefront of digital innovation is becoming increasingly critical for competitiveness (Nambisan et al. 2017; Yoo et al. 2012). Specifically, new digital ventures compete for customers, market share, and reputation, also in established industries, and may thereby alter or disrupt the competitive landscape (Gregory et al. 2018). Examples are the famous Kodak-Moment (Lucas and Goh 2009) or the disruptive introduction of mobility providers such as UBER or Lyft into the automotive sector (Bohnsack et al. 2021). In established contexts, digital innovation requires "a new organizational form that departs dramatically from traditional industrial production" (Berente 2020, p. 92), since creating digital innovation puts pressure on both the offered products and services and institutionalized organizational forms (Yoo et al. 2012). Accordingly, organizational determinants (Hund et al. 2021), such as the establishment of a digital innovation unit, can have a favorable influence on enabling and fostering digital innovation (e.g., Barthel et al. 2020; Svahn et al. 2017). Therefore, while digital innovation units are dedicated to creating digital innovation (Svahn et al. 2017a), their establishment, as a structural alteration of the main organization, represents a manifestation of a firm's digital transformation (Göbeler 2020; Jöhnk et al. 2022). Digital transformation propels organizations into a continuous state of change and reconfiguration with the purpose of successfully developing and supplying digital innovation as well as preserving continual adaptability within digital business ecosystems (Hanelt et al. 2021a). Considering the turbulent and challenging context of digital transformation triggered by the widespread diffusion of digital technology (Hanelt et al. 2021a), researchers argue that the dynamic capabilities perspective provides an effective lens through which to perceive a firm's transformation endeavor (Warner and Wäger 2019). Firms have been urged to develop dynamic capabilities capable of swiftly creating, implementing, and transforming business models to remain ahead in the emerging digital environment (e.g., Karimi and Walter 2015; Teece 2018).

More broadly, the continual adaptation, implementation, and refinement of an organization's business and organizational structures necessitate the development of dynamic capabilities (Teece 2007; Teece 2018). Due to the inherent dynamism of digital innovation (Nambisan et al. 2017; Yoo et al. 2012), the demand for dynamic capabilities is more of an ongoing requirement than a selective one (Warner and Wäger 2019). To stay competitive in the digital age, firms must provide organizational foundations to build and realize dynamic capabilities (Karimi and Walter 2015; Steininger et al. 2022). Despite their crucial role in firms' digital innovation and digital transformation activities, there is a scarcity of research on how firms can build and realize dynamic capabilities (Warner and Wäger 2019).

Digital Innovation Units' Objectives and Implications

Digital innovation units have been illustrated as an important initiative to carry out digital research and development (Dremel et al. 2017; Svahn et al. 2017), to enable the implementation of a digital transformation strategy (Chanias et al. 2019), to overcome digital transformation inertia (Haskamp et al. 2021c) or to enable organizational hybridity (Schumm and Hanelt 2021). While different types of digital innovation units may have distinct attributes, they all share an emphasis on digital technologies at their core (Fuchs et al. 2019; Raabe et al. 2020a), which distinguishes this phenomenon from those discussed in other streams of literature, such as new business incubators (e.g., Gassmann and Becker 2006). Recent Information Systems research identifies multiple objectives for digital innovation units, all of which stem from a strong emphasis on digital innovation, including research, selection, development, and dissemination of digital offerings (Holotiuk and Beimborn 2019). Creating and providing novel digital products or services, digital innovation units' outcomes entail various beneficial ramifications for their main organizations (Holotiuk and Beimborn 2019; Raabe et al. 2021). Research associates the creation and integration of novel digital offerings into an existing product landscape as superior to gaining new customers and market share (Gregory et al. 2018), which can be related to an improvement in (financial) performance (Hanelt et al. 2021b). Further, by participating actively in digital innovation, digital innovation units are related to building up digital capabilities, for example, in the field of big data analytics (Dremel et al. 2017). Consequently, establishing digital innovation units is deemed to serve as a foundation to build and realize dynamic capabilities (Fuchs et al. 2019; Jöhnk et al. 2022; Raabe et al. 2021). Concluding, digital innovation units' purpose includes the research on or the development of digital offerings (Barthel et al. 2020; Fuchs et al. 2019), the enablement of the main organization's digital transformation endeavors (Dremel et al. 2017), as well as, at a higher abstraction level, the building, and realization of new, dynamic capabilities (Hellmich et al. 2021; Svahn

et al. 2017). Yet, even though research on digital innovation units is generally associated with a positive effect (e.g., Dremel et al. 2017), these studies have not determined whether the establishment of the observed digital innovation units results in a measurable improvement (e.g., Mayer et al. 2021; Raabe et al. 2020b). Further, establishing digital innovation units into a pre-digital environment has been shown to have a generally beneficial impact (Smith and Beretta 2021), yet numerous tensions and hurdles during their integration have been noted (Svahn et al. 2017). Relatedly, there have been reports about relatively high closure rates among digital innovation units in business practice (Lau et al. 2021). Thus, large-scale empirical insights on digital innovation units' performance implications are currently missing and would contribute to a greater understanding of their underlying impacts and benefits. Regarding the theoretical lens, additional research is required to determine whether digital innovation units can serve their main organizations as an organizational foundation for building and realizing dynamic capabilities.

II.10 Hypotheses Development

Prior research on digital innovation has shown the increased need for digital capabilities (Hund et al. 2021; Yoo et al. 2012). These can be built by drawing on dynamic capabilities, aiding organizations in adjusting their ordinary capabilities to the digital era (Karimi and Walter 2015). Dynamic capabilities, with their key elements of *sensing*, *seizing,* and *transforming* (Teece 2007), enable organizations to adapt their business models to substantial changes in their environment (Steininger et al. 2022). Therefore, dynamic capabilities are said to be related to competitive advantage in changing and turbulent business environments (Teece 2007; Teece et al. 1997). Organizational foundations to build and realize dynamic capabilities should be internally incorporated, not bought, to enable an intrinsic link to the firm's strategy and activities (Teece 2018). Therefore, digital innovation units may be considered foundations where dynamic capabilities can be built and realized (Hellmich et al. 2021) since they provide the structural, processual, and entrepreneurial framework deemed essential for the emergence of dynamic capabilities (Teece 2007).

Moreover, digital innovation units as dedicated digital innovation engines are aimed at searching for, developing, and integrating novel digital offerings into the existing product landscape of an incumbent (Svahn et al. 2017). Therefore, expanding the current business with digital products and services is considered to generate additional income (Matt et al. 2020) and thus can be advantageous to the firm's performance (Hanelt et al. 2021b). In conclusion, digital innovation units may positively influence firm performance, yet their inherent advantages may vary since they are based on conditions

that render benefits particularly valuable (Göbeler 2020; Holotiuk 2020). Their impact may be amplified, particularly in contexts where the internal hurdles and external threats to participating in digital innovation are comparably high.

Performance Implications. The continuous and increased utilization of digital technology places firms in the position of requiring novel capabilities to generate new digital products and services to foster firm performance (Yoo et al. 2012). Establishing digital innovation units may therefore have a positive effect on firms' performance (Hellmich et al. 2021; Warner and Wäger 2019), as they can serve as a foundation to build and realize dynamic capabilities, which may lead to competitive advantage (Teece 2007; Teece et al. 1997). More specifically, via *sensing* and *seizing*, digital innovation units may "serve as a fast lane for developing new ideas and products" (Haskamp et al. 2021a, p. 1), resulting in the exploration of new client groups and the establishment of new or advanced revenue streams, which can improve the firm's performance (Hanelt et al. 2021b). Smith and Beretta (2021), for example, describe a digital innovation unit inside an industrial pump manufacturer that is responsible for identifying (sensing) and developing (seizing) digital components with the goal of extending existing physical goods to create "intelligent pumps". These new digital features provide the main organization with a plethora of technical data that can be used to optimize internal development and maintenance processes while paving the way for new business models in platform-based ecosystems (Smith and Beretta 2021). This digital enhancement can result in new digital income streams, increasing the overall firm performance. Further, establishing digital innovation units may facilitate critical digital transformation efforts (Barthel et al. 2020; Fuchs et al. 2019), such as by supplying and supporting the main organization with digital knowledge and expertise (Fuchs et al. 2019; Raabe et al. 2021). Dremel et al. (2017) present an example of a digital innovation unit developing and integrating new (digital) capabilities in the field of big data analytics to change (*transforming*) the organizations' capabilities to current digital requirements. Another example illustrates how a digital innovation unit may serve as a best practice for new working methods, cultural changes, and digital transformation strategy enhancements (Chanias et al. 2019). These *transforming* capabilities pave the way for integrating novel capabilities and digital innovations into established business models (Barthel et al. 2020; Fuchs et al. 2019). To conclude, the study suggests that digital innovation units contribute to performance improvement by producing digital innovations and assisting in their integration. Further, they can be seen as the foundation to build and realize vital dynamic capabilities (e.g., Fuchs et al. 2019; Hellmich et al. 2021) relevant to increasing competitive advantage (Teece 2007; Teece et al. 1997).

This leads to the following hypothesis:

H1: The establishment of Digital Innovation Units is positively associated with future firm performance.

Contextual conditions

The need to change in response to the diffusion of digital technologies and, hence, the importance of dynamic capabilities for firm performance may differ from firm to firm depending on the respective contextual conditions (Singh and Hess 2020). Digital innovation units' outcomes are characterized to be especially advantageous when external environmental "pressure [...] is exacerbated by pervasive digitalization" (Göbeler 2020, p. 10) and internal hurdles to creating digital innovation are significant (Barthel et al. 2020). Thus, digital innovation units' influence on firm performance and, thus, their inherent advantages may vary. Their impact on firm performance may be influenced in two ways: (1) internally, by the current organizational hurdles to develop digital innovations, characterized by the extent to which an industry relies on physical, tangible assets; and (2) externally, by environmental concerns prompted by new actors threatening traditional industrial roles.

Internal Digital Transformation Hurdles. The internal digital transformation hurdles may be linked to the (in)ability to produce digital components and the prospect of digitizing a firm's present business model (Firk et al. 2022). Digital innovation is considered a central requirement for all industries and firms to preserve or expand competitive advantage in recent times (Nambisan et al. 2017; Yoo et al. 2012). Yet, the ability and effort to create them seem to differ between industries (Karimi and Walter 2015; Piccinini et al. 2015). While business models depending on non-physical, intangible assets are rather associated with digitization (Yoo et al. 2012), business models based substantially on tangible assets come with specific pitfalls and hurdles in digital innovation as to the semantic difference in the underlying knowledge and the static nature of physical materiality (e.g., Piccinini et al. 2015). Given that firms in physical-product industries have a long history of manufacturing physical, non-digital goods (Bohnsack et al. 2021; Hylving and Schultze 2020), they often lack critical digital capabilities and organizational preconditions necessary to build digital innovation (Yoo et al. 2012). This is plausible, given their "strong hardware legacy, where development processes and organizational structures are typically adjusted and reflected in the physical product" (Hylving and Selander 2012, p. 2). It presents distinct internal hurdles since there is not only a scarcity of knowledge for obtaining digital capabilities but also a scarcity of organizational flexibility and autonomy for innovative activities (Smith and Beretta 2021). Accordingly, the study argues that in industries that

rank high in tangible assets, firms face more internal hurdles in creating digital innovation (Dremel et al. 2017; Svahn et al. 2017). Thus, digital innovation units have a greater impact on performance as the need for the dynamic capabilities they instantiate is comparatively higher (Teece 2007; Teece 2018), and digital products and services are more vital to be provided by digital innovation units (Dremel et al. 2017; Svahn et al. 2017). Concluding, firms with a strong emphasis on tangible assets may experience a positive influence on digital innovation units' performance implications. This leads to the following hypothesis:

H2a: The level of tangible assets positively moderates the positive association between the establishment of Digital Innovation Units and future firm performance.

External Digital Transformation Threats. The external digital transformation threats may be linked to the presence of digital ventures entering the respective industry (Firk et al. 2022). The existence of digital ventures underscores the critical need to create and develop digital innovation (e.g., Huang et al. 2017). Previous research demonstrated their influence on established industries via large-scale empirical studies and observed a triggering impact on incumbents to respond (Firk et al. 2021; Zapadka et al. 2022). Flexible and agile digital ventures that can leverage digital technologies successfully and swiftly (Huang et al. 2017) are infiltrating current competitive environments or creating new ones that supersede previously dominating ones (Skog et al. 2018). These digital ventures can rapidly test new business models and scale up successful concepts globally (Kelestyn et al. 2017). Accordingly, the presence of digital ventures equals an increase in environmental change that drives the importance and benefits of dynamic capabilities (Teece 2018). Firms could particularly profit from digital innovation units' digital outcomes since they are described as an explicit initiative when "new market entrants from the technology industry increase the competitive pressure" (Holotiuk 2020, p. 7). When organizations face larger external threats due to a strong presence of digital ventures, digital innovation units' ability to predict disruptive digital challenges may create more value since firms must respond even quicker. Being able to supply digital offerings on their own may positively impact firm performance in sectors where digital competition is comparably strong (Holotiuk 2020). Furthermore, when the external environment is more threatening, digital innovation units may have a stronger influence on competitive advantage since the demand for the dynamic capabilities they can aid to build (Teece 2007; Teece 2018) and the main organization's pressure to accept and integrate digital innovation units' digital outcomes is comparatively higher. Concluding, the study argues that digital innovation units' impact on firm performance may be even higher in the presence of intense digital competition.

Consequently, the following hypothesis is proposed:

H2b: The number of digital ventures in the industry positively moderates the positive association between the establishment of Digital Innovation Units and future firm performance.

II.11 Research Strategy

Sample Selection

The study focuses on a longitudinal sample of S&P 500 firms over the years 2011 to 2019. Data related to establishing digital innovation units was hand-collected from press releases and media articles in newswires on the LexisNexis database. Further data on firm performance, tangible assets, and further financial and industry characteristics were retrieved from Datastream, whereas data on digital ventures were retrieved from the CrunchBase database. Based on the availability of this data, the study ends up with a final sample covering 618 firms and 4,823 firm years.

Variables

Dependent Variable – Firm performance. The study used a market-based performance measure to measure firm performance, similar to prior research in the Information Systems economics literature Feld (Banker et al. 2011; Ho et al. 2017; Van Peteghem et al. 2019). Specifically, it focused on the firm's stock returns (market return 2fy) over the next two years (t+1 and t+2). The study decided on a market-based measure instead of an accounting-based measure as accounting measures are often criticized for not appropriately capturing the performance of digital business models (e.g., due to long lead times) (Govindarajan et al. 2018). The RI variable, as specified in Datastream, was used to calculate the two-year stock returns.

Independent Variable – Digital Innovation Units Establishment. The study exploited press and company announcements regarding digital innovation units to measure the establishment of digital innovation units. In order to gather all relevant search strings, the current digital innovation unit literature was carefully studied. It contains several distinct descriptions, archetypes, and names (e.g., Barthel et al. 2020; Raabe et al. 2020a). A list of 12 unique descriptions for digital innovation units, like "Digital Lab", "Digital Innovation Lab", "Innovation Lab", "Innovation Hub", "Digital Innovation Hub" etcetera was derived from compiling a list of their descriptions that considers different terms. All press releases and business announcements were manually hand-collected and coded from newswires on the LexisNexis database, based on the S&P 500 firms, between 2011 and 2019. The study verified the digital innovation

unit's assignment to the main organization to ensure that it is directly related to the main organization and not, for example, mentioned in terms of a consortium of firms cooperating. The final digital innovation unit variable takes the value of one if a main organization established a digital innovation unit in the respective year and zero otherwise.

Moderator variable – Internal digital transformation hurdles. The study focused on the firm's reliance on tangible assets such as machinery or other equipment to measure internal digital transformation hurdles. Similar to prior research, (Antia et al. 2010; Custódio et al. 2019) the study measured a firm's reliance on tangible assets by dividing the level of property, plant, and equipment by a firm's total assets (*Tangible assets*).

Moderator variable – External digital transformation threats. To measure the threats that digital ventures place on incumbent firms, the study followed prior research and used a measure that captures the number of new digital ventures per industry incumbent. Specifically, Firk et al. (2021) extracted all ventures in the Crunchbase database and evaluated whether they were digital ventures by evaluating the descriptions. They further classified each digital venture's industry affiliation. In line with prior studies (e.g., Zapadka et al. 2022), the study carefully matched this industry-level construct to the firm-level abstraction. Based on the classification of Firk et al. (2021), the study counted the number of new digital ventures in each industry and year and divided this number by the number of industry incumbents (i.e., all firms that had been listed for more than 3 years in the Datastream database) to measure the external digital transformation threat variable (*digital ventures*). Finally, similar to Firk et al. (2021), the study calculated the average of this variable over a 3-year period (t, t-1 and t-2) as the pressure of new ventures was expected to evolve over time.

Control variables. The study selected several variables that may drive both the firm's decision to establish a digital innovation unit and firm performance to control for confounding effects. Prior research focused on the relationship between IT-related constructs and firm performance was screened to select control variables (Banker et al. 2011; Ho et al. 2017; Mithas et al. 2012). The study included *firm size* as the natural logarithm of net sales. It then included a *firm's leverage* proxied by total debt about total assets and *firm risk* as the standard deviation of the equity return over the last 3 years divided by its mean. The study included *R&D intensity* measured as R&D expenditure by net sales. Moreover, the current performance by including *ROA* as a measure for profitability and *sales growth* was captured as the 3-year growth in sales prior to the respective year. Finally, the study followed Mithas et al. (2012) and included the yearly

average of the *industry's Tobin's q* as well as the *industry concentration* calculated via a Herfindahl index. For both a Fama-French 30 classification was used.

Empirical Method

The study followed the Information Systems economics literature to examine the performance implications of establishing digital innovation units by estimating a firm-fixed effects regression (Mithas et al. 2012; Pan et al. 2016). This decision was supported by running a Hausman (1978) test. The firm-fixed effects regression assigns each firm an individual effect to control for any firm-specific unobservable factors. The study further specified the firm-fixed effects model as a treatment effects model. The treatment effect model is a type of selection model that can be used to mitigate self-selection concerns (Certo et al. 2016). To apply the treatment effect model, the study first employed a probit model that estimates the likelihood of establishing a digital innovation unit and calculated an inverse Mills' ratio based on its results. Second, the study included the inverse Mills' ratio as an additional variable in the firm-fixed effects model to control for self-selection. Literature outlines the importance of including appropriate exclusion criteria in the first-stage probit model (Lennox et al. 2012). The study used the peer industry average of firms with at least one digital innovation unit established as the exclusion variable. The study believed that this variable could be appropriate because the peer industry average of firms could influence the firms' decisions to establish a digital innovation unit (relevance condition). Further, it was expected that this variable is rather exogenous from a focal firm's performance and that it was valid to exclude this variable from the second stage estimation (exclusion restrictions). In the first stage probit model (untabulated), the study further included all the second stage control variables and added the market performance in the two years before the digital innovation unit establishment. Based on the results, the study then calculated the inverse Mill's ratio and estimated the following regression to test the first hypothesis.

I. $Market\ Return\ 2fy_{i,(t+1,t+2)} = \alpha + \beta_1(DIU)_{i,t} + \gamma_1 IMR_{i,t} + \gamma_2(CONTROLS)_{i,t} + Y_t + \eta_i + \varepsilon_{i,t}$

Besides the dependent variable (*Market Return 2fy*) and the independent variable (*digital innovation unit*), the item $CONTROLS$ represents a matrix reflecting the selected control variables. The item IMR stands for the inverse-Mill's ratio that addresses selection concerns. The remaining items are the year fixed effects (Y_t), the constant term (α), the firm-fixed effects (η_i), and the error term ($\varepsilon_{i,t}$).

To test Hypothesis 2a and Hypothesis 2b, the study further added the moderator variables and interaction terms between the moderator variables and the digital innovation unit variable. The moderator variables were standardized before adding them to the model. The study used the following regression to estimate Hypothesis 2a and Hypothesis 2b.

II. $$Market\ Return\ 2fy_{i,(t+1,t+2)} = \alpha + \beta_1(DIU)_{i,t} + \beta_2(DIU * Tangible\ assets)_{i,t} + \beta_3(DIU * Digital\ ventures)_{i,t} + \beta_4(Tangible\ assets)_{i,t} + \beta_5(Digital\ ventures)_{i,t} + \gamma_1 IMR_{i,t} + \gamma_2(CONTROLS)_{i,t} + Y_t + \eta_i + \varepsilon_{i,t}$$

II.12 Findings

Descriptive Results

Table 10 illustrates the diffusion of digital innovation units in the sample. The establishment of digital innovation units has grown significantly in recent years. While the study observed barely twenty digital innovation unit establishments in the first three years of the sample period (i.e., 2011-2013), it observed seventy digital innovation unit establishments in the last three years of the sample period (i.e., 2017-2019). In total, 131 digital innovation unit establishments were found over the entire sample period. Furthermore, about fifteen percent of all firms established at least one digital innovation unit in the sample period.

Table 10 – Digital Innovation Units Establishments

Year	Obs.	Digital Innovation Unit establishments	Digital Innovation Unit establishments (%)	Digital Innovation Unit users	Digital Innovation Unit users (%)
2011	536	9	1.7%	9	1.7%
2012	544	7	1.3%	15	2.8%
2013	544	4	0.7%	18	3.3%
2014	542	11	2.0%	27	5.0%
2015	541	14	2.6%	38	7.0%
2016	532	16	3.0%	46	8.6%
2017	523	24	4.6%	57	10.9%
2018	531	29	5.5%	74	13.9%
2019	530	17	3.2%	81	15.3%
Total	*4823*	*131*	*2.7%*	*365*	*7.6%*

Table 11 displays the regression variables' mean, standard deviation, and bivariate correlations. The means and SDs are comparable to prior research. All continuous variables have been winsorized at the 1st and 99th percentiles, thus mitigating any issue due to exceptional outliers. The correlations further indicate a positive and small correlation between digital innovation units and firm performance. Moreover, the correlations did not indicate multicollinearity issues as all correlations were below 0.5 and most far below 0.2.

Table 11 – Descriptive Statistics and Correlation Matrix

Variable names	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13
(1) Market ret. 2fy	0.13	0.20	1.00												
(2) DIU	0.03	0.16	-0.01	1.00											
(3) Tangible assets[b]	0.28	0.27	-0.09	-0.07	1.00										
(4) Digital ventures[b]	0.05	0.09	0.03	0.01	-0.22	1.00									
(4) Firm size[a]	15.67	1.29	-0.11	0.17	-0.18	-0.08	1.00								
(5) Leverage	0.26	0.18	-0.06	-0.03	0.20	0.03	-0.02	1.00							
(6) R&D intensity	0.02	0.04	0.13	0.06	-0.17	0.07	-0.19	-0.16	1.00						
(7) Sales growth	0.33	0.54	0.14	-0.03	-0.03	0.04	-0.14	-0.05	0.23	1.00					
(8) ROA[c]	7.46	7.18	0.18	0.03	-0.15	0.06	-0.02	-0.05	0.07	0.01	1.00				
(9) Firm risk	0.28	1.65	0.02	0.02	0.00	-0.03	0.02	-0.02	0.00	0.02	0.02	1.00			
(10) Ind. Tobin's q	1.97	0.87	0.12	0.08	-0.43	0.42	-0.03	0.04	0.36	0.08	0.33	0.00	0.40	1.00	
(11) Ind. concentr.	0.12	0.09	-0.03	-0.01	-0.14	0.07	0.15	0.11	-0.10	-0.03	0.07	-0.01	0.16	0.10	1.00

Notes: N = 4,823; a = natural logarithm; b = standardized variable is used in the regression model; c = measured in percent; all variables except from the binary variable *DIU* have been winsorized at the 1st and 99th percentiles; correlations exceeding the value of 0.02 are significant at the 10 percent level.

Regression Results

The results of firm fixed effects models estimating the influence of establishing a digital innovation unit and future market returns are displayed in Table 3. Model 1 shows the direct influence of establishing a digital innovation unit. The study finds a positive and significant coefficient ($p < 0.05$) for the digital innovation unit variable. In practical terms, establishing a digital innovation unit is associated with a 9-percentage point increase in market returns over the next two years. Hence, the results support the first

hypothesis suggesting that establishing digital innovation units is positively associated with firm performance.

Model 2 to Model 4 of Table 12 test the moderating influence of digital transformation hurdles *(tangible assets)* and the moderating influence of digital transformation threats (digital ventures). With regard to internal digital transformation hurdles, the study finds a positive interaction term between the level of tangible assets and digital innovation unit establishment in Model 2 ($p < 0.05$) and Model 4 ($p < 0.01$). In practical terms, the results of Model 2 suggest that a 1SD increase in the level of tangible assets strengthens the positive association between establishing digital innovation units and future market returns by 38 percent. This result supports the hypothesis H2a suggesting that firms with more tangible assets that have a higher digital transformation hurdle could particularly benefit from establishing digital innovation units. With regard to external digital transformation threats, the study finds a positive interaction term between digital ventures and digital innovation unit establishment in Model 3 ($p < 0.1$) and Model 4 ($p < 0.01$). The results of Model 4 indicate that a 1SD increase in the level of digital ventures in the industry strengthens the positive association between establishing digital innovation units and future market returns by 18 percent. Hence, these results support hypothesis H2b, suggesting that firms in industries with more digital ventures, and thus a higher external digital transformation threat, benefit more from digital innovation units' presence. Further, both interaction terms (untabulated) were plotted. The plots supported the positive moderation of tangible assets as well as digital ventures.

Table 12 – Regression Results: Digital Innovation Unit Establishments and Firm Performance

Model	1	2	3	
Dependent Variable	Market return 2fy	Market return 2fy	Market return 2fy	Market return 2fy
Method	Firm-fixed effects	Firm-fixed effects	Firm-fixed effects	Firm-fixed effects
DIU (H1)	0.090**	0.121***	0.090**	0.124***
	(0.034)	(0.009)	(0.036)	(0.007)
*DIU * Tangible assets (H2a)*		0.045**		0.054**
		(0.039)		(0.010)
*DIU * Digital ventures (H2b)*			0.016*	0.021***
			(0.059)	(0.003)
Tangible assets		-0.038***		-0.038***
		(0.007)		(0.007)
Digital ventures			0.006	0.005
			(0.732)	(0.772)
Inverse mills ratio	0.029*	0.034*	0.030*	0.035**
	(0.087)	(0.051)	(0.082)	(0.048)
Firm size	-0.076***	-0.085***	-0.076***	-0.085***
	(0.000)	(0.000)	(0.000)	(0.000)
Leverage	0.012	0.006	0.011	0.006
	(0.817)	(0.902)	(0.826)	(0.911)
R&D intensity	-0.667*	-0.615	-0.662*	-0.613
	(0.079)	(0.116)	(0.083)	(0.119)
Sales growth	-0.003	-0.004	-0.003	-0.004
	(0.792)	(0.713)	(0.787)	(0.708)
ROA	0.003***	0.003***	0.003***	0.003***
	(0.000)	(0.000)	(0.000)	(0.000)
Firm risk	0.002	0.002	0.002	0.002
	(0.301)	(0.287)	(0.310)	(0.294)
Industry Tobin's q	0.101***	0.101***	0.100***	0.100***

	(0.000)	(0.000)	(0.000)	(0.000)
Industry concentration	-0.003	-0.005	0.012	0.009
	(0.985)	(0.979)	(0.947)	(0.960)
Intercept	1.088***	1.199***	1.088***	1.200***
	(0.000)	(0.000)	(0.000)	(0.000)
Firm effects	yes	yes	yes	yes
Year effects	yes	yes	yes	yes
N	4823	4823	4823	4823
Adjusted R-Square	0.308	0.310	0.308	0.310

Notes: *p<0.10; **p<0.05; ***p<0.01. Robust standard errors clustered at the firm-level. P-values in parentheses. The moderator variables *Tangible assets* and *Digital ventures* are standardized (i.e., mean value of zero and a standard deviation of one) to facilitate the interpretation of the moderating effects.

Robustness of Results

Endogeneity concerns. The establishment of digital innovation units and firm performance could be simultaneously driven by an unobservable factor. To address such endogeneity concerns, the study used in the main analysis a firm-fixed effects regression and a correction factor that accounts for self-selection issues. To further tackle endogeneity concerns, the study also employed three matching procedures: propensity score matching, coarsened exact matching as well as entropy balancing. All these matching procedures aim to account for the fact that observations with digital innovation unit establishments (i.e., treatment group) are not randomly distributed in the dataset. Matching procedures adjust the control group (i.e., observation with no digital innovation unit establishments) to reduce systematic differences in observable characteristics between the treatment and the control group. The idea is that this likely reduces differences in unobservable characteristics between the two groups (Hainmueller and Xu 2013; Shipman et al. 2017) and thus endogeneity issues. For the propensity score matching, the study specified a one-to-one match and thus matched the control observation with the most similar propensity score to a respective treatment observation (Shipman et al. 2017). In the coarsened exact matching, the study divided the controls into "bins" (quartiles) and then matched treatment observations and control observations that are in the same bin (Iacus et al. 2012). Both the propensity score matching and the coarsened exact matching reduces the number of total observations. Entropy balancing, however, does not exclude dissimilar control observations. It

reweights the observations in the dataset to diminish any systematic differences between observations in the control and the treatment group (Hainmueller and Xu 2013). For all matching procedures, the study used all the control variables and the market performance over the last two years. Table 13 displays regression results on the matched samples. The results consistently support the previous findings.

Table 13 – Regressions Results on Matched Samples

	PS matched		CEM matched		Entropy balanced	
Model	1	2	3	4	5	6
Dependent Variable	Market return 2fy	Market return 2fy	Market return 2fy	Market return 2fy	Market return 2fy	Market return 2fy
Method	OLS	OLS	OLS	OLS	OLS	OLS
DIU (H1)	0.046***	0.065***	0.037***	0.040***	0.032***	0.051***
	(0.005)	(0.003)	(0.004)	(0.003)	(0.008)	(0.001)
*DIU * Tangible assets (H2a)*		0.055*		0.021**		0.055**
		(0.093)		(0.074)		(0.015)
*DIU * Digital ventures (H2b)*		0.050***		0.022**		0.028***
		(0.002)		(0.046)		(0.001)
Tangible assets		-0.034*		-0.004		-0.027*
		(0.094)		(0.539)		(0.072)
Digital ventures		-0.011		0.001		0.013**
		(0.448)		(0.948)		(0.016)
Control variables	yes	yes	yes	yes	yes	yes
Year effects	yes	yes	yes	yes	yes	yes
N	255	255	2501	2501	4823	4823
Adjusted R-Square	0.440	0.462	0.375	0.376	0.371	0.390

Notes: *p<0.10; **p<0.05; ***p<0.01. Robust standard errors clustered at the firm-level. P-values in parentheses. The moderator variables *Tangible assets* and *Digital ventures* are standardized (i.e., mean value of zero and a standard deviation of one) to facilitate the interpretation of the moderating effects.

Alternative specifications. The study runs several (untabulated) robustness tests. First, the study alternatively runs a random effects model and finds consistent results. Second, alternative time windows for the market return variable were tested, and the

study found that the effects also hold for a shorter window of one-year as well as a longer window of three years. Third, the study also tested Tobin's Q as an alternative performance measure and found similar results to those reported. Finally, the study also tested an alternative specification of the digital innovation unit variable. The number of digital innovation units, as well as the first digital innovation unit establishment, were used as an alternative variable and found support for the hypotheses again.

Additional Analysis

The investigation revealed that establishing digital innovation units has a considerable effect on the main organizations' firm performance. The arguments for the positive performance effect of digital innovation units are based on the idea that digital innovation units might be able to serve as a foundation to build and realize dynamic capabilities (Fuchs et al. 2019; Hellmich et al. 2021). Specifically, this implies that digital innovation units may lead to increased dynamic capabilities concerning their key elements of - *sensing, seizing,* and *transforming* (Teece 2007). Hence, in additional tests, the study focused on three outcome variables that could indicate an increase in terms of these three key elements.

First, digital innovation units can be considered an organizational entities tasked with performing research and screening for (external) digital possibilities (Barthel et al. 2020; Raabe et al. 2020a). From the dynamic capability perspective, this may position firms in a leading role when it comes to *sensing* the environment for possible future business opportunities, putting them one step ahead of the competition in terms of gaining new digital expertise and meeting new customer expectations (Teece 2007; Teece 2018). Building this dynamic capability likely has a beneficial influence on digital knowledge (Warner and Wäger 2019). Hence, the study follows earlier research using digital patents as a proxy for a firm's internal digital knowledge base (e.g., Firk et al. 2022) and test whether digital innovation units are positively associated with the filings of digital patents in the next two years and if they can serve as a foundation to build the dynamic capability of *sensing*. The study revised all patent profiles for digital ones and measured them similarly to Firk et al. (2022) as the natural logarithm of the number of digital patents in the next two years. The data is collected from the USPTO database.

Second, digital innovation units aim to assist their main organizations by developing new digital components, such as digital products and services, that may result in new income streams (Svahn et al. 2017). Applying the dynamic capability perspective, *seizing* emerging opportunities is critical when attempting to build and execute new (digital) business models and may lead to a competitive advantage (Teece 2018). Regarding the theoretical lens, earlier studies observed a theoretical connection between this dynamic

capability and digital product and service innovation (Limaj et al. 2016). Hence it was investigated whether digital innovation units are associated with more digital market offerings (i.e., digital products and services) in the next two years and if they can serve as a foundation to build the dynamic capability of *seizing*. The study focuses on press releases and news articles regarding product and service releases and then classifies these product and service releases as a new digital market offering or not. Again, the number of digital market offerings was counted, and the natural logarithm of digital market offerings over the next two years was calculated.

Third, establishing digital innovation units can be associated with facilitating a firm's internal organizational and cultural transformation (Göbeler 2020; Jöhnk et al. 2022). When it comes to aligning and enhancing existing business models and capabilities with new ones, the dynamic capability of *transforming* may be seen as a unique benefit in gaining a competitive advantage (Teece 2018). This capability is associated with both the adoption of new technologies (Karimi and Walter 2015) and the change of existing business models and structures (Ellström et al. 2021). Hence, the study decided to further investigate the influence of digital innovation units on the firm's digital transformation in the next two years and investigate if digital innovation units can serve as a foundation to build the dynamic capability of *transforming*. To measure digital transformation, the study follows the approach of prior studies (Li et al. 2021a) by applying textual analysis to the firm's annual report. Specifically, the increase of digital-related words (e.g., identified by using a word embedding model; see Li et al. (2021b)) in the firm's 10k report from the time t to t+2 was measured. The study first calculates the relative occurrence of digital words in a 10k report and then measures the relative increase over the next two years.

The results of these tests are summarized in Table 14. The study found that digital innovation units are associated with more digital patents (Model 1) and digital market offerings (Model 2) in the next two years. The study also found a positive and significant association between digital innovation units and the firm's digital transformation (Model 3). Hence, digital innovation units' outcomes can be empirically associated with the subdivided outcomes of dynamic capabilities - *sensing*, *seizing*, and *transforming,* which leads to the assumption that they aid in the creation and realization of dynamic capabilities.

Table 14 – Additional Analyses: Digital Innovation Unit Establishments and Subdivided Digital Innovation Unit Outcomes

Model	1	2	3
Dependent Variable	Digital patents 2fy	Digital market offerings 2fy	Digital transformation 2fy
Method	Firm-fixed effects	Firm-fixed effects	Firm-fixed effects
DIU	0.636***	0.220**	0.196*
	(0.004)	(0.026)	(0.066)
Firm effects	yes	yes	yes
Control variables	yes	yes	yes
Year effects	yes	yes	yes
N	3,745	4,832	3,759
Adjusted R-square	0.06	0.10	0.09

Notes:

*p<0.10; **p<0.05; ***p<0.01. Robust standard errors clustered at the firm-level. P-values in parentheses. The control variables included are the same as the ones used in Table 3. The study also included the two moderator variables, *digital ventures* and *tangible assets,* in the models. *Digital Patents 2fy* refers to the natural logarithm of the number of digital patents (see Firk et al. 2022) in the next two years. For digital patents 2fy, the study could only rely on data until 2019, which reduced the sample significantly. *Digital Market Offerings 2fy* refers to the natural logarithm of the number of digital service and product releases in the next two years. *Digital transformation 2fy* refers to the change in the relative number of digital words in a firm's 10k report. The study could here only rely on data until the year of 2020 and to firm-years where the study could match a 10k-report in the EDGAR database.

II.13 Discussion of Findings

This study used a cross-industry and longitudinal dataset to provide empirical insights about the performance implications of digital innovation unit establishments. The study first demonstrates a wide distribution of digital innovation units in the sample. With a digital innovation unit presence in about 15% percent of all 618 firms examined, the study may deduce that digital innovation units are not a theoretical phenomenon but a real-world initiative embraced by a diverse variety of businesses across several industries and sectors (Haskamp et al. 2021a; Raabe et al. 2020b). Second, a positive association between digital innovation unit establishment and future firm performance was found. This demonstrates how establishing a digital innovation unit may help firms address digital challenges and threats (Haskamp et al. 2021b; Mayer et al. 2021) and provides first empirical support for conceptual and qualitative literature emphasizing benefits of digital innovation units in digitalizing environments (Fuchs et al. 2019; Raabe et al. 2021).

Additionally, the research uncovers moderators on the performance implications of digital innovation units, as defined internally by the degree to which an industry depends on physical goods and high tangible assets and externally by the existence of digital ventures. According to the results, a high amount of tangible assets positively moderates the firm performance implications of digital innovation units. In accordance with previous research (Svahn et al. 2017), the study proposes that enterprises with a long history of developing physical goods seem to encounter greater hurdles when it comes to developing digital innovations within their present organizational structures (Hanelt et al. 2021b). These firms have institutionalized tightly coupled product architectures and bureaucratic organizational structures (Hylving and Schultze 2020). Yet, to build digital innovation and their loosely coupled product architectures (Yoo et al. 2010), more adaptable, agile and flexible, hence post-bureaucratic, forms of organizing as well as new digital capabilities are required (Vial 2019; Yoo et al. 2012). The study argues that digital innovation units can serve as a foundation to build capabilities and embed post-bureaucratic forms of organizing for digital innovation (Hellmich et al. 2021; Raabe et al. 2020a). Accordingly, firms in physical product-based industries may profit even more from digital innovation units' performance implications. Furthermore, the study discovered that firms in industries with a higher number of digital ventures benefit more from digital innovation units' effects on firm performance. According to previous research, firms in those competitive environments appear to face greater competitive threats to their business models since digital ventures can leverage digital technologies more quickly (Huang et al. 2017) and infiltrate current industries or create new ones that supersede previously dominating ones (Skog et al. 2018). As customers get more used to the impact of digital technologies provided by digital ventures (Lucas and Goh 2009; Vial 2019), firms in such industries may benefit even more from digital innovation units' outcomes and gain greater profit from creating their own digital innovations. The findings indicate that both internal and external influences have a favorable impact on digital innovation units' effects on firm performance. This may be related to the assumptions underlying the theoretical perspective. According to the dynamic capability framework, dynamic capabilities' competitive advantage is particularly advantageous in environments with significant turbulence and pressure for change (Teece 2018). Both internal and external factors increase the need to change, which elevates the value of dynamic capabilities. Taken together, the main effect and the moderating effects lend support to the idea that digital innovation units can be considered as a foundation to build and realize dynamic capabilities in the digital era and can corroborate that dynamic capabilities positively influence firm success in an environment of digital threats and turbulence (Ellström et al. 2021; Steininger et al. 2022).

The additional analysis further supports the view that digital innovation units lead to the building and realizing of dynamic capabilities. The findings suggest that the beneficial impact of establishing digital innovation units may be threefold. First, the study demonstrates a positive influence on firms' digital patents. This may be related to digital innovation units' ability to build *sensing* capabilities (Teece 2007). Second, the data show a significant positive association between establishing digital innovation units and future digital market offerings. This can be related to digital innovation units' aiding in building *seizing* capabilities (Teece 2007). Third, a positive influence on the digital transformation of firms that have established digital innovation units has been observed. It can be related to digital innovation units' ability to serve as a foundation to gain *transforming* capabilities (Teece 2007). All three subdivided outcomes can be related to the applied perspective of dynamic capabilities. The findings imply that, in addition to a more theoretical correlation between digital innovation units and dynamic capabilities (Hellmich et al. 2021), there is also a correlation between their objectives and outcomes, connected to *sensing, seizing, and transforming capabilities* (Teece 2007; Teece 2018), leading to the assumption that digital innovation units can serve as a foundation to build and realize dynamic capabilities.

II.14 Implications

The findings contribute to prior Information Systems research regarding digital innovation units, digital innovation, and digital transformation. First, regarding the digital innovation unit research stream, the study identified several implications. The study shows a significant beneficial influence on firm performance via establishing digital innovation units. The study suggests that digital innovation units are more than a management trend or a nice-looking practice to pretend digital innovation activities; but help to create real value. Apart from several qualitative studies based on (possibly biased) employee impressions about digital innovation units (Haskamp et al. 2021b), this quantitative analysis demonstrates the positive correlation between the establishment of digital innovation units and firm performance. It allows acknowledging that digital innovation units and main organizations can incorporate mechanisms to overcome the anticipated hurdles and tensions resulting from their establishments (Svahn et al. 2017a). Moreover, the additional analysis provides a more nuanced picture of digital innovation units' beneficial influence on firm performance and their role in serving as a foundation to build and realize dynamic capabilities (Hellmich et al. 2021). The results may be further interpreted as an attempt to provide additional metrics to measure the effectiveness of digital innovation units (Haskamp et al. 2021b; Mayer et al. 2021). Both on a broad level, as measured by firm performance, and on a more granular

level, as measured by digital patents, digital market offerings, and digital transformation. Further, the additional analysis results contribute quantitatively to the literature's categorization of digital innovation units' objectives and outcomes, which had hitherto been presented rather qualitatively (e.g., Barthel et al. 2020). The study contributes to the digital innovation unit literature by shedding light on possible positive moderators on the effects of digital innovation units (Barthel et al. 2020; Raabe et al. 2021). Thereby, it illuminates the influence of external and internal environments on digital innovation units and their effectiveness. It becomes observable that industries with a high number of digital ventures are more receptive to digital innovation units' outcomes and gain even more from their competitive advantage. The same notion in physical product-based industries is noticeable, although they face distinct tensions in combining digital and physical components (Hylving and Schultze 2020), termed a digital-physical paradox (Piccinini et al. 2015). Accordingly, these results reveal that digital innovation units' ramifications co-evolve in relation to external pressure and internal circumstances. The study observes that their beneficial impact increases reciprocally and in co-evolution with digital ventures (i.e., digital competitors) in the industrial environment. In addition, the study demonstrates that their performance implications are more substantial and hence appear to co-evolve when internal hurdles, as reflected by high tangible assets, are greater. Finally, the study contributes to the digital innovation unit literature by highlighting their widespread presence within the US. Despite a large number of European researchers and a strong research emphasis in Europe (e.g., Dremel et al. 2017; Lau et al. 2021; Svahn et al. 2017), the data demonstrate that digital innovation units are not a uniquely European phenomenon.

Second, the results contribute to the Information Systems literature with distinct implications for the digital innovation stream. The substantial number of established digital innovation units in the samples qualifies them as a commonly utilized initiative targeted at tackling digital innovation-related challenges. While other initiatives, such as digital mergers and acquisitions (Hanelt et al. 2021b), have been empirically investigated, this step was missing regarding digital innovation units. The additional analysis further contributes to the stream of digital innovation, particularly by empirically examining different positions in theoretical stage models (e.g., Kohli and Melville 2019). By observing three kinds of outcomes, digital patents, digital market offerings, and digital transformation, the study argues that they are comparable with three stages of digital innovation such as discovery (associated with digital patents), development (associated with digital market offerings), diffusion (associated with digital transformation) - and impact (associated with overall firm performance) by Fichman et al. (2014). The final contribution to the digital innovation literature regards the

moderators. By emphasizing the importance of digital innovation units in physical product-based industries, the findings may prove the difficulties inherent in developing digital innovations within their bureaucratic, traditional organizational contexts (Piccinini et al. 2015; Svahn et al. 2017).

Moreover, the results contribute to research on digital transformation. In this regard, digital innovation units may be considered as another step in the overall "shift toward malleable organizational designs which enable continuous adaptation" (Hanelt et al. 2021a, p. 3) by providing a glimpse of how to design hybrid organizational forms suitable for the digital age (Schumm and Hanelt 2021). Given the beneficial performance implications of digital innovation units, the study hypothesizes that this phenomenon will be a persistent one rather than a passing management fad. Nonetheless, this may result in ongoing challenges and stumbling blocks in contemporary hybrid organizations (Piccinini et al. 2015; Svahn et al. 2017).

Regarding the theoretical lens, the results contribute to the dynamic capabilities literature. First, the study presents a large-scale and practical example of how dynamic capabilities can be built and realized in the context of digital innovation and digital transformation (Steininger et al. 2022). Additionally, the study establishes a baseline of actual evidence on the competitive advantages associated with dynamic capabilities in today's turbulent, digitalized economy (Warner and Wäger 2019). Although only one approach to how dynamic capabilities can be built and realized was examined, the study offers applicable metrics to evaluate the advantages of the dynamic capabilities *sensing* (digital patents), *seizing* (digital market offerings), and *transforming* (digital transformation) in the digital age (Ellström et al. 2021; Warner and Wäger 2019). Finally, the beneficial impact on firm performance demonstrates that the perspective of dynamic capabilities is significantly relevant and applicable in today's digital environment (Steininger et al. 2022).

Finally, the study has significant managerial implications. To begin with, amid the prevalent conversation around digital innovation and digital transformation, managers seeking viable initiatives to mitigate challenges and achieve progress may consider establishing digital innovation units. Furthermore, managers determining the applicability of digital innovation units to their environment and circumstances may consider the moderators as an appropriate variable. Although the study found that digital innovation units have a generally positive effect on firm performance, it can be proposed that managers consider their firms' present internal and external environments. Establishing digital innovation units may be particularly beneficial in physical-based product industries with high tangible assets, as well as in surroundings

with a high concentration of digital ventures. Finally, managers and organizations unsure how to target their digital innovation units' objectives and purpose may discover direction in terms of sensing for digital patents, seizing new digital market offerings, and transforming the main organization.

II.15 Limitations and Future Research

The study's findings should be interpreted in light of the following limitations. The sample is limited to the United States; thus, it cannot be assured whether the findings hold outside this context. Future research may focus on whether the findings also hold in-non U.S contexts. It would also be interesting to consider differences in culture or the national digital infrastructure (Firk et al. 2021) as a country-level moderator for digital innovation unit performance effects. In this context, more nuanced measures for digital transformation threats, such as investments in digital ventures, would be interesting to explore. Second, while the study considers, in addition to market returns, several outcomes related to digital innovation and digital transformation, these proxies might not be able to capture the full picture of digital innovation and digital transformation outcomes. For example, while the study can measure the number of digital market offerings, it cannot track the specific performance of these offerings, or while digital patents likely capture an increase in digital innovation expertise, they may not fully capture more tacit digital innovation expertise in the firm. Third, despite the best efforts (i.e., firm-fixed effects, self-selection controls and matched sample analyses), the study cannot completely rule out all endogeneity concerns. Fourth, the work does not attempt to consider other theoretical interpretations. For example, assumptions regarding the establishment costs of digital innovation units and their real financial effects give intriguing insights for future research, particularly when considering transaction costs and resource dependence. Further, more nuanced characteristics of digital innovation units could be tested to gain a deeper understanding of the detailed effects of digital innovation units. Finally, the study noticed that although the outcomes of digital innovation units impact their main organization, research currently knows very little about particular processes and practices for joint and collaborative digital innovation, innovation transfer, and digital transformation endeavors between digital innovation units and main organizations. Further empirical investigations are required to close this knowledge gap about how digital innovation units and main organizations collaborate and develop their intertwined relationship and how they can overcome potential (paradoxical) tensions.

II.16 Concluding Remarks

Studies 2 and 3 provide valuable findings as to how digital innovation units are established and facilitate the development of applicable digital innovations. In addition, they examine whether and how the effort of establishing digital innovation units helps the development of digital inventions and has a favorable impact on business performance. They both help answer RQ2 - "How can the establishment of digital innovation units a) facilitate the development of digital innovation within industrial-age incumbents, and b) how do they co-evolve over time?" - and derive a number of findings on digital innovation units' activities and benefits in facilitating digital innovation:

1) they can provide an advantageous environment for the creation, selection and retention of novel digital outcomes;
2) they can serve as a foundation for building dynamic and digital capabilities;
3) their outcomes – digital patents, digital market offerings and supporting digital transformation initiatives – have positive business performance implications and encourage digital innovation;
4) they secure the applicability and integration of their digital outcomes and capabilities by building legitimacy for themselves within the main organization;
5) they co-evolve with their main organization through continuous and reciprocal alignment.

Studies 2 and 3 both highlight the positive impact of digital innovation units in industrial-age contexts and their ability to enable digital innovation in those industries. Additionally, the influence of digital innovation units and their ability to facilitate digital innovation are greatest in high-pressure environments and within firms whose products are physical assets. Thus, increased external pressure to adapt and internal hurdles to digitalize accelerate and expand the positive impact of digital innovation units. It appears that the abilities of digital innovation units to facilitate digital innovation and their impact on firm performance co-evolve with increasing environmental pressure and internal hurdles. Although Study 3 quantifies this positive effect, Study 2 reveals distinct tensions when integrating and merging digital and physical components. Previous research has referred to these tensions as the physical–digital paradox (Piccinini et al. 2015), which arises from the peculiarity of digital innovation in physical product contexts, which is based on a layered modular architecture that consists of both physical and digital components (Yoo et al., 2010). In this modular-layered product architecture, their combination can expose and reveal various tensions (Hylving and Schultze 2020).

Additionally, with regard to organizational dimensions, digital and physical innovation and manufacturing are notably distinct from one another in terms of velocity, presuppositions, structure and cultural work underpinnings (Hylving and Schultze 2020).

Although separating digital innovation into independent digital innovation units enables a distinct focus on digital innovation activities (Raabe et al. 2021), that separation also makes it increasingly challenging to interact and collaborate with the main organization and thus to combine digital and physical components and capabilities (Svahn et al. 2017; Yoo et al. 2010). Faced with increasing innovation, time and resource pressures, incumbents can ill afford the frictions and costly delays (Piccinini et al. 2015) that can result from negotiations and conflicting interactions between separate units and the main organization when they operate under contradictory assumptions (e.g., Svahn et al. 2017). Despite the fact that Study 2 introduces approaches that help build legitimacy for digital innovation units and their outcomes as an initial effort to address these tensions, distinct mechanisms for overcoming them are scarce in contemporary research, which leads to RQ3.

III. Managing Digital Innovation Units to Overcome Digital Innovation Tensions

This section focuses on the third research perspective, managing digital innovation units to overcome digital innovation tensions, and is related to RQ3, "How do industrial-age incumbents and their digital innovation units overcome digital innovation-related tensions to collaboratively engage in digital innovation?" To answer this question, this section builds on Study 4, which is related to a previously submitted paper (Schumm and Hanelt Under Review).

Study 4: Digital Innovation Units in Industrial-Age Contexts – Paradoxes, Ambidexterity, and Symbiotic Collaboration

III.1 Introduction

Survival or growth without embracing digital innovation appears to be unattainable in recent times (Nambisan et al. 2017; Yoo et al. 2012). This holds true not only for actors in IT or service industries but also for incumbent firms in industrial-age contexts (Hylving and Schultze 2020). Thereby, industrial-age incumbents confront increasing challenges to engage in digital innovation (e.g., Dremel et al. 2017; Svahn et al. 2017) since they are built on a rich history of incremental, pre-specified innovation within a physical product setting (Hylving et al. 2012). Thus, lacking vital digital capabilities to engage in digital innovation (Sambamurthy et al. 2003; Yoo et al. 2012), incumbents face a significant threat of being superseded by born-digital complementors (Gregory et al. 2018; Skog et al. 2018).

Industrial-age incumbents, to close capability gaps for digital innovation, have engaged in several initiatives (Jöhnk et al. 2022) such as the investment in digital mergers and acquisition (Hanelt et al. 2021b), the forging of external digital partnerships (Chanias et al. 2019) or the recruitment of digital talents (Ciriello and Richter 2015). Apart from that, academia, like practice, considers the internal establishment of dedicated digital innovation units as a viable digital innovation initiative (e.g., Jöhnk et al. 2022). A digital innovation unit can be defined as a segregated entity that builds on inherent digital capabilities and purposefully utilizes post-bureaucratic organizational forms and methods to support their main organization in digital innovation (e.g., Haskamp et al. 2021d; Raabe et al. 2020a; Svahn et al. 2017). Compared to other measures, digital innovation units are unique since they are not targeted at the mere sourcing of specific capabilities but represent a structural, organizational alteration aimed to create digital components internally, thus developing idiosyncratic knowledge. Prior research on digital innovation units has mainly delineated objectives, types and characteristics (e.g., Raabe et al. 2021), while research on the cooperation between digital innovation units and their main organization remains scarce. Closing this knowledge gap is crucial to understand how industrial-age incumbents utilize digital innovation units' inherent digital capabilities to pave the way for digital innovation.

In industrial-age contexts, digital innovation, defined as "the carrying out of new combinations of digital and physical components to produce novel products" (Yoo et al. 2010, p. 2), is based on a layered modular architecture that consists of both physical and digital components (Yoo et al. 2010). Research indicates "that developing this

architectural prerequisite of digital innovation is fraught with tensions and conflicts" (Hylving and Schultze 2020, p. 2) as observed in a study on the implementation of sensor and connectivity platforms into the car (Hylving and Schultze 2020, p. 2). Among another instance, i.e., Volvo's connected car initiative, Svahn et al. (2017) theorize that similar tensions, termed competing concerns, emerge when distinct, contradictory elements that nevertheless belong together must be combined during the process of digital innovation (Svahn et al. 2017; Yoo et al. 2010). The resulting tensions have been characterized as paradoxical in nature (Agarwal et al. 2022; Smith and Lewis 2011) and are further framed as physical-digital paradoxes (Piccinini et al. 2015). Prior research has established that paradoxical tensions can be mitigated by ambidexterity (Gregory et al. 2015), "an organization's ability to pursue two disparate things at the same time" (Gibson and Birkinshaw 2004, p. 210). According to ambidexterity research, spatial segregation is one method for accelerating innovation efforts (O'Reilly and Tushman 2004). However, even though separating digital capabilities into independent units enables a distinct digital innovation focus (Raabe et al. 2021), this separation makes it increasingly challenging to interact and collaborate with the main organization (Hylving and Schultze 2020, p. 2), thus, to combine digital and physical components and capabilities (Svahn et al. 2017; Yoo et al. 2010). Faced with increasing innovation, time, and resource pressure, incumbents cannot afford frictions and costly delays (Piccinini et al. 2015) resulting from negotiations and conflicting interactions between separated units and the main organization operating under contradictory assumptions (e.g., Svahn et al. 2017). This situation emphasizes the paradox perspective on ambidexterity (Gregory et al. 2015), which promotes synthesis and transcendence over separation, and regards both poles of a paradox cooperatively rather than competitively (Papachroni et al. 2014). While research knows that industrial-age incumbents struggle to engage in digital innovation and consider digital innovation units as one potential digital innovation initiative, it does not know how the critical process of effective and symbiotic cooperation between digital innovation units and main organizations can be achieved.

To investigate the exploratory research question, a Delphi study (Paré et al. 2013) was conducted. The study is based on the insights of 23 industry experts from digital innovation units within the automotive industry as this context presents a recent and suitable setting to investigate the challenges of digital innovation in industrial-age contexts (Hanelt et al. 2021b; Svahn et al. 2017). Furthermore, research acknowledged that automotive OEMs ought to expedite digital innovation efforts by launching digital innovation units (e.g., Dremel et al. 2017; Svahn et al. 2017; Wulf et al. 2017). The Delphi study provides a final list of 13 consolidated and rated key factors. Three meta-patterns were distilled – *Maintaining Structural Autonomy, Strategic Boundary Spanning,*

Operational Synchronizing – that influence the organization on different layers to provide a more effective and symbiotic cooperation between digital innovation units and main organizations. The study synthesizes the empirical findings into a modular-layered model of organizing and relates to the paradox perspective on ambidexterity (Papachroni et al. 2014) as it deduces factors that alleviate the tension-filled segregation of digital innovation units and main organizations and extends the previous separation-dominated perspective on this research subject.

The study contributes to Information Systems research, particularly in the field of digital innovation in incumbents, by demonstrating how layered product architectures result in organizational adaptations (Hanelt et al. 2021a; Hylving and Schultze 2020) and how this affects various layers of organizing (Arghavan Shahlaei and Kazan 2020; Drechsler et al. 2020). Further, the study contributes to the emerging literature on digital innovation units by providing three distinct meta-patterns which can foster collaboration between digital innovation units and main organizations and thus facilitate the combination of physical and digital components. These insights provide a fruitful blueprint for practitioners to set up digital innovation units in industrial-age contexts.

III.2 Background

Digital Innovation Challenges in Industrial-Age Contexts

Digital innovation in industrial-age contexts is unique. While it seems as if born-digital organizations are proficient at developing digital innovation (Huang et al. 2017), this process is considered especially challenging in industrial-age contexts (e.g., Hanelt et al. 2021b; Piccinini et al. 2015), since they draw on "a strong hardware legacy, where development processes and organizational structures are typically adjusted and reflected in the physical product, i.e., the car" (Hylving and Selander 2012, p. 2). This leads to a lack of important digital capabilities (Yoo et al. 2012), which incumbents are aided to close, as they face a significant threat of being superseded by born-digital complementors (Gregory et al. 2018; Skog et al. 2018), which are inherently built on digital capabilities (Keller et al. 2022; Tumbas et al. 2017b). Establishing digital innovation units as one vital digital innovation initiative (Jöhnk et al. 2022) enables incumbents to create an internal unit that a) focuses its efforts and resources expressly on the creation of digital innovations (Raabe et al. 2020a) as well as b) incorporates and expands digital capabilities via its agile and post-bureaucratic organizational form (Hellmich et al. 2021).

However, since digital innovation in industrial and physical settings consists of the combination of physical and digital components (Yoo et al. 2010), attempting to resolve digital innovation challenges by establishing a separated internal digital innovation engine, uncovers and exacerbates certain tensions (Svahn et al. 2017). In detail, industrial-age incumbents face considerable tensions when merging physical and digital components to create digital innovations - which are amplified when created by two separate entities (Hanelt et al. 2021b; Hylving and Schultze 2020; Svahn et al. 2017). It results from the peculiarity that physical components are constructed in a rather static and hierarchical architecture and require a solid pre-specification as well as defined attributes before production (Baldwin et al. 2000), while digital components follow an iterative, evolving, and reprogrammable functional logic and architecture (Yoo 2010), which remains flexible during the innovation process (Henfridsson et al. 2014). Albeit decoupled, both layers are interconnected (Yoo et al. 2010) and lead scholars to assert that "a pervasive cause of [...] tensions and conflicts is inherent in the hybrid architecture" (Hylving and Schultze 2020, p. 2), termed as physical-digital paradox (Piccinini et al. 2015). Further, these tensions embedded in the product architecture can also emerge at the organizational level, as the organizational governance of manufacturing physical items is rather hierarchical and sequential, while digital products impose more networked and loosely coupled organizational structures (Hanelt et al. 2021b). This leads to several organizational conflicts on several levels, e.g., roles, boundary openness, knowledge sharing and responsibilities, as two diverse organizational structures and logics must be connected, merged, and coordinated (Hylving and Schultze 2020; Svahn et al. 2017). Concrete automotive industry examples illustrate tensions caused by (1) different development cycles, which may differ by years but must be combined; (2) disparate work cultures, routines, and ideologies that must be aligned with customer requirements; and (3) legal constraints as well as competing for resource needs that management must reconcile (McKinsey 2020; Porsche-Consulting 2020). Concluding, merging physical and digital components to achieve digital innovation in incumbents raises tensions (Piccinini et al. 2015), as each layer consists of its own set of product and organizational rules and standards that must be followed and combined (Henfridsson et al. 2009). Paradoxically, although establishing digital innovation units is critical and beneficial for acquiring digital capabilities and developing digital components (Hellmich et al. 2021), their separated establishment seems to increase rather than relieve tensions between the physical and digital worlds (Svahn et al. 2017).

Collaborative Innovating between Digital Innovation Units and their Main Organizations

Research demonstrates the vital necessity of post-bureaucratic organizing for digital innovation units in terms of light governance mechanisms and low authority hierarchies that allow for high degrees of freedom, autonomy and a focus on creativity (Ciriello and Richter 2015; Fuchs et al. 2019; Jöhnk et al. 2020). Digital innovation units can incorporate this post-bureaucratic organizing since they are structurally and culturally separated from the main organization's bureaucratic environment (Holsten et al. 2021). However, pursuing digital innovation requires a symbiotic and effective collaboration on par with both intertwined layers of physical and digital components (Yoo et al. 2010). Consequently, the digital innovation units' outcomes and capabilities must be merged and combined with those of the main organization (Svahn et al. 2017). While current research on digital innovation units emphasizes their purpose to facilitate digital innovation and their detachment from the main organization, little is known about the mechanisms and approaches of cooperation and collaboration with and integration into the main organization (Brauer et al. 2021). Although digital innovation units are established inside an organization, there is a dearth of research on the organizational or procedural foundations necessary for establishing symbiotic and effective cooperation. Closing this knowledge gap is crucial for realizing digital innovation units' benefits (e.g., Svahn et al. 2017). As such, it is necessary to investigate prospects for establishing an organizational foundation for collaborative development and longitudinal cooperation between digital innovation units and their main organizations.

Paradoxes and Organizational Ambidexterity

Given the complexities of modern societies and economies, paradoxes and their underlying tensions are fundamental elements of organizational life (Papachroni et al. 2014). Paradoxical tensions are understood as the presence of two "elements that seem logical individually but inconsistent and even absurd when juxtaposed" (Smith and Lewis 2011, p. 382). Prior research has established ambidexterity as one approach to mitigate paradoxical tensions (Gregory et al. 2015) as it is defined as an organizational capability to pursue divergent things simultaneously (Gibson and Birkinshaw 2004). Besides a rather separation-oriented research stream that deems structural, contextual, or temporal distinction and segregation as an applicable approach to achieve ambidexterity (Papachroni et al. 2014), recent studies have embraced a paradox perspective to successfully handle two diametrically opposed organizational poles at the same time (Andriopoulos and Lewis 2009; Danneels and Viaene 2022; Papachroni et al. 2014). They consider that resolving paradoxical tensions and ambidexterity are

intrinsically related and should be examined in conjunction (Gregory et al. 2015). Consequently, the goal is to establish sustainable solutions that encourage symbiotic synthesis and transcendence (Chen 2003) instead of establishing distinct local optima, which leads to an increasing segregation (Smith and Lewis 2011). Thus, to address tensions between two contradictory and segregated, yet cohesive, organizational entities, the lens of paradox may aid in accomplishing ambidexterity (Papachroni et al. 2014). Appropriate approaches to mitigating paradoxical tensions between organizational entities are described by Gregory et al. (2015) as a) *blending*, which aims to persuade involved actors to reconcile two seemingly opposing poles, and b) *balancing*, which aims to iteratively elaborate compromises between contrasting demands through ongoing coordination efforts. Among the many paradoxes of organizational life (Papachroni et al. 2014), the combination of physical and digital components to create digital innovation in industrial-age contexts has been described as inherently burdened with paradoxical tensions (Piccinini et al. 2015). This physical-digital paradox (Piccinini et al. 2015), is based on the contradicting logic associated with innovation involving top-down configured physical components and bottom-up configured digital components (Hanelt et al. 2021b; Hylving and Schultze 2020). Following prior literature (Gregory et al. 2015), ambidexterity is associated with such a situation and might be pursued by measures of organizational separation such as setting up digital innovation units. Indeed, initial research associates the establishment of digital innovation units with ambidexterity (e.g., Fuchs et al. 2019; Göbeler 2020). Exemplarily, Jöhnk et al. (2020, p.2) claim that digital innovation units "purposefully [...] foster ambidexterity" and facilitate the development of digital components by structurally separating physical and digital into two distinct poles. These studies examine the relationship between digital innovation units and main organizations via a predominantly separation-oriented lens on ambidexterity (e.g., Brauer et al. 2021; Holotiuk and Beimborn 2019). A paradox perspective on ambidexterity, however, would allow proceeding beyond separation-oriented prescriptions and toward synthesis or transcendence of two paradoxical poles that may aid organizations in achieving greater success (Papachroni et al. 2014) and "find some new perspective which eliminates the opposition between A and B" (Poole and Van de Ven 1989, p. 565). This perspective can lay the groundwork for future symbiotic integration and cooperation between digital innovation units and main organizations, but it is currently missing in the scholarly discourse.

III.3 Research Strategy

The applied method, i.e., the Delphi method, is described in depth in Section A.III.3.4; this section focuses on study-specific details. However, it provides a brief methodological foundation to contextualize these study-specific details.

The Delphi method requires significantly suitable participants with appropriate expertise (Okoli and Pawlowski 2004; Singh et al. 2009; Skinner et al. 2015). Selecting the appropriate sample group is a critical component when generating reliable and worthwhile findings (Singh et al. 2009). To successfully identify suitable experts, the study followed the detailed guidelines of Okoli and Pawlowski (2004). In the first step, criteria for suitable experts were carefully defined, which narrowed the selection accordingly (Okoli and Pawlowski 2004). The study concentrates on the automotive sector because it exemplifies a typical industrial-age incumbent (Haskamp et al. 2022; Hylving and Selander 2012; Svahn et al. 2017), and research acknowledges that automotive manufacturers aim to enhance their digital innovation abilities by launching digital innovation units (e.g., Dremel et al. 2017; Svahn et al. 2017; Wulf et al. 2017). Since the study focuses on the factors contributing to a sustainable collaboration between digital innovation units and main organizations, the study limited the panel to specialists assigned directly to digital innovation units. As digital innovation units generally interface with many different partners within the main organization (Fuchs et al. 2019) it can be ensured - in contrast to main organization employees - that the experts share a broad range of experience in terms of collaboration. In addition, the study underscored the importance of including experts from digital innovation units that have been on the market for at least five years and have experienced constant staff growth, which can indicate their vital position and integration into the main organization. The study identified suitable digital innovation units by conducting a comprehensive search and contacting all digital innovation units inside one of the world's leading multinational, multi-brand automotive OEMs. After selecting eligible experts from the direct network, they were contacted by mail, via telephone, or in personal contact and asked to name other potential participants as recommended by Okoli and Pawlowski (2004). The study engaged 23 participants in 17 distinct digital innovation units. Significant weight was placed on participants' digital innovation unit competence as well as on the units' selection criteria. This is reflected by the high level of professional expertise (e.g., 9 experts with 11-15 years and 10 experts with > 16 years), the widespread sharing of long-term digital innovation unit experiences (e.g., 14 experts with 4-6 years and 2 experts with > 7 years), and the exclusive focus on decision-makers, e.g., digital

innovation unit (sub-)division manager, team-leader or digital innovation unit-founder. Table 15 provides an overview of the panelists.

Table 15 – Panelists

Characteristics	**Panelist's profile (N=23)**	
Years of working experience	1-5 years: 0 5-10 years: 4	11-15 years: 9 > 16 years: 10
Years of experience in context of DIUs	1-3 years: 7 4-6 years: 14	> 7 years: 2
Actual job position	Team or Project lead: 4 Sub-division manager: 10 Division manager: 2	Lead of a lab: 4 C-level: 1 Others: 2
Educational qualifications	Apprenticeship: 0 Bachelor's degree: 1 Master's degree: 18	Ph.D.: 2 Others: 2

Following Schmidt (1997), the data collection process consisted of three phases: brainstorming, selection, and rating (see Section A.III.3.4). By the end of the first phase, 23 panelists named 128 factors. To increase the clarity of responses and to avoid redundancies, in the next step, the study a) cleared the list of factors from duplicate responses and b) consolidated them in case of similar responses (Schmidt et al. 2001; Singh et al. 2009). The aggregated list consists of 36 individual factors. The study classified them into categories that were subsequently and inductively formed. In the second phase, the consolidated list undergoes a selection process in which the experts are asked to choose the ten most relevant factors without considering any action of ranking (Schmidt 1997). The experts are supplied with a list of factors in a randomized order to avoid biases (Schmidt 1997). After the appropriate time and number of reminders, the second phase was completed with 19 responses, a satisfactory response rate of 83%. Based on Singh et al. (2009), a cut-off value of 30% was chosen to reduce the list of factors to a manageable range of 12-15 factors (Skinner et al. 2015). In this case, this reduction leads to 13 factors. The final phase required the experts to rank the remaining factors according to their personal significance and relevance. Following Singh et al. (2009), controlled guidance in the form of the previous round's percentage of choice was provided (Schmidt 1997). To obtain a robust result of a Delphi study, a certain level of consensus between the experts' answers is necessary (Schmidt 1997). To evaluate the consensus of non-parametric rankings, various metrics are available in the literature, among which Kendall's coefficient of concordance (W) is the most suitable one for Delphi studies (Okoli and Pawlowski 2004; Paré et al. 2013) since dissensus and consensus are immediately recognizable and the decision to proceed is unambiguous (Skinner et al. 2015).

Kendal's W ranges from 0 to 1, with 0 meaning no consensus and 1 meaning perfect consensus among all respondents (Kendall and Babington Smith 1939). Different W-values can be narrowed down: Values from 1 to 0.7 are referred to as strong consensus levels, values from 0.7 to 0.5 as moderate consensus levels, and values from 0.5 to 0 as weak consensus levels (Schmidt 1997).

In the third phase, 17 participants achieved a W-factor of 0.23 in the first round. It is common practice to conduct further rounds in Delphi studies - as long as at least moderate consensus is reached - to increase the level of consensus through guided feedback (Paré et al. 2013; Singh et al. 2009). In this process, participants are asked to refine their ranking based on additional information, including, for example, the ranking obtained in the previous round and the participants' comments (Schmidt 1997; Skinner et al. 2015). Schmidt (1997), however, argues that the continuation of the study lies in the researchers' hands and can also be stopped by other factors. The so-called stopping rules are: reaching a satisfactory consensus, no significant change in consensus between two successful rounds, or jeopardizing the feasibility of another round by a high drop-off of participants (Schmidt 1997). In case of overload or excessive time and resource usage due to further ranking rounds, a low consensus can also be considered valid (Paré et al. 2013). Based on the participation of the experts in the previous phases, it was decided to conduct another round. In the second round of phase 3, a W-factor of 0.53 among 13 participants was attained. It was decided not to conduct another round for two reasons. First, a fatigue of the experts to participate in further rounds was felt, which was shown by the visible drop-off and the number of reminders sent. This meets the criteria for a stop when a) a considerable drop-off occurs and b) continuance is not assured in terms of resources and time (Okoli and Pawlowski 2004). Second, with the level of consensus, a W-factor that has been comparably high across successfully conducted and well-published Delphi studies (e.g., W=0.52 in Kasi et al. (2008)), leading to a resilient research contribution (Skinner et al. 2015) was achieved.

III.4 Findings

During the brainstorming phase, a total of 123 factors that are deemed likely to contribute to a sustainable collaboration between digital innovation units and main organizations were uncovered (see Appendix D for the completed list). They were distilled into 36 distinct factors, which were then divided into eight categories. The categories are termed *Organizational Forms and Structures (OFS)*, *Culture (CU)*, *Leadership and Management (LM), Communication (CO), Value Creation (VC), Strategy (S), Processes & IT (PI)* and *Funding (F)*. In the second round, the selection phase, the experts were asked to name their ten most important factors from the

brainstorming phase. By applying a 30% cut-off value (Singh et al. 2009), the list was reduced to a manageable size of 13 factors (Skinner et al. 2015). Afterward, the factors were ranked by the experts in the last phase. Table 16 presents the results of phases two and three. Remarkably, the sole factor directly connected to IT was omitted from consideration during the selection process. In addition, both factors concerning the "outside world" (connections and partnerships to universities and startups) were not accounted for. In summarizing the data from the second phase, the panelists believe that factors about the direct link between the digital innovation unit and the main organization are more significant than those pertaining to either one of the two poles. Overall, 9 of the 13 factors retained for the final phase are directly related to the relationship between digital innovation units and main organizations. In contrast, many factors solely related to structures or processes within the main organizations or digital innovation units were broadly excluded. The final phase involved two rounds of ranking. After an unsatisfactory W-factor in the first round, a correspondingly higher result was generated after the second round. Based on the second ranking, the factor *Advisory board in the main organization & structural linkage of the top management of the main organization* was proved to be the most relevant one.

Table 16 – Final Ranking

Factor (Category)	Selection Phase (of experts)	Round 1 Mean rank	Round 2 Mean rank	Final Rank
Advisory board in the MO & structural linkage to the top management of the MO (OFS)	47%	4,53	2,92	1
DIUs strategy and vision derived from the overall strategy of MO to avoid (uncoordinated) co-existence (CU)	68%	3	3,77	2
Top management commitment & support from MO (LM)	74%	3,12	3,92	3
Organizational & structural incentives for collaboration with DIUs (OFS)	42%	4,88	5,08	4
Focus on digital products with high added value and high innovation in the DIUs (S)	37%	4,41	5,23	5
Partnership-based and transparent value creation between DIUs & MOs - from idea to operation (VC)	47%	4,59	5,46	6
Adaptable & flexible organizational structures in DIUs (OFS)	37%	6,18	7,46	7
DIUs act at eye level with MO through mutual understanding and trust (CU)	42%	5,18	7,61	8
Mutual, demand-oriented portfolio development between labs & MO (with end customers) (VC)	47%	4,65	8,15	9
Rotation principle of the employees between DIU & MO (OFS)	32%	6,59	9,38	10
Prevention of personal "power games between DIUs & MO (LM)	32%	5,24	9,76	11
Long-term financial funding and security for DIUs, to focus on innovation (F)	53%	5,35	10,08	12
Focus on short-term innovation milestones with clear scope instead of long-term product strategy within DIUs (S)	32%	6,53	12,15	13

The results of the third phase can be grouped into three overarching meta-patterns: (1) *Maintaining Structural Autonomy* (see factors rank 5, 7, 12, 13 in Table 16), (2) *Strategic Boundary Spanning* (see factors rank 1, 2, 3 in Table 16) and (3) *Operational Synchronizing* (see factors rank 4, 6, 8, 9, 10, 11 in Table 16). All three meta-patterns relate broadly to several coping initiatives for paradoxical tensions (e.g., Gregory et al. 2015; Poole and Van de Ven 1989; Smith and Lewis 2011).

III.5 Discussion of Findings

This study investigated factors that contribute to an effective and symbiotic cooperation between digital innovation units and main organizations. The results aim to ease tensions arising from the physical-digital paradox (Piccinini et al. 2015) and related

competing concerns, such as those articulated by Svahn et al. (2017), e.g., between governmental control and flexibility. Abstracting from the detailed factors displayed in the preceding section, three overarching meta-patterns can be derived, which are compiled in Table 17.

Table 17 – Meta Patterns Study 4

Maintaining Structural Autonomy	**Strategic Boundary Spanning**	**Operational Synchronizing**	
Factors that aim at creating and sustaining the structural autonomy of DIUs by fostering divergence in objectives, working and organizing.	Factors that aim at bridging the boundaries between DIUs and MOs by fostering their integration in the upper echelons and strategic agendas of the organization.	Factors that aim at synchronizing the practices of DIUs and MOs operationally by fostering the alignment of offerings, interfaces and values.	Description
Focus on digital products and services with high-added value. Thinking and acting in short-term milestones rather than long-term products. Adaptable and flexible organizational structures within DIUs.	Introduction of a strategic advisory board in the MO with structural bridge to the MO. Strategic TMT support toward DIUs. DIUs' strategy and vision derived from overall strategy of MO.	Collaborative value creation and joint portfolio development. Incentivized collaboration and co-worker transfer between DIUs and MOs. DIU and MO employees interact and meet as equals while avoiding personal power games.	Panelists' Factors
Incumbents' traditional, bureaucratic organizational forms are insufficient for gaining digital capabilities or developing DIs (Yoo et al. 2012). Autonomous entities with post-bureaucratic organizational forms are required, to remain unconcerned with the incumbent's hierarchical influences to focus on DI (Svahn et al. 2017).	Segregated governance structures and processes between physical and digital units challenge the combination of their outcomes (Hylving and Schultze 2020). Contrasting strategic focus in resource planning, budgeting horizons and business orientations between DIUs and MOs (Svahn et al. 2017).	Contrary rules and routines between physical and digital focused units, require operational linking practices to combine the outcomes (Hylving and Schultze 2020). Cultural differences and lack of understanding causes friction during joint development initiatives (Visnjic et al. 2021).	Related Tensions

Maintaining Structural Autonomy. The meta-pattern of *Maintaining Structural Autonomy* subsumes factors to ensure the digital innovation units' structural demarcation from the main organization to develop novel capabilities related to digital innovation. The pattern's factors serve and promote the structural aspect of separation in the spirit of "a 'second speed' [...] function by keeping the emerging logic separate

from the existing ideas" (Tumbas et al. 2018, p. 12). *Maintaining Structural Autonomy* becomes particularly visible through four different factors. First, to encourage a certain autonomy, the organizational structures within digital innovation units should be designed to be adaptable and flexible (see factor 7 in Table 16). Secondly, there should be a *focus on digital products with high added value and high innovation in the digital innovation units* (see factor 5 Table 16). Thirdly, thinking and acting in short-term milestones rather than long-term products should be supported (see factor 13 Table 16). Additionally, a certain level of financial stability is necessary to maintain an undivided focus on digital innovation (see factor 12 Table 16). The focus on digital innovation can be facilitated by structurally decoupling individual units from the restrictions and shackles of the main organization (Svahn et al. 2017; Tumbas et al. 2018). A narrowed focus in these units enables a rise in innovation power and exploration skills, culminating in vital and novel digital capabilities (Svahn et al. 2017; Yoo et al. 2012). In this context, both the approach of short and iterative milestone cycles and the use of post-bureaucratic organizational forms constitute factors that increase the focus on digital innovation (Hund et al. 2021). Concluding, *Maintaining Structural Autonomy* permits the uninterrupted growth and expansion of digital capabilities, as well as the focused creation of digital components. Separated units can develop and institutionalize post-bureaucratic organizational procedures, strategies, and work cultures that enable organizations to transcend hierarchical constraints and enable a greater emphasis on digital innovation and the development of critical digital technologies (Svahn et al. 2017; Yoo et al. 2012). Further, by maintaining structural segregation and autonomy, this meta-pattern may assure the sustainability and longevity of digital innovation units necessary for developing digital innovations (Svahn et al. 2017).

Strategic Boundary Spanning. The meta-pattern *Strategic Boundary Spanning* subsumes factors to enable an intentional and coordinated integration of digital innovation units to establish a new unified whole, that is, an adapted organization of which the digital innovation unit and the main organization become a part and contribute to its overall goals. *Strategic Boundary Spanning* becomes visible through three distinct factors with a strategic, top-down orientation. The most relevant factor in the study suggests the introduction of an *advisory board in the main organization and a structural linkage to the top management of the main organization*. Such a platform provides space for strategic coordination and orchestration and can serve as a central element in blending two distinct demands (Gregory et al. 2015). Battilana et al. (2014) define organizational “spaces of negotiation” (Battilana et al. 2014, p. 1660) as a vital boundary-spanning factor between segregated units. The factor ranked as second most critical - *digital innovation units' strategy and vision derived from the overall strategy*

of the main organization to avoid (uncoordinated) co-existence - reveals the importance of strategic alignment to build trust and joint sensemaking (Weick 1995). The third boundary-spanning factor identified by the experts is the strategic support of digital innovation units by the main organization's top management (see factor 3 in Table 16). While top management support is by no means a new issue in change processes or innovation topics (e.g., Bantel and Jackson 1989), the high ranking nevertheless demonstrates the importance of this factor. TMT support is seen as particularly relevant in times of digital innovation, as the TMT – recently described as "pluralist managers" (Besharov 2014, p. 1503) - not only need to expand the existing business, but additionally to present itself as a thought leader, supporter, and facilitator of new technologies, incorporating a highly relevant role as an enabler of digital innovation (Firk et al. 2022). Spanning the boundary between the "old" and the "new" world of an organization, the TMT can serve a bridging role (Tumbas et al. 2018). Further, symbiotic and sustainable corporation between two separated units requires a strategical orchestrating and moderation authority that structurally spans between boundaries and creates a new unified whole (Chanias et al. 2019; Hylving and Schultze 2020). To summarize, *Strategic Boundary Spanning* may alleviate tensions originating in separate governance structures for physical and digital product units (Hylving and Schultze 2020), as well as in independent sets of organizational norms and standards (Henfridsson et al. 2009). Additionally, it can reconcile divergent priorities in resource planning, budgetary negotiations, and overall orientation (Svahn et al. 2017) through a strategic and boundary-spanning integration.

Operational Synchronizing. The meta-pattern of *Operational Synchronizing* subsumes factors to enable a practical alignment of value-creation underpinned by a reciprocal acceptance and appreciation between digital innovation units and main organizations with the goal of linking distinct work practices. The third meta-pattern, *Operational Synchronizing*, becomes visible through six individual factors. Collaborative value creation (see factor 6 in Table 16) and joint portfolio development (see factor 9 in Table 16) between digital innovation units and main organizations are deemed particularly advantageous for the cooperative development of digital innovations since they enable the resolution of tensions in the early conception and development stages of digital innovation (Dremel et al. 2017; Hylving and Selander 2012). Instead of laboriously combining two individually developed artifacts, competencies can thus be pooled right at the beginning of value creation (Hylving and Schultze 2020). Rotation between digital innovation unit and main organization employees, identified in the literature as a significant transformation driver (Raabe et al. 2020a), may be used as an instrument to facilitate early cooperation in practice (see

factor 10 in Table 16). Further, the structural and organizational introduction of incentives for a joint collaboration between digital innovation units and main organizations is considered relevant (see factor 4 in Table 16). An introduction of incentives to engage a specific action is a common tool to resolve tensions, e.g., on joint organizational learning and knowledge transfers (Smith and Beretta 2021), on organization-wide strategic digital innovation engagements (Danneels and Viaene 2022), or on changing business logics (Tumbas et al. 2018). Further, in addition to strategic and operational alignments, the experts consider cultural alignments and mutual understanding to be relevant. The alignment of understanding (Karpovsky and Galliers 2015) in the process of dynamic problem-solving and decision-making is defined as a core competency for successful digital innovation management (Nambisan et al. 2017). Further, cultural alignments and mutual understanding can be characterized as necessary preconditions for partnership work (Visnjic et al. 2021). The experts explicitly state that digital innovation units' and main organizations' employees should interact and meet as equals (see factor 8 in Table 16) while avoiding personal power games between the two entities (see factor 11 in Table 16). To avoid anxiety and negativity, building relationships and cultivating social interaction is seen as highly relevant in the contexts of two separate business models (Visnjic et al. 2021). It can be anchored in the literature of organizational culture and indicates the relevance of social factors in the innovation process (e.g., Boland et al. 2007; Lokuge et al. 2019). Concluding, *Operational Synchronizing* may aid in resolving tensions that originate in distinct value-creation cycles (e.g., McKinsey 2020; Porsche-Consulting 2020) or cultural differences and a lack of reciprocal understanding (Visnjic et al. 2021). Additionally, it may assist in aligning two poles in order to facilitate the operational and procedural integration of physical and digital components inside layered-modular product architectures (Hylving and Schultze 2020).

Figure 18 displays the interplay between all three meta-patterns. In line with prior research, the factors in achieving effective and symbiotic cooperation between digital innovation units and main organizations operate at multiple layers of organizing (Arghavan Shahlaei and Kazan 2020; Drechsler et al. 2020). Likewise, three layers of organizing were identified, which are mostly consistent with prior studies. The meta-patterns reveal (1) a *structural layer*, (2) a *strategic layer*, as well as (3) an *operational layer*. Further, the study observes that one layer (1) maintains the structural segregation between digital innovation units and the main organization (Figure 18, a) and that two layers (2&3) strategically and operationally synthesize digital innovation units and main organizations (Figure 18, b). Inspired by the layered-modular product architecture (Yoo

et al. 2010), the study refers to the combination of the meta-patterns as *Multi-Layered Organizing* (Figure 18, c).

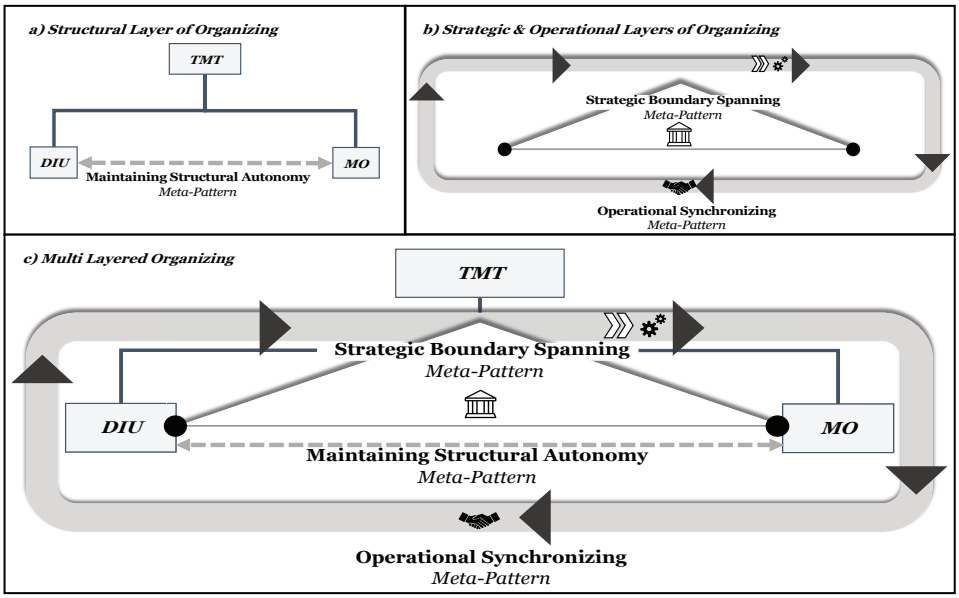


Figure 18 – Layers of Organizing

III.6 Synthesis

In a further abstraction of the findings, connections to the theory on paradoxes and ambidexterity can be identified (Gregory et al. 2015; Smith and Lewis 2011). Considering the panelists' replies, a continuing need to *Maintain Structural Autonomy* to meet the demands of digital innovation can be observed. This resembles the ambidextrous capability of establishing and sustaining a new contradictory pole to enable a distinct focus on innovation activities (O'Reilly and Tushman 2004; Smith and Tushman 2005). Yet, to overcome the inherent tensions of layered-modular digital innovation (Hylving and Schultze 2020), ones view needs to go beyond the separation-oriented perspective of ambidexterity (Papachroni et al. 2014). By strategically integrating digital innovation units into main organizations, the second meta-pattern, *Strategic Boundary Spanning*, provides *blending* capabilities to mitigate paradoxical tensions (Gregory et al. 2015). Further, the third meta-pattern, *Operational Synthesizing*, might overcome paradoxical tensions by *balancing* both poles (Gregory et al. 2015) and linking digital innovation units and main organizations on an operational level.

In detail, the meta-pattern *of Maintaining Structural Autonomy* contributes to establishing and sustaining a structurally segregated and autonomous unit. Following ambidexterity research, it is comparable to the application of separation in order to enable two poles with an unique and undivided focus (Smith and Tushman 2005). However, applying the paradoxical perspective on ambidexterity it seems as if this meta-pattern is insufficient and only a first step, allowing for an initial boost in exploratory potential but requiring an additional synthesizing approach once the digital innovation outcomes or new capabilities need to be transferred into the main organization (Smith and Lewis 2011).

The meta-pattern *Strategic Boundary Spanning* contributes to the coupling between digital innovation units and main organizations. Ambidexterity research underlines a comparable need for establishing orchestrating structures, strategies, and TMT actors to transcend segregated ambidextrous poles (O'Reilly and Tushman 2004; Smith and Tushman 2005; Tumbas et al. 2018). Likewise, the meta pattern resembles the *blending* activities outlined by Gregory et al. (2015), which entails harmonizing two seemingly opposing poles. Regarding the paradox perspective on ambidexterity, the second meta-pattern is comparable to bridging contradictions between two paradox poles (Lewis 2000). Further, developing a mutual perspective in strategy allows “to reframe the tension from a trade-off to a paradox perspective” (Visnjic et al. 2021, p. 20).

The meta-pattern *Operational Synchronizing* contributes to the linkage between digital innovation units and main organizations. Regarding the theory of ambidexterity, this resembles the need to establish cross-functional linkages and interfaces on an operational firm level, to align knowledge, value-creation and teams as proposed by Jansen et al. (2009). From a paradox perspective on ambidexterity, the third meta-pattern resembles the *balancing* activities outlined by Gregory et al. (2015), which involve constantly devising compromises between contradicting demands via iterative and continuous coordination. The application of this meta-pattern enables two different domains (i.e., digital innovation units and main organizations) to not be seen in a battle between professions (Abbott 1988), but to provide interlinked pathways which may result in the mitigation of paradoxical tensions between two separated units (Smith and Lewis 2011).

Concluding, prior research, as well as the panelists’ replies, anticipate that adopting a paradoxical perspective on ambidexterity can move the understanding beyond the dominant separation-oriented prescriptions (Papachroni et al. 2014; Smith and Beretta 2021; Smith and Lewis 2011). Taken together, the three meta-patterns underscore the assertion by Andriopolous and Lewis (2009) "that integration and differentiation offer

powerful, complementary tactics for fostering ambidexterity, [as] this combination helps reduce the anxiety and defensiveness that tensions spark and that can spur vicious, rather than virtuous, cycles" (Andriopoulos and Lewis 2009, p. 708). Yet, approaches to resolving tensions can thus trigger new tensions, as “one challenge is the possibility that the resolution of one paradox may inadvertently create another” (Poole and Van de Ven 1989, p. 576). This requires providing practices for recurrent tensions on a more operational/bottom-up level while reacting to new arising tensions through the same paradox lens on a more strategic/top-down level, (Visnjic et al. 2021). Hence, it seems all the more relevant to constantly consider the paradox lens iteratively and dynamically (Papachroni et al. 2014; Visnjic et al. 2021) not only in recognizing tensions but also in resolving them (Smith and Lewis 2011). The complex construct between two distinct units may only be triggered by a comparably and inherently complex approach - it can be traced back to Ashby's *Law of Requisite Variety* which postpones that "only variety (complexity) can adsorb variety (complexity)" (Ashby 1956, p. 207).

III.7 Theoretical and Managerial Implications

The findings contribute to several streams of literature. First, the study contributes to the ongoing research on digital innovation and discusses ways in which it emerges and is integrated into traditional organizations (Nambisan et al. 2017). The study focuses on incumbents' capacity to combine digital and physical components generated in two independent units (Svahn et al. 2017), which is seen as an extremely relevant but nascent part of the field (Ciriello et al. 2018; Hund et al. 2021). Further, the study deepens knowledge on layered-modular digital innovation by adding necessities and possibilities for organizational integration practices resulting from this architecture (Yoo et al. 2010). While previous research has considered the effects on products, the study notes that a layered modular architecture also has consequences for organizing. To cope with the converging digital and physical boundaries (Hund et al. 2021), organizational boundaries, i.e., those between two separated units, converge as well. Through the Strategic Boundary Spanning and Operational Synchronizing meta-patterns, the study observes how these converging processes take place on several layers of organizing. It may facilitate successful cooperation and integration both between digital and physical components and organizational units. Lastly, inspired by the modular-layered product architecture (Yoo et al. 2010), this dissertation refers to the combination of the three collaboration mechanisms as multi-layered organizing. This observation makes it possible to detect a reciprocal development between the organizational components of digital innovation units and main organizations and digital and physical product components. It can be related to a co-evolutionary adaptation because it postulates a

structural similarity between the design of a modular-layered product and the organizational structure responsible for its manufacture and maintenance. On one hand, the technical paradoxical nature of the physical–digital combination (Piccinini et al. 2015) results in paradoxical tensions within the ambidextrous organizational setting (i.e., between digital innovation units and main organizations (Andriopoulos and Lewis 2009; Svahn et al. 2017). On the hand, firms adopt a layered-modular architecture perspective on their organizing to deal with anticipated tensions (Hylving and Schultze 2020). The study demonstrates this by describing the various layers of organizing between digital innovation units and main organizations, which is comparable to a modular-layered product architecture that provides specific organizational capabilities like structures and strategies to an overarching yet loosely coupled organization while also providing specific technological capabilities to an overarching yet loosely coupled product.

In this regard, the study contributes to research on changing organizational forms following Hanelt et al. (2021), who observe a "shift towards malleable organizational designs which enable continuous adaptation" (Hanelt et al. 2021a, p. 1161). The study, hence, provides a further jigsaw piece to the big picture of recent organizational designs. Applying the paradox perspective on ambidexterity (Gregory et al. 2015; Papachroni et al. 2014), it sheds light on specific hybrid forms of organizing triggered by the adoption of digital technologies (Schumm and Hanelt 2021). The study contributes by demonstrating that this perspective may also create and contribute significantly to Information Systems and, more particularly, digital innovation research since, as Gregory et al. (2015) argue, resolving paradoxical-ambidextrous tensions becomes especially critical in the digital age. Lastly, the study contributes to the emerging literature of digital innovation units by providing collaboration approaches and ideas on how to overcome intraorganizational boundaries (e.g., Haskamp et al. 2021d; Raabe et al. 2020a).

For practitioners, the results have concrete applicability. First, managers who reflect on how to realize digital capabilities and build digital innovations internally should reconsider digital innovation units as an appropriate venue for this endeavor. Second, managers who work in or collaborate with digital innovation units may utilize the prioritized list of key factors (Table 16) as quick wins to strengthen the existing relationship. Thirdly, managers and organizations interested in establishing a digital innovation unit may use the meta-patterns as a blueprint and consider: a) sufficient breathing room for innovation; b) joint strategies and the formation of a mutual TMT board; and c) mutual operational value creation, for example through joint innovation projects.

III.8 Limitations and Future Research

The study is not without limitations. First, the research is focused on the automotive industry. Despite offering an appropriate field of research, its nature imposes certain limitations on the generalizability of the results at a detailed level. Nevertheless, the results may be transferred to other industrial-age contexts. Second, the results are based on a limited number of experts, although the study has made the highest efforts to ensure an appropriate panel size. The number of participants complies with other Delphi studies, which built on a lower (e.g., Daniel and White 2005; Nambisan et al. 1999) or a comparable (e.g., Kasi et al. 2008; Piccinini et al. 2015) panel size, as well as with the methodological guidelines (Okoli and Pawlowski 2004; Schmidt 1997; Skinner et al. 2015). Further, the experts are exclusively located in digital innovation units. Future research can extend the study by integrating experts from both poles. Another future research avenue is the practical application of the paradoxical perspective on ambidexterity, and the derivation of concrete coping strategies for paradoxical tensions as this is a nascent part of the Information Systems field (Ciriello et al. 2018; Hund et al. 2021). The study engages future research to build on the meta-patterns and add specifying details from practical investigations. Although the results are considered to be generalizable, future research can build on those by investigating other forms of hybrid organizations besides those involving digital innovation units.

III.9 Concluding Remarks

In sum, Study 4 derives valuable insights in understanding the mechanisms of how digital innovation units can close capability gaps for their main organization and how they can develop mechanisms to overcome digital innovation-related paradoxical tensions. By demonstrating how layered product architectures result in organizational adaptations (Hylving and Schultze 2020) and how that affects various layers of organizing (Arghavan Shahlaei and Kazan 2020; Drechsler et al. 2020) while applying the paradoxical lens of ambidexterity, Study 4 aims to derive mechanisms that can enable collaborative digital innovations; it thus answers RQ3 - "How do industrial-age incumbents and their digital innovation units overcome digital innovation-related tensions to collaboratively engage in digital innovation?".

Study 4 provides valuable findings to close this research gap. The study distills three meta-patterns – maintaining structural autonomy, strategic boundary spanning and operational synchronizing – that influence the organization on different layers to provide a more effective and symbiotic cooperation between digital innovation units and their main organizations. The main findings are as follows:

1) establishing digital innovation units reveals and increases paradoxical tensions;
2) the paradoxical perspective on ambidexterity can assist in resolving those tensions;
3) separating digital innovation units from the main organization requires transcending and synthesizing collaboration and cooperation mechanisms;
4) collaboration and cooperation require strategic boundary spanning and operationalized synchronizing mechanisms;
5) the management of digital innovation units and their main organizations co-evolves with the product architecture that they jointly create.

C Contributions[6]

Part C is the concluding section of this dissertation. First, it provides a summary of the findings to address the three RQs posed (Chapter C.I.1– C.I.3). Second, it conceptualizes a synthesis based on co-evolution by observing multilevel co-evolutionary notions (Chapter C.I.4). Third, implications for theory and practice are presented (Chapter C.II.1–C.II.2). Finally, after a discussion of limitations and future research opportunities (C.III.1–III. 2), a few final thoughts are provided (C.IV).

I Findings

In the subsequent sections, the three overarching RQs are addressed. First, the main findings are summarized and discussed in light of those questions and the funneled research perspective. In addition, this chapter uses these findings to synthesize a dynamic multi-layered, co-evolutionary framework. This section concludes with the hypothesis that the observed co-evolutionary framework, as one possible strategy, can assist in resolving paradoxical tensions that are embedded in the modular-layered product architecture.

I.1 Findings Regarding the Understanding of Digital Technologies' and Digital Innovations' Impact on Organizational Forms

The impact of digital innovations and their inherent digital technologies has been characterized as pervasive and persistent (Verhoef et al. 2021; Yoo et al. 2012). Previous research outlines that organizations, particularly industrial-age incumbents, need to alter their organizational forms to participate in digital innovation (Berente 2020; Lyytinen et al. 2016). This "organizational change that is triggered and shaped by the widespread diffusion of digital technologies" (Hanelt et al. 2021a, p. 1160) is referred to as digital transformation and has become an increasingly common subject of inquiry (Wessel et al. 2021). To understand this phenomenon, this dissertation posed and investigated RQ1: "How do industrial-age incumbents adapt their organizational forms to emerging digital technologies and innovation?"

Study 1 provides valuable insights in this regard. In aiming to close this gap, this thesis examines previous IT-enabled organizational transformations (Besson and Rowe 2012) in order to investigate possible commonalities to learn from and build on and to

[6] Some (sub-)chapters are based on research papers that have been previously submitted by the author. Detailed information on the papers is summarized in Table 1.

investigate peculiarities and novelties in today's digital world. It prevents reinventing the wheel, enables building on a cumulative research tradition and contributes novel insights to knowledge of the crossroads between digital innovation and digital transformation (Appio et al. 2021). Study 1 derives numerous findings regarding organizational adaptation as a response to emerging digital technologies and innovation:

1) an ongoing decentralization that transcends organizational and industrial boundaries;
2) an archetypal transformation in organizational form from bureaucratic to post-bureaucratic;
3) a constant need for change and adaptation and the primacy of transition, which is manifest in more adaptable and malleable organizational forms;
4) a shifting role for technologies in the process of transformation and in defining new organizational forms;
5) a co-evolutionary development between digital technologies and organizational forms in which digital technologies' role changes from enabling dynamics to triggering dynamics.

In more detail, digital innovations and their inherent digital technologies lead to an ongoing decentralization of organizational forms. Study 1 reveals a constant decentralization of organizational forms toward nearly boundaryless organizations like networks or platforms (Wang 2021). In addition to previously recognized organizational decentralizations on the level of decision making and structures (Ferioli and Migliarese 1996), the influence of digital innovations with their inherent digital technologies leads to a decentralization that transcends existing organizational boundaries (Ravichandran and Giura 2019) and even established industrial boundaries (Brynjolfsson et al. 2013). This pervasive decentralization is triggered by the advent of digital technologies that blur and converge existing boundaries (Hund et al. 2021). It subsequently leads, in the most advanced state of organizational decentralization, to an embedding in and interconnection with digital business ecosystems that are built around a digital core and follow completely different logics of management and control (El Sawy and Pereira 2013). To reach this stage of decentralization, however, the majority of industrial-age incumbents, which were not born around a digital product and are not inherently integrated into a digital ecosystem (Verhoef et al. 2021), must undertake a first step and alter their existing centralized organizational forms and embed more decentralized forms of organizing (Lyytinen et al. 2016; Yoo et al. 2012).

Further, the ongoing decentralization results in the emergence of novel archetypes of organizational forms. Digital innovations and technologies lead organizations to

incorporate post-bureaucratic organizational forms and principles into their existing bureaucratic contexts to enable participation in digital ecosystems and a move toward more malleable organizational forms (Hanelt et al. 2021a). These post-bureaucratic forms of organizing are amplified by digital infrastructures and standards (Tilson et al. 2010), agile and adaptable processes (Schwer and Hitz 2018), fast and non-hierarchical digital communication channels (Dery et al. 2017), an error culture (Lucas and Goh 2009) and the ability to continuously and swiftly adapt to novel requirements (Huang et al. 2017). These characteristics are rarely associated with industrial-age incumbents (Verhoef et al. 2021), so incumbents will be required to modify their traditional form of organizing. Since industrial-age incumbents, particularly manufacturers of physical goods, are typically built on long, successful histories of bureaucratic and centralized organizing (Hylving and Schultze 2020), they need to find hybrid organizational stages and ways to establish and integrate post-bureaucratic islands into their existing contexts while simultaneously maintaining their bureaucratic and centralized core of value creation (Kolbjørnsrud 2018). The findings of Study 1 indicate that these hybrid stages are long-lasting in an ongoing and continuing organizational evolution. The literature stream of organizational ambidexterity provides a perspective to further investigate and enable this hybridity (Tushman and O'Reilly 1996). Hence, research has recognized it as a valuable theoretical lens in the contemporary digital context (Nadkarni and Prügl 2021; Vial 2019). A current phenomenon to investigate this hybrid and ambidextrous approach is the establishment of digital innovation units, which are post-bureaucratic entities embedded within incumbent firms (Fuchs et al. 2019; Holotiuk 2020).

Additionally, this embedding of post-bureaucratic forms of organizing (i.e., digital innovation units) reveals that organizational forms are becoming increasingly adaptable, enabling constant evolution and transformation (Verhoef et al. 2021; Vial 2019). The influence of digital technologies implies incremental, ongoing and continuous adaptations that to an ongoing primacy of transition, as revealed in Study 1. This observation is consistent with contemporary research, which posits a shift toward more malleable organizational forms that allow an ongoing adaptation to emerging digital technologies in their immediate surroundings (Hanelt et al. 2021a). While the existing literature (Weick and Quinn 1999) and the empirical data from Study 1 indicate that notions of constant adaptability are not new, the current phenomenon is based on and relates to more flexible and reprogrammable digital technologies, which influence the recent wave of organizational transformations in terms of malleability and pace (Hanelt et al. 2021a).

Based on this and in accordance with important research, this dissertation has identified a significant deviation between the contemporary organizational adaption known as

digital transformation and previous ones, which are better described as IT-enabled organizational transformations (Wessel et al. 2021). While information systems have long acted as facilitators for transformation, development has reversed, and information systems serve on one hand as the prevailing driver of transformational dynamics and on the other as the nucleus around which new organizational forms evolve, as exemplified by networks and platform ecosystems. Historically, technologies have enabled transformation (Brynjolfsson et al. 1994; Ferioli and Migliarese 1996), but technology now tends to operate as a trigger of transformations (e.g., Chen and Horton 2016; Yoo et al. 2012). In sum, the impact of digital innovations and digital technologies on firms and their forms of organizing has shifted (Wessel et al. 2021). Since digital products and services have become so central to value creation, the dynamic of adaptation is changing. The new narrative of organizational forms and information systems results from highly dynamic innovations and products and thus demands highly dynamic solutions (Nambisan et al. 2017).

Lastly, these findings are unified by the concept of co-evolution, in which digital technologies and organizational forms change reciprocally (Breslin 2016). However, due to the unique characteristics of digital innovations, their effect on co-evolutionary transformations shifts from an enabling to a triggering dynamic. The value assigned to technology within an organization has evolved over time (Yoo 2010). Consequently, today's pressure for change moves beyond the transformations of previous information system implementations, in both IT-related and non-IT-related organizations (Vial 2019), since digital technologies blur and converge existing boundaries (Hund et al. 2021) in a generative manner (Henfridsson and Bygstad 2013). Consequently, their impact cannot be confined to siloed areas or limited by inter- or intraorganizational boundaries; rather, it is felt at multiple levels. Moreover, digital transformation requires a change in perspective from an episodic view to a continuous change approach, which is triggered by the reprogrammable and flexible nature of digital technologies (Hanelt et al. 2021a).

To conclude, the co-evolution between organizational forms and information systems changes from enabling dynamics to inherent dynamics. It is not restricted by distinct boundaries and occurs at a dynamic pace. These characteristics mark a starting point for an organization-wide co-evolution between digital technologies and organizational forms on multiple levels, as displayed in Figure 19

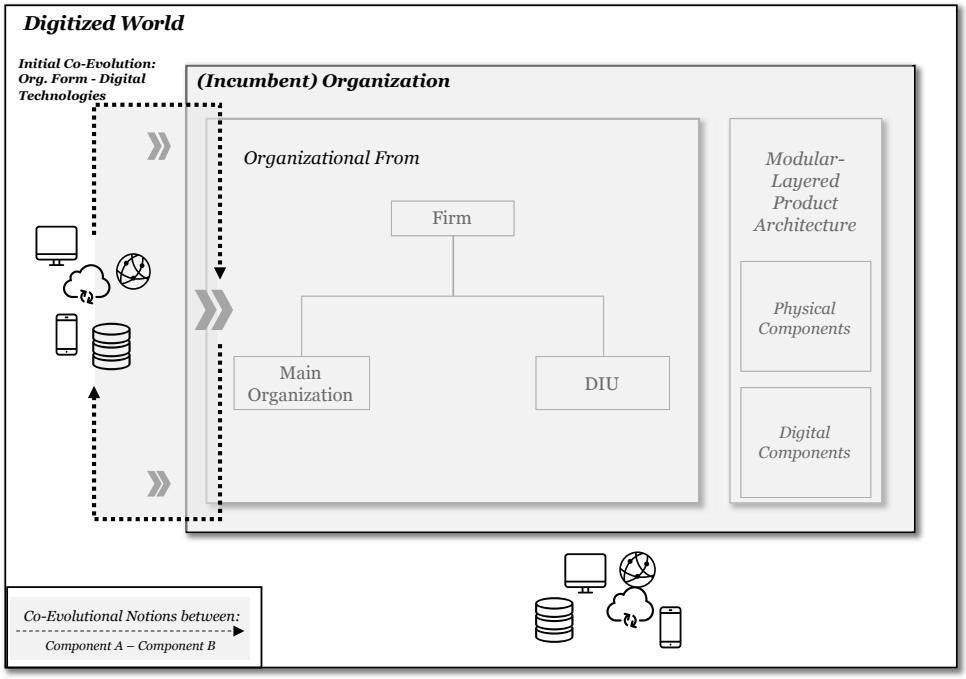


Figure 19 – Co-Evolutionary Transformation 1

I.2 Findings Regarding the Establishment of Digital Innovation Units to Enable Digital Innovation in Industrial-Age Incumbents

Previous research has associated industrial-age incumbents' participation in digital innovation with the need to embed "a new organizational form that departs dramatically from traditional industrial production" (Berente, 2020, p. 92). Digital innovation units are considered a strategic initiative for industrial-age incumbents to embed new organizational forms as prerequisites to facilitating digital innovations (Jöhnk et al. 2022; Svahn et al. 2017). However, little is known about how these units can be established and how they evolve in the context of industrial-age industries, as well as whether they actually create significant advantages for their main organizations. To investigate how digital innovation units can be successfully established and embedded and how they create value, this dissertation poses and investigates RQ2: "How can the establishment of digital innovation units a) facilitate the development of digital innovation within industrial-age incumbents, and b) how do they (co-)evolve over time?"

Studies 2 and 3 provide valuable findings in this regard. Aiming to close knowledge gaps, this dissertation first investigates how digital innovation units are established and how they facilitate the development of applicable digital innovations. Second, it investigates whether the effort to establish digital innovation units to facilitate the development of digital innovations actually bears fruit and positively influences firm performance. The main findings on digital innovation units are as follows:

1) they can provide an advantageous environment for the creation, selection and retention of novel digital outcomes;
2) they can serve as a foundation to build dynamic and digital capabilities;
3) their establishment and outcomes – digital patents, digital market offerings and supporting digital transformation initiatives – have positive performance implications and encourage digital innovation;
4) they secure the applicability and integration of their digital outcomes and capabilities by building legitimacy for themselves within the main organization;
5) they co-evolve with their main organization through continuous and reciprocal alignment.

In detail, establishing distinct and separated units that are freed from the bureaucratic shackles of an industrial-age incumbent can create a valuable space to create variations to the traditional innovation practices (Fuchs et al. 2019; Raabe et al. 2021). Digital innovation units are built on the premises of post-bureaucratic organizational forms, including an open and agile culture (Hellmich et al. 2021), flat or non-existent

hierarchies (Raabe et al. 2020a) and a focus on and broad expertise in agile work principles such as design thinking, Kanban, and Scrum (Haskamp et al. 2021b; Holsten et al. 2021). Additionally, they are solely focused on objectives and outcomes with a digital core (Barthel et al. 2020; Haskamp et al. 2021b; Raabe et al. 2021), which enables an undiluted focus on digital innovation (Dremel et al. 2017). Digital innovation units purposefully explore innovation opportunities in relation to the existing main organization. In doing so, they reflect the intentional alteration of current routines and habits in order to generate variations (Hodgson 2013; Winter and Nelson 1982). Further, digital innovation units hedge innovation opportunities in relation to the existing main organization to ensure customer benefits. As a result, they reflect the selection of variants that best fit in terms of interaction with the environment (Hannan and Freeman 1977; Van de Ven and Poole 1995). They thus facilitate the development of applicable and integrable digital innovations by agile and iterative trailing (Chan et al. 2019; Sambamurthy et al. 2003) in line with the main organization (Dremel et al. 2017; Raabe et al. 2020a). Lastly, digital innovation units transfer their digital outcomes to the main organization, which indicates the retention of previously selected variants (Van de Ven and Poole 1995) and thus the adoption of new digital components, processes and capabilities by the main organization. They facilitate this transfer by providing a solid capability and technology infrastructure that enables the retention of novel and disruptive digital innovations, which emphasizes the generativity of digital technologies (Henfridsson and Bygstad 2013). Digital innovation units, as a manifestation of a post-bureaucratic organizational form and due to their ability to (re-)act swiftly and instantly to environmental changes and to fulfill novel digital requirements, can facilitate digital innovation similar to external digital ventures (e.g., Huang et al. 2017).

Further, digital innovation units can serve as the foundation for dynamic and digital capabilities, both of which are vital to facilitating the development of digital innovations, since digital capabilities "allow organizations to use digital resources for innovation purposes" (Wiesböck and Hess 2020, p. 80) and dynamic capabilities have been reported to incorporate the capacity to "innovate, adapt to change, and create change that is favorable to customers and unfavorable to competitors" (Teece et al. 2016, p. 18). Their potential to serve as a foundation for dynamic and digital capabilities can be deduced from their organizational characteristics and outcomes. First, digital innovation units may be thought of as foundations where dynamic capabilities can be conceived, developed and realized (Hellmich et al. 2021), since they can provide the structural, processual and entrepreneurial framework that is essential for the emergence of dynamic capabilities (Teece 2007). Second, Study 3 reveals three developments that are intimately linked to the dynamic capability perspective. Specifically, it discovered

the beneficial effect of digital innovation units on the number of digital patents, which can be associated with the capability of sensing , the positive impact of digital innovation units on the number of digital market offerings, which can be associated with the capability of seizing , and the value of digital innovation units for a firm's digital transformation, which can be associated with the capability of transforming. Together, these discoveries show that establishing digital innovation units can serve as a valuable foundation to build and realize dynamic capabilities.

Additionally, the establishment of digital innovation units can be quantifiably related to a beneficial influence on firm performance, as Study 3 shows. This study establishes a correlation between the establishment of digital innovation units and an increase in digital patents, digital outcomes and digital transformation performance. Consequently, these outcomes can be linked to the abilities through which digital innovation units facilitate digital innovation in industrial-age incumbents. Additionally, the influence of digital innovation units and their ability to facilitate digital innovation are greatest in high-pressure environments and in firms whose products are built on physical assets. Thus, increased external pressure to adapt and internal hurdles to digitalize accelerate and expand the positive impact of digital innovation units. It appears that the abilities of digital innovation units to facilitate digital innovation and their impact on firm performance co-evolve with rising environmental pressure and internal hurdles.

Digital innovation units also facilitate digital innovation and secure the application and integration of their outcomes and capabilities by acquiring legitimacy through the reciprocal adaptation of work practices with the main organization and the provision and deployment of infrastructural technologies that lead to a better perception of outcomes and the retention of digital components and processes in order to overcome cultural and competence barriers (Weiblen and Chesbrough 2015).

Lastly, digital innovation units increase their legitimacy through an ongoing and co-evolutionary adaptation to the main organizations' context and constraints (Fisher et al. 2017; Überbacher 2014). They consider several IT(-security) and processual constraints from their main organization to decrease irritations and frictional losses in their cooperation and to adopt their counterparts' most effective work practices. While considering these constraints, they expand and integrate new digital components and capabilities into the main organization. This enables the main organization to use and build their own value (creation) on digital innovations. The spread and use of these digital innovations increases the acceptance and legitimacy – and thus the growth – of digital innovation units. In sum and more generally, a state of joint co-evolution between

digital innovation units and main organizations is enabled through digital innovation even as it triggers the creation of digital innovation.

In sum, and as outlined in Study 1, digital innovations and their inherent digital technologies trigger a broad and dynamic co-evolution between digital innovations and their digital technologies and organizational forms. This co-evolution appears to persist at a more granular level. First, digital innovation units co-evolve with external digital pressure and internal digital innovation hurdles. Second, digital innovation units and their main organizations co-evolve reciprocally and on an ongoing basis. Therefore, procedures, structures, technologies and capabilities become reciprocally aligned through ongoing adaptations to reduce and avoid friction and ambiguity while creating digital innovations. Both observed co-evolutionary developments are directly triggered by digital innovations and their inherent digital technologies or indirectly triggered by their pervasive influence on organizational forms. This dynamic multilevel co-evolution is displayed in Figure 20.

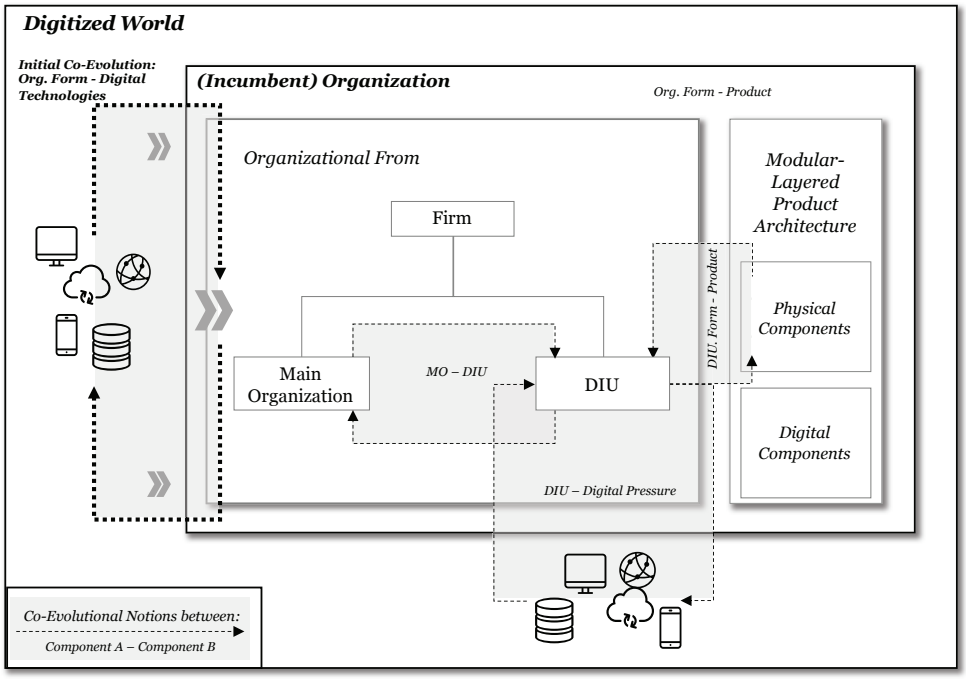


Figure 20 – Co-Evolutionary Transformation 2

I.3 Findings Regarding the Management of Digital Innovation Units to Overcome Digital Innovation Tensions

Digital innovation units are associated with post-bureaucratic organizational forms while being structurally and culturally separated from the main organizations' bureaucratic constraints (Holsten et al. 2021). This enables them to focus solely on digital innovation without being directly influenced by the main organizations' physical environment (Raabe et al. 2020a). However, pursuing digital innovation requires symbiotic and effective collaboration on a par with both intertwined layers of physical and digital components (Yoo et al. 2010). Consequently, digital innovation units' outcomes and capabilities must be mergeable and combinable with those of the main organization (Svahn et al. 2017). This peculiarity can result in distinct and paradoxical tensions (e.g., Piccinini et al. 2015; Svahn et al. 2017), since digital innovation units strive for new and disruptive digital innovations (Raabe et al. 2020a) that nevertheless need to become aligned with the physical product environment (Svahn et al. 2017). Yet, little is known about digital innovation units' mechanisms and approaches of cooperation and collaboration with and outcome and capability integration into the main organization (Brauer et al. 2021). To investigate how digital innovation units can be managed to create mechanisms that overcome these tensions, this dissertation posed and investigated RQ3: "How do industrial-age incumbents and their digital innovation units overcome digital innovation-related tensions to collaboratively engage in digital innovation?"

Study four provides valuable findings to close this research gap and to answer RQ3. The study distilled three meta-patterns – maintaining structural autonomy, strategic boundary spanning and operational synchronizing – that influence the organization on different layers to provide a more effective and symbiotic cooperation between digital innovation units and their main organizations. The main findings are as follows:

1) establishing digital innovation units reveals and increases paradoxical tensions;
2) the paradoxical perspective on ambidexterity can assist in resolving these tensions;
3) separating digital innovation units from the main organization requires transcending and synthesizing collaboration and cooperation mechanisms;
4) effective and sustainable cooperation can be built on strategic boundary spanning and operationalized synchronizing mechanisms;
5) the management of digital innovation units and their main organizations co-evolves reciprocally with the product architecture they jointly create.

In detail, in order to understand emerging paradoxical tensions and make them tangible, the nested and underlying paradoxes need to be embraced (Andriopoulos and Lewis 2009; Smith and Lewis 2011). Situating the paradox is a necessary first step in comprehending the tensions to come in their entirety (Danneels and Viaene 2022; Papachroni et al. 2014). Study 4 distilled the organizational tensions that occur in digital innovation between digital innovation units and their main organizations and linked them to the peculiarities of the modular-layered product architecture, which is characterized as inherently loaded with tensions (Hylving and Schultze 2020). Embracing the nested and underlying paradoxes allows and enables the exploration and development of suitable coping strategies (Danneels and Viaene 2022; Papachroni et al. 2014).

Further, one possible coping strategy for this specific paradox is investigated and described in Study 4. Prior research has established ambidexterity as one approach to mitigate paradoxical tensions (Gregory et al. 2015); it is defined as an organizational capability to pursue divergent things simultaneously (Gibson and Birkinshaw 2004). Besides a rather separation-oriented research stream that deems structural, contextual or temporal distinctions and segregation as suitable approaches to achieve ambidexterity (Papachroni et al. 2014), recent studies have embraced a paradox perspective to successfully handle two opposed organizational poles at the same time (Andriopoulos and Lewis 2009; Danneels and Viaene 2022; Papachroni et al. 2014). Resolving paradoxical tensions and ambidexterity are intrinsically related and should be examined together (Gregory et al. 2015). This dissertation applies this lens and builds on this perspective to derive appropriate coping strategies.

Additionally, by applying that lens, the dissertation aims to establish sustainable solutions that will encourage symbiotic synthesis and transcendence (Chen 2003) as opposed to establishing distinct local optima that lead to increased segregation (Smith and Lewis 2011). The findings indicate that to address tensions between two contradictory and segregated yet cohesive organizational entities, the perspective of paradox may aid in the accomplishment of ambidexterity (Papachroni et al. 2014). By applying this paradoxical lens to particular tensions, Study 4 identifies mechanisms for the management of digital innovation units to overcome digital innovation-related tensions.

These mechanisms include – in addition to a layer that maintains the structural separation between digital innovation units and their main organizations – two layers that strategically span boundaries and operationally synthesize the two poles. The mechanism of separation contains factors that aim at creating and sustaining the

structural autonomy of digital innovation units by fostering divergence in objectives, working and organizing. Further, the mechanism of strategic boundary spanning contains factors that help to bridge the boundaries between digital innovation units and main organizations by fostering their integration in the upper echelons and strategic agendas of the organization. Additionally, the mechanism of operational synthesizing contains factors that aim at synchronizing the practices of digital innovation units and main organizations operationally by fostering the alignment of offerings, interfaces and values.

Lastly, inspired by the modular-layered product architecture (Yoo et al. 2010), this dissertation refers to the combination of the three collaboration mechanisms as multi-layered organizing. This observation makes it possible to detect a reciprocal development between the organizational components of digital innovation units and main organizations and digital and physical product components. It can be related to a co-evolutionary adaptation because it postulates a structural similarity between the design of a modular-layered product and the organizational structure responsible for its manufacture and maintenance. On one hand, the technical paradoxical nature of the physical–digital combination (Piccinini et al. 2015) results in paradoxical tensions within the ambidextrous organizational setting (i.e., between digital innovation units and main organizations;(Andriopoulos and Lewis 2009; Svahn et al. 2017). On the hand, firms adopt a layered-modular architecture perspective on their organizing to deal with anticipated tensions (Hylving and Schultze 2020). The dissertation demonstrates this by describing the various layers of organizing between digital innovation units and main organizations, which is comparable to a modular-layered product architecture that provides specific organizational capabilities like structures and strategies to an overarching yet loosely coupled organization while also providing specific technological capabilities to an overarching yet loosely coupled product.

In conclusion, these findings suggest another co-evolution that is triggered by the advent of digital innovations and their inherent digital technologies. They cause the organizational setup to evolve and are structured and designed to mesh with the peculiarities of the modular-layered product architecture. Hence, digital technologies are again the trigger for a dynamic and multilevel co-evolutionary development, as displayed in Figure 21.

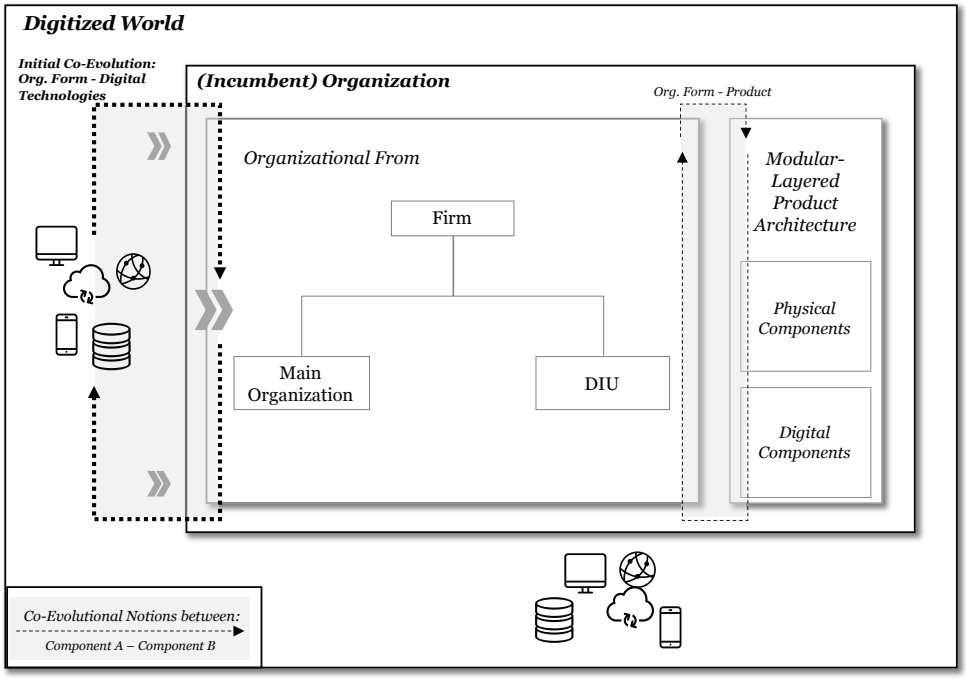


Figure 21 – Co-Evolutionary Transformation 3

I.4 Synthesis: A (Co-)Evolutionary Perspective

All four studies that are part of this thesis reveal notions of a constant, ongoing co-evolution. Study 1's findings indicate that organizational forms co-evolve with their technological environment. Hence, in the contemporary age of digital innovations and their inherent digital technologies, the role of technology in this co-evolution is shifting. While it has long been credited as an enabler, contemporary digital innovations and technologies embed triggering dynamics. Additionally, in this dynamic environment, digital technologies imply blurring and converging boundaries (Hund et al. 2021) that provide novel influences on co-evolutionary transformations. First, the dynamics of digital technologies appear to influence the rate of organizational adaptations resulting in ongoing notions of change (Hanelt et al. 2021a). Second, co-evolutionary transformations are no longer limited by intra- and interorganizational boundaries; they now affect all aspects of an organization and its environment (Verhoef et al. 2021). Studies 2–4 acknowledge these dynamics and their boundary-blurring and converging consequences and reveal continuous co-evolutionary transformations at several organizational levels. To synthesize these concerns, Chapter I.4.1 establishes a framework describing multilevel co-evolutionary transformations, while Chapter I.4.2 argues that this may lead to a new concept, enhancing the well-known punctuated equilibrium theory established by Romanelli and Tushman (1985), which seems to be unappropriated in the digitized and dynamic world (Fischer and Baskerville 2022). Chapter I.4.3 acknowledges this framework of multilevel co-evolutionary transformations and its dynamic equilibrium, arguing that it may assist in resolving the paradoxical tensions embedded in digital innovation.

I.4.1 Dynamic and Multilevel Co-Evolution

Triggered by the advent of pervasive digital innovations and their inherent digital technologies, industrial-age incumbents must alter their organizational forms (Berente 2020; Lyytinen et al. 2016). Digital technologies have become the trigger for adaptations and play a major role in determining the impact, direction and velocity of contemporary organizational transformations (Verhoef et al. 2021). This launches a co-evolutionary transformation between digital technologies and organizational forms (Schumm and Hanelt 2021). With their boundary-blurring and converging characteristics (Hund et al. 2021), digital innovations and their inherent digital technologies further imply co-evolutionary developments, since they are no longer restricted by intra- or interorganizational boundaries. Co-evolution thus appears to influence multiple levels and dimensions.

Study 1 investigates and underlines the initial impact of this multilevel co-evolution; it describes the general influences of digital technologies on organizational forms and the transformational dynamics that result. Triggered by the co-evolution between digital technologies and organizational forms in general, these dynamics prompt further co-evolutions, as revealed in Studies 2–4. Study 2 identifies how digital innovation units and their main organizations co-evolve during the creation of digital innovations. More generally, a state of joint co-evolution is enabled through digital innovation and simultaneously triggers the creation of digital innovation. Study 3 reveals that digital innovation units' ramifications co-evolve in relation to external pressure and internal circumstances. The study observes that their beneficial impact increases reciprocally with digital ventures (i.e., digital competitors) in the industrial environment. In addition, the study demonstrates that their performance implications are more substantial and hence appear to co-evolve when internal hurdles, as reflected by high tangible assets, are greater. Study 4 reveals another co-evolution. To resolve the paradoxical tensions nested inside the modular-layered product architecture (e.g., Hylving and Schultze 2020; Piccinini et al. 2015), its organizational counterpart – the organizational architecture between digital innovation units and their main organizations – must be designed as co-evolutionary. Consequently, the organizational form evolves in accordance with the characteristics of the modular-layered product architecture. Thus, digital technologies are once again the cause of a co-evolutionary development. In addition, this multilevel co-evolution is highly dynamic. Study 1 describes an ongoing co-evolutionary transformation by emphasizing the primacy of transition. Study 2 reveals that digital innovation units are expanding rapidly and undergoing swift transformations (e.g., Huang et al. 2017), in co-evolution with the main organizations. Study 4 shows an ongoing and reciprocal adaptation within a highly dynamic environment.

The specific nature and characteristics of digital innovations with their inherent digital technologies, particularly their inherent dynamics (Lyytinen 2022), their ongoing flexibility and reprogrammability (Henfridsson and Bygstad 2013) and their ability to blur and converge existing boundaries (Hund et al. 2021) induce a dynamic multilevel co-evolutionary transformation. The dissertation develops a synthesized framework that considers these dynamics and co-evolutionary transformations on multiple levels. As Lewin and Volberda (1999, p. 520) noted, a dynamic multilevel co-evolutionary perspective on transformation offers the opportunity to integrate "micro- and macro-level evolution within a unifying framework, incorporating multiple levels of analyses and contingent effects, and leading to new insights, new theories, new empirical methods, and new understanding." Additionally, this "co-evolving at different levels is

[...] a key aspect in understanding the dynamics [...] in the future development of research in organization studies" (Breslin 2016, p. 63). In sum, synthesizing a dynamic and multilevel co-evolutionary framework of transformations can provide a valuable tool to investigate different perspectives of research, as was the aim in this dissertation (see the funneled multi-level research perspectives in Figure 12) and can further consider co-evolutionary transformations in dynamic environments (see for example, Geels 2006; Rodrigues and Child 2003).

Figure 22 displays the framework of dynamic and multilevel co-evolutionary transformations.

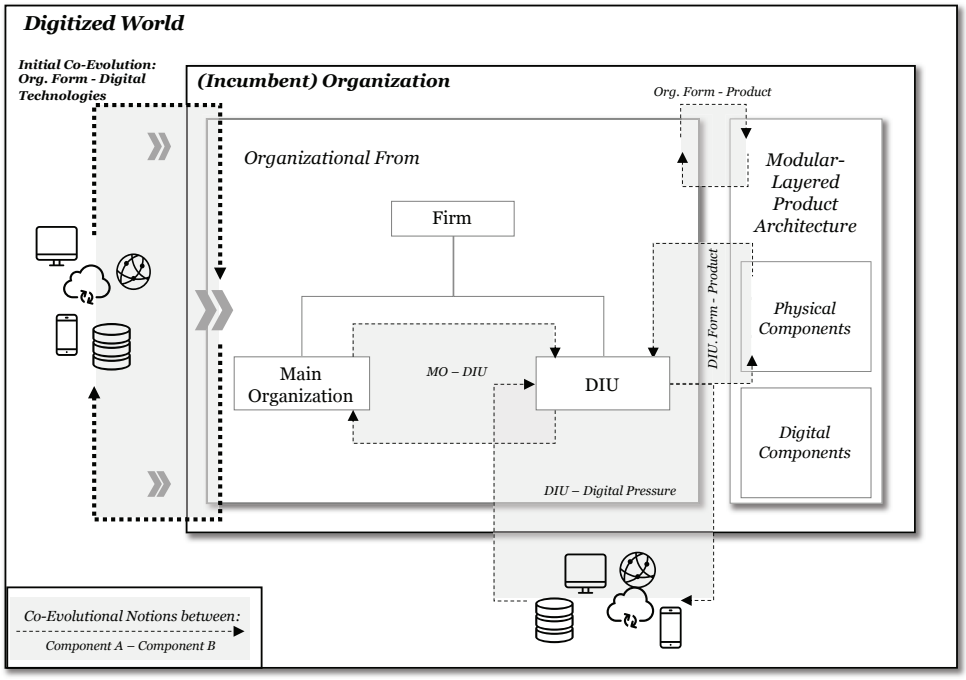


Figure 22 – Dynamic, Multilevel, Co-Evolutionary Framework

I.4.2 Dynamic Co-Evolutionary Equilibrium

The dynamic, multilevel co-evolutionary framework can be interpreted as an organizational reaction to a highly dynamic environment. Hanelt et al. (2021a) characterize the ongoing digital transformation as comparatively dynamic and co-evolutionary. They state that Lewin's well-known perspective on change, which follows an unfreezing – transforming – freezing logic (Weick and Quinn 1999), may have evolved into a constant state of adaptation where ongoing and dynamic transformations persist for longer periods of time (Verhoef et al. 2021). This is underscored by the inherently dynamic and turbulent nature of digital environments (El Sawy and Pereira 2013), which may lead organizational transformations to "culminate in a state of constant unfreezing" (Hanelt et al. 2021a, p. 1178). These ongoing and holistic co-evolutionary transformations may result in a state devoid of convergent equilibriums (El Sawy and Pereira 2013). While Romanelli and Tushman (1985) argue for a punctuated equilibrium within (co-)evolutionary transformations, defined as relatively long periods of convergence with or without only minor notions of change punctuated by short phases of strategic transformation and re-organization that re-create the existing organization, this theory may no longer hold in times of constant dynamic change (Hanelt et al. 2021a). Fischer and Baskerville (2022, p. 1) support this hypothesis by arguing that "approaching sociotechnical change with 'punctuation of equilibrium' is becoming increasingly ineffective". Concepts of swift transformations (Huang et al. 2017) or continuous and holistic organizational changes (Verhoef et al. 2021), the findings of this dissertation and the developed framework of a dynamic, multilevel co-evolution can be viewed as a necessary extension of Romanelli's and Tushman's (1985) theory. Since change-initiating events triggered by digital technology occur in an ongoing rather than punctuated fashion (e.g., El Sawy and Pereira 2013; Huang et al. 2017), and firms respond by adopting malleable organizational forms to enable quick changes (Hanelt et al. 2021a), swift transformations to rebalance activities and culture (Huang et al. 2017) and the primacy of transition to be constantly adaptable (see Study 1), this dissertation implies that the recent transformational co-evolution follows a dynamic rather than a punctuated equilibrium. Therefore, as observed in Study 2, it argues that co-evolution in digital times consists of relatively long phases of ongoing co-evolutionary adaptation that leads to a dynamic equilibrium driven by continuous negotiation and adaptation (e.g., Henfridsson and Yoo 2014). These dynamic phases may be "occasionally punctuated by episodic bursts when the malleability of the organizational design does not allow to react to [...] variations" (Hanelt et al. 2021a, p. 1178). Yet, even these interruptions can "lead to new phases of continuous change in organizations, which may endure for a comparably long time" (Hanelt et al. 2021a, p. 1178).

In conclusion, digital innovations and their inherent digital technologies lead to a multilevel co-evolutionary transformation that appears to be inherently dynamic. Therefore, this dissertation indicates that the relatively stable (co-)evolutionary perspective on previous transformations provided by Romanelli and Tushman (1985) has changed from a punctuated equilibrium to a dynamic equilibrium in contemporary transformations (see Figure 23) triggered by digital technologies and enabled by malleable organizational forms (Hanelt et al. 2021a), swift transformations (Huang et al. 2017) and embedded post-bureaucratic organizational forms (Studies 1 and 4).

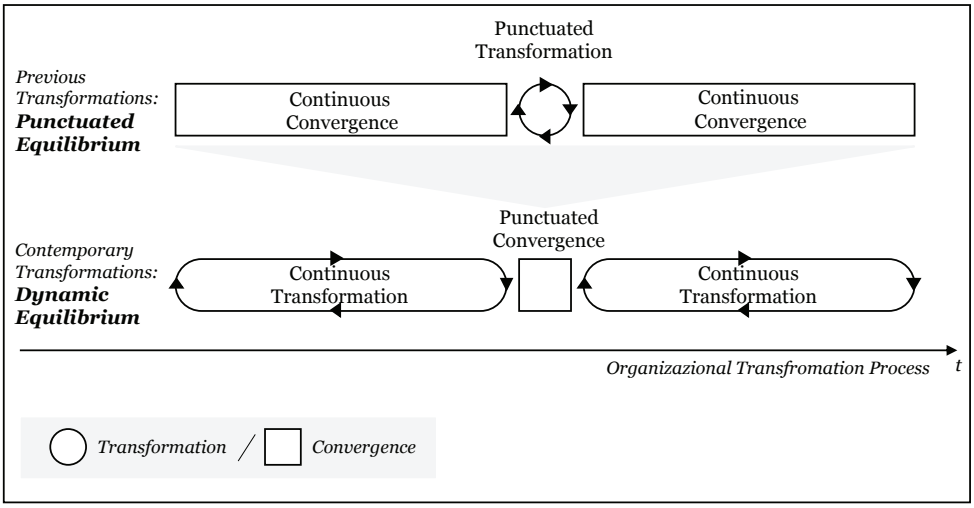


Figure 23 – Co-Evolutionary Dynamic Equilibrium

I.4.3 Co-Evolutionary Notions to Resolve Paradoxical Tensions

Since this dissertation aims to find appropriate ways of organizing for digital innovation, it needs to identify organizational approaches that can successfully overcome the physical–digital paradoxes (Piccinini et al. 2015) nested within the modular-layered product architecture (e.g., Hylving and Schultze 2020). Study 4 offers organizational mechanisms that overcome these paradoxical tensions, based on the blending and balancing activities outlined by Gregory et al. (2015). In addition, and more generally, these mechanisms are influenced and based on a co-evolutionary adaptation between the organizational architecture and the product architecture. Hence, this dissertation indicates that co-evolutionary dynamics between two (tension-filled) poles can aid in resolving paradoxical tensions.

This consideration can be founded in the linkage between these two theoretical considerations and comparable assertions implicitly made in previous studies related to co-evolution and paradox. Regarding co-evolutionary research, for instance, Sarasvathy (2001) suggests that a co-evolution between exploratory and exploitative business units requires responding to the demands of contradictory poles to encourage and expedite a reciprocal co-evolution and alignment. Additionally, previous research argues that the dynamic interplay of contradicting demands between internal and external forces leads to co-evolutionary adaptation within transformations (McKelvey 2004; Montealegre et al. 2014). These contradictory demands may present the observable surface of nested paradoxes (Smith and Lewis 2022) and could thus actually be related to paradoxical tensions. Additionally, in the literature on paradoxes, a few studies directly link co-evolution and the resolution of paradoxical tensions. Jarzabkowski et al. (2013), for instance, explain that various paradoxical tensions co-evolve over time and that a cycle of adjusting responses, which could be characterized as co-evolution, contributes to the development of unique managerial approaches that are characterized in their paper as “cumulative and co-evolving responses to paradox over time” (p. 265). Albert et al. (2015) provide a second example in which co-evolutionary interdependencies must be considered in a strategic renewal in order to resolve paradoxical tensions. Moreover, multiple paradox studies describe notions that could be considered co-evolutionary. For example, Leonard-Barton (1992, p. 123) describes a need “for continuous organizational renewal,” including an alignment between paradoxical poles, to solve the tensions that arise between novel product development and building on existing products. Another example describes the need to co-create novel boundaries to overcome an existing boundary paradox within an organizational transformation (Zietsma and Lawrence 2010). This could be related to the co-evolutionary development between digital

innovation units and their main organizations to overcome existing paradoxical tensions (see Study 4). Smith and Baretta (2021) present a comparable strategy that is directly related to digital innovation units for handling paradoxes. They argue that organizational responses to contradictory demands require "an ongoing process that unfolds through everyday work in which underlying tensions persist over time and shape each other" and that the result is a "dynamic ambidextrous organizing model whose initial design is altered and adjusted over time [...] and [is] open toward emergent change in their organizational design [to] efficiently manage tensions by adapting the organizing model to the situation at hand" (Smith and Beretta 2021, p. 188). This proposed strategy for addressing paradoxical tensions fits well with the co-evolutionary concept of reciprocal and ongoing adaptation.

Following these examples, this dissertation takes the additional step of clarifying the relationship between the two theoretical concepts of paradoxical tensions and co-evolution. It proposes, based on Smith and Lewis's (2011) widely cited paradox study, that their idea of a dynamic equilibrium to resolve paradoxical tensions and the dissertation's framework of a dynamic, multilevel co-evolution with a dynamic equilibrium at its core may be aligned. To make that alignment apparent, Smith and Lewis's (2011) definition of a dynamic equilibrium and the co-evolutionary notions observed in this dissertation should be compared. Smith and Lewis define their concept as follows:

> "The metaphor of dynamic equilibrium highlights the model's key features – the persistence of conflicting forces [1] and purposeful, cyclical responses [2] over time that enable sustainability [3]. Static equilibrium denotes a system at steady state, when all components are at rest. When episodic action creates an imbalance, the system responds to regain equilibrium. Dynamic equilibrium, in contrast, assumes constant motion across opposing forces. The system maintains equilibrium by adapting to a continuous pull [4] in opposing directions." (p. 386, numbering added)

The dynamic multilevel co-evolution framework can be characterized by comparable notions marked with numbers in the quoted definition. Comparable to Smith and Lewis's (2011) definition, the derived co-evolutionary framework identifies the following aspects.

[1] The capacity to merge and combine two contractionary poles that retain their differences but depend on each other and co-evolve over time, such as the co-evolutionary organizational development of digital innovation units and their main organizations, which retain their key characteristics, to enable the development and

integration of novel and disruptive yet applicable digital innovations consisting of digital and physical components (observable in Studies 2 and 4).

[2] The purposeful, cyclical and iterative adaptations to response to contradictory characteristics, such as the reciprocal adaption of processes, structures and capabilities between digital innovation units and their main organizations (observable in Study 2) and (regarding a meta-level, longitudinal perspective) the primacy of transition and the co-evolution between (digital) technologies and organizational forms in general (observable in Study 1).

[3] The dynamic co-evolutionary development that leads to the sustainable collaboration of contradictory and separate poles, as observed in the co-evolutionary design of the organizational and product architectures(observable in Study 4).

[4] The ongoing transformation and primacy of transition triggered by digital technologies and enabled by malleable organizational forms (Hanelt et al. 2021a), swift transformations (Huang et al. 2017) and embedded post-bureaucratic organizational forms (Studies 1 and 4) to maintain a dynamic equilibrium, such as the constant and dynamic cycle of organizational transformations in response to the influence of (digital) technologies and an organization's inherent tendency to seek stability (observable in Study 1) and further observable as the reciprocal and co-evolutionary survival and growth of digital innovation units and their main organizations (observable in Study 2).

In conclusion, comparable to Smith and Lewis's (2011) concept of a dynamic equilibrium, the dynamic multilevel co-evolution framework offers a method for "balancing demands that firms simultaneously excel at both exploration and exploitation" and between "stability and flexibility" (Smith and Lewis 2011, p. 396). Moreover, both notions offer a way to deal with "blurring boundaries" and "increasing complexity" (Smith and Lewis 2011, p. 396) through concepts of synergy and transcendence rather than separation and seek sustainable and acceptable resolutions (Gregory et al. 2015).

Moreover, the co-evolutionary principle of accepting and coping with multidirectional causalities and forces (Vessey and Ward 2013) can be aligned with Gregory et al.'s (2015) coping strategy of blending, which aims to persuade the actors involved to reconcile two seemingly contradictory poles. Further, the co-evolutionary principle of containing recursive relations that result in interdependencies and circular causality (Lewin and Volberda 1999) can be paired with the concept of balancing, which aims to iteratively elaborate compromises between contrasting demands through ongoing coordination efforts (Gregory et al. 2015).

Consequently, rather than generating different local optima and thus increasing segregation, the goal of this co-evolutionary framework is the convergence of two separate (Montealegre et al. 2014) poles to create sustainable solutions that encourage synthesis and transcendence (Chen 2003), just as Smith and Lewis (2011) compare a paradox with the segregated but unified yin/yang symbol (see Figure 24).

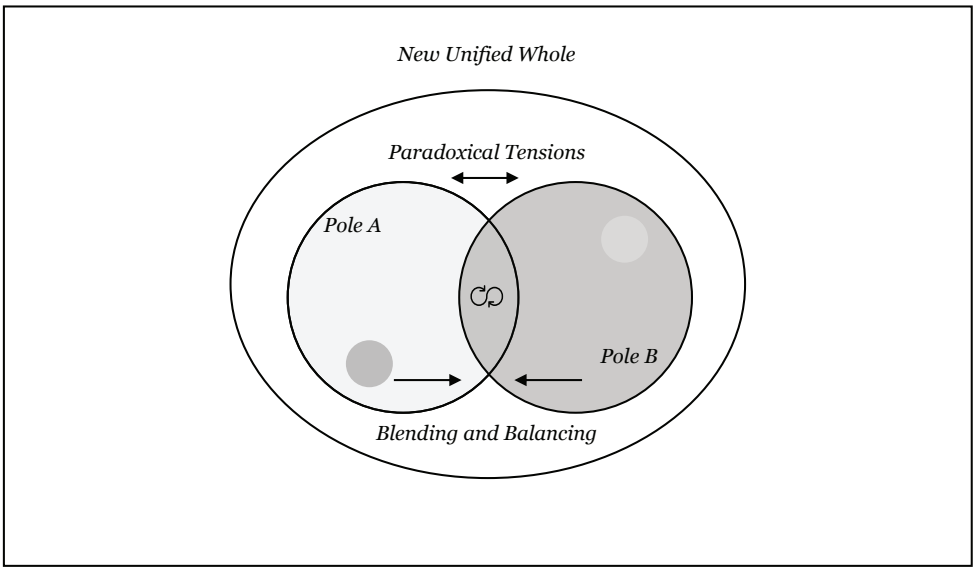


Figure 24 – Co-Evolutionary Yin and Yang

In accordance with Smith and Berg (1987, p. 215), who state of paradoxes that "by immersing oneself in the opposing forces, it becomes possible to discover the link between them, the framework that gives meaning to the apparent contradictions," this dissertation immerses itself in the distinct, separate and contradictory poles of co-evolution and offers one possible framework that can help to overcome opposing and paradoxical forces.

II Implications

This dissertation offers a number of valuable implications. Below, the implications for research are presented first, specifically as to the research streams of information systems, organization science and strategic management. Managerial implications are then provided to offer valuable insights for business practice.

II.1 Implications for Research

The implications for research are threefold. The focus is on information systems research since this dissertation is mainly conducted in and contributes primarily to this field. Additionally, the stated findings contribute to organizational science and strategic management (see Table 18).

Table 18 – Theoretical Contributions

Contribution		Insights
Information Systems	(a) Digital innovations and their inherent digital technologies trigger an organizational adaptation toward post-bureaucratic forms of organizing, which is a manifestation of digital transformation.	1) Digital innovation units, as post-bureaucratic structural alterations to engage in digital innovation, can serve as a linkage between digital innovation and digital transformation.
		2) A comparison of IT-enabled and digital transformations based on the changing roles and dynamics of (digital) technologies provides commonalities and differences.
		3) Dynamic and ongoing co-evolutionary transformations between digital innovations and organizational forms culminate in a dynamic equilibrium.
	(b) Digital innovations impose specific characteristics that lead to distinctive implications in industrial-age incumbents.	1) Industrial-age incumbents are able to engage successfully in digital innovation through the establishment of strategic digital innovation initiatives, specifically digital innovation units.
		2) Digital innovation in industrial-age incumbents comes with distinct tensions that are paradoxical and nested in the modular-layered product architecture but can be handled by dynamic, co-evolutionary organizational adaptations.
		3) Digital innovations' characteristics have distinct ramifications for boundaries, dynamics and capabilities in industrial-age contexts.

	(c) Digital innovation units can serve as a valuable initiative to enable participation in digital innovation.	1) Digital innovation units create applicable digital value, which has a significant beneficial implication for the main organization.
		2) Digital innovation units can develop collaboration and cooperation mechanisms to enable sustainable integration.
		3) Digital innovation units survive and grow in co-evolution with their main organization by building on capabilities and activities that are comparable to external digital ventures.
		4) Digital innovation units may serve as a foundation for the creation and realization of digital and dynamic capabilities.
		5) Digital innovation units are neither a purely European phenomenon nor a management fad.
Organization Science	(a) Organizational challenges and tensions can result from the characteristics of digital innovation and lead to co-evolutionary alterations.	1) Digital innovations and their inherent digital technologies cause organizational challenges and tensions.
		2) Today's co-evolutionary organizational transformation leads to a dynamic equilibrium that can enhance the previous concept of a punctuated equilibrium.
	(b) Applying the lens of paradox can aid in overcoming paradoxical, organizational tensions in ambidextrous contexts.	1) The application of the paradoxical perspective of ambidexterity can aid the investigation of contemporary hybrid organizational forms.
		2) Approaches of transcendence and synthesis can overcome paradoxical tensions and foster the successful realization of ambidexterity to embed novel digital organizational units and overcome paradoxical tensions.
Strategic Management	Digital innovation units can serve as a vital coping strategy in the digitized world.	1) Digital innovation units enhance digital innovation and can accelerate digital transformation strategies.
		2) Digital innovation units lead to beneficial performance implications and can be associated with dynamic capabilities.

Information Systems Research

This dissertation provides multiple contributions to information systems research. Foremost, it shows that digital innovations and their inherent digital technologies trigger an organizational adaptation toward post-bureaucratic forms of organizing as a manifestation of digital transformation.

First, it provides insights into the two separate yet interconnected phenomena of digital innovation and digital transformation (Drechsler et al. 2020). By conducting research at the crossroads of these two phenomena, this dissertation provides additional knowledge on their intersection. The investigation of organizational responses to the pervasive impact of digital innovations and their related threats aims to span the two research strands (Appio et al. 2021). The digital innovation units investigated here change the organizational form and represent a substantial and broad appearance of an organization's digital transformation, defined as "as organizational change that is triggered and shaped by the widespread diffusion of digital technologies" (Hanelt et al. 2021a, p. 1160). Therefore, this dissertation argues that the establishment of a digital innovation unit as a digital innovation initiative and structural alteration of the main organization may bridge digital innovation and digital transformation. Hence, this research contributes to the literature by characterizing digital innovation units as an organizational linkage between digital innovation and digital transformation and their ongoing evolution as a distinct process of an incumbent's transformation toward hybrid (Schumm and Hanelt 2021) and more malleable organizational forms (Hanelt et al. 2021a). In conclusion, this dissertation contributes by highlighting that digital innovation units, as post-bureaucratic structural alterations designed to facilitate engagement in digital innovation, can serve as a linkage between digital innovation and digital transformation.

Second, this dissertation contributes to the research on digital transformation by identifying its characteristics and distinguishing it from earlier IT-enabled organizational transformations (Wessel et al. 2021). It contributes to the ongoing discussion on both concepts by, first, highlighting similarities like ongoing decentralization (Chwelos et al. 2010; Fiedler et al. 1996) and a shift in organizational forms toward more flexible archetypes (Schwarz et al. 2007; Stebbins et al. 1995; Yoo et al. 2012) and, second, deriving specific differences like the changing role of technologies (Yoo 2010) and converging and blurring (organizational and industrial) boundaries (Hund et al. 2021). It links recent research to well-established theories, such as ambidexterity (Birkinshaw and Gibson 2004; Tushman and O'Reilly 1996) and post-bureaucratic organizational forms (Fiedler et al. 1996), and builds on the cumulative

tradition of existing information systems research. Moreover, it contributes by highlighting contemporary characteristics, such as an inherent technology value (Yoo 2010) and an ongoing organizational transformation toward digital platform ecosystems (Cennamo and Santaló 2019; Wang 2021), which necessitate differentiated and novel forms of organizing (Verhoef et al. 2021). In conclusion, this dissertation makes a contribution by providing a comparison of IT-enabled and digital transformations, based on the changing roles and dynamics of (digital) technologies.

Third, this dissertation examines a co-evolutionary development between pervasive digital innovations with their inherent digital technologies and organizational forms (Montealegre et al. 2014). It thus contributes to previously observed notions of co-evolution in digital times (Breslin 2016) and recognizes organizations' transformation toward more malleable organizational forms (Hanelt et al. 2021a) to facilitate swift adaptations to the flexible and ever-changing requirements of digital innovations and technologies (Huang et al. 2017), resulting in an iterative, ongoing and multilevel transformation. By developing a dynamic multilevel framework of co-evolutionary transformation, this dissertation contributes by arguing for a dynamic equilibrium of organizational (co-)evolution and thus expanding the present understanding of this topic (El Sawy and Pereira 2013; Fischer and Baskerville 2022) and enhancing the concept of a punctuated equilibrium (Romanelli and Tushman 1994). In conclusion, this dissertation makes a contribution by highlighting a dynamic and ongoing co-evolutionary transformation between digital innovations and technologies and organizational forms, which culminates in a dynamic equilibrium.

Additionally, this dissertation responds to contemporary calls for research in the area of digital innovation and digital transformation by addressing existing and emerging digital innovation- and transformation-related challenges. Regarding Verhoef et al. (2021), this dissertation contributes to the understanding of "the relative impact of identified [...] capabilities on digital transformation and performance" (Verhoef et al. 2021, p. 869). In particular, Study 3 answers this call for further research by investigating the significance of dynamic capabilities for digital innovation and by quantitatively elaborating the potential performance implications through capability-associated outcomes. Regarding the question of how to construct self-organizing teams to attain digital transformation (Verhoef et al. 2021, p. 869), the dissertation offers a detailed discussion of the growth and expansion of self-organized units; that is, the evolution of digital innovation units (see Study 2). This dissertation further contributes to the question of "which configurations of innovation and integration mechanisms in digital transformation yield high firm performance" (Hanelt et al. 2021a, p. 1181) by describing the organizational structure and characteristics of digital innovation units

(study 2) and their mechanisms of linking with and integrating into their main organizations (study 4); it further relates these findings to the benefits of digital innovation units on firm performance (Study 3). The beneficial impact of digital innovation units as organizational and structural alteration of their main organization (Study 3) also helps answer the question of "how transforming firms can benefit from new organizational structures and management styles" (Verhoef et al. 2021, p. 869).

Furthermore, this dissertation contributes by revealing that digital innovations impose specific characteristics that lead to distinctive implications in industrial-age incumbents.

First, by characterizing the strategic initiative of digital innovation units (Studies 2-4) and demonstrating their ability to create digital innovations (Study 2) that have beneficial performance implications (study 3), this research demonstrates that industrial-age incumbents, despite all shortcomings and hurdles, nevertheless have the opportunity to successfully engage in digital innovation (Lucas and Goh 2009). However, by investigating and highlighting industrial-age incumbents' capability gaps, missing organizational preconditions and incipient tensions, this dissertation confirms that digital innovation in industrial-age incumbents is associated with specific pitfalls and hurdles, which accords with most contemporary research (Sebastian et al. 2020; Verhoef et al. 2021). In conclusion, this dissertation contributes by highlighting that industrial-age incumbents are able to engage successfully in digital innovation through the establishment of strategic digital innovation initiatives, specifically in the form of digital innovation units.

Second, this dissertation contributes to research on digital innovation challenges by identifying and distilling the paradoxical tensions nested inside the modular-layered product architecture (e.g., Hylving and Schultze 2020; Piccinini et al. 2015) and correlating them with organizational tensions (see Studies 2 and 4). Calling attention to these nested paradoxical tensions and aligning them with previously observed organizational tensions contributes to research in two ways. First, revealing a nested paradox can aid in its resolution (Smith and Lewis 2022), so the findings here can aid in enhancing digital innovation in industrial-age incumbents (Hund et al. 2021). Second, acknowledging both social and technological influences on tensions in the modular-layered product architecture is rare in current research (Hylving and Schultze 2020) and thus enhances the contemporary understanding in this field (Viljoen et al. 2022). Further, research on paradoxical tensions and opportunities for overcoming them in the realm of digital innovation contributes to the existing body of knowledge, as it is a timely topic (Hund et al. 2021; Wimelius et al. 2021). The dissertation contributes to the contemporary literature by developing a dynamic, multilevel co-evolutionary

framework with a dynamic equilibrium at its core (see Chapter C.I.4 for a thorough explanation) and identifying distinct mechanisms that could help overcome paradoxical physical–digital tensions (e.g., Piccinini et al. 2015; Smith and Lewis 2011). In conclusion, this dissertation makes a contribution by highlighting that digital innovation in industrial-age incumbents comes with distinct tensions that are paradoxical and nested in the modular-layered product architecture but can be handled by dynamic, co-evolutionary organizational adaptations.

Third, by pointing out the leading role of digital innovations and their inherent digital technologies in contemporary co-evolutionary transformations (see especially Study 1), this dissertation contributes to digital innovation research by underlining their specific characteristics and implications (Berente 2020; Henfridsson et al. 2018; Hund et al. 2021). By identifying the following instances and linking them to industrial-age contexts, the dissertation contributes to research by confirming and concretizing broad conceptions regarding the characteristics of digital innovations and by providing insights into co-evolutionary, organizational adaptations. Observable examples include the following:

- digital innovations' inherent dynamics (Lyytinen 2022), were observed, especially in Study 1, through ongoing and recently accelerated transformational and co-evolutionary dynamics;
- digital innovations' inherent reprogrammability and flexibility (Yoo et al. 2010) implicate organizations, as observed (especially in Studies 2-4) by the embedding of digital innovation units to enable the transformation to more malleable organizational forms (Hanelt et al. 2021a);
- digital innovations' requirement for novel, digital capabilities (Yoo et al. 2012) was observed (especially in Study 3) by the vital need to establish strategic initiatives as a foundation to build and realize digital innovation units;
- digital innovations' boundary-spanning and converging implications (Hund et al. 2021) were observed inter-organizationally through the emergence of organizational archetypes such as networks or platforms (see especially Study 1) or intra-organizationally through the embedding and integration of digital innovation units into the main organization (see especially Studies 2 and 4);
- digital innovations' generativity, an "overall capacity to produce unprompted change driven by large, varied, and uncoordinated audiences" (Zittrain 2006, p. 1980), which acknowledges digital technologies as the impetus for change, was observed in all four studies.

In conclusion, this dissertation highlights that digital innovations' characteristics have distinct ramifications on boundaries, dynamics, and capabilities in industrial-age contexts.

Lastly, by investigating digital innovation units in detail, the dissertation provides novel and detailed insights for this sub-stream of digital innovation research: that digital innovation units can serve as a valuable initiative to enable participation in digital innovation.

First, this dissertation used a large amount of empirical data to quantitively identify digital innovation units' significant beneficial influence on firm performance. In contributing to contemporary research, the dissertation thus suggests that digital innovation units are more than a management trend or a nice-looking practice to give the pretense of engaging in digital innovation activities (Santarsiero et al. 2021); rather, they can create real, quantifiable value. In addition to a number of qualitative studies on digital innovation units based on employee perceptions (Haskamp et al. 2021a), the quantitative analysis of Study 3 shows a positive correlation between the establishment of digital innovation units and firm performance. Furthermore, the additional analysis in Study 3 offers a more comprehensive picture than the current literature since it relates concrete outcomes with beneficial ramifications. The results may be further interpreted as an attempt to provide additional metrics to measure the effectiveness of digital innovation units (e.g., Mayer et al. 2021; Raabe et al. 2020b). Further, this dissertation provides qualitative implications by providing detailed empirical information on the mechanisms by which digital innovation units integrate applicable digital outcomes into their main organizations (Svahn et al. 2017). In conclusion, this dissertation highlights that digital innovation units create applicable digital value, which has significant beneficial implications for their main organizations.

Second, as digital innovation units are of particular significance to performance in industrial-age incumbents, it is reasonable to acknowledge that digital innovation units and main organizations can incorporate mechanisms to overcome the anticipated hurdles and tensions emerging from their establishments (Svahn et al. 2017). This dissertation provides novel valuable insights into how to overcome these hurdles and tensions. It contributes by offering mechanisms to overcome the hitherto unexplored but highly significant physical–digital tensions (Piccinini et al. 2015) and tensions related their integration (Svahn et al. 2017). This dissertation contributes to the existing literature by identifying distinctive collaboration (Study 4) and integration (Study 2 mechanisms that had not previously been studied at this level of depth but are particularly pertinent in this research stream (Raabe et al. 2021; Trischler et al. 2022). In

conclusion, this dissertation highlights that digital innovation units can develop collaboration and cooperation mechanisms for sustainable outcome integration.

Third, the dissertation identifies growth and adaptation mechanisms of digital innovation units. While digital innovation units have largely been investigated with a punctuated perspective, evolutionary observations remain scarce in research (Lorson et al. 2022; Trischler et al. 2022). While significant insights into the internal survival and growth mechanisms and the evolutionary stages of external digital ventures do exist (e.g., Huang et al. 2022; Huang et al. 2017), specific knowledge on their internal counterparts is comparatively scant. This dissertation contributes to the literature by providing an evolutionary perspective on internal digital innovation units and by aligning the findings to the research stream on external digital innovation units, like digital ventures or startups. In detail, that stream, provides numerous detailed insights on (rapid) growth strategies (Huang et al. 2017), digital innovation mechanisms (Huang et al. 2022) and survival in competitive environments (Tumbas et al. 2017a). This dissertation contributes by highlighting parallels and similarities between the two streams. Specifically, it outlines a substantial organizational adaptation and growth as well as a thematic development within most of the studied digital innovation units, which can be paralleled to those of external ventures (see Study 2). Therefore, by identifying distinct commonalities between internal and external digital innovation units, this study helps bridge the gap in collaboration and reciprocal learning between the two research streams and aims to connect them to enable additional investigations that will deepen our theoretical knowledge. In conclusion, the dissertation highlights that digital innovation units survive and grow in co-evolution with their main organizations by building on capabilities and activities that are comparable to external digital ventures.

Fourth, this dissertation contributes to the digital innovation unit literature by presenting those units as a foundation on which to build and realize dynamic capabilities (Hellmich et al. 2021). By leveraging their outcomes with the three core dynamic capabilities (Teece 2007) – discovering the beneficial effect of digital innovation units on the number of digital patents produced, which can be associated with the capability of sensing , the impact of digital innovation units on the number of digital market offerings, which can be associated with the capability of seizing , and the value of digital innovation units for a firm's digital transformation, which can associated with the capability of transforming – this dissertation examined one approach to how dynamic capabilities may be built and realized (Ellström et al. 2021; Warner and Wäger 2019). In conclusion, this dissertation highlights that digital innovation can serve as a foundation for the creation and realization of digital and dynamic capabilities.

Fifth, this dissertation contributes to the digital innovation unit literature by highlighting the widespread presence of digital innovation units in the United States. Despite a large number of European researchers and the strong research emphasis in that region (e.g., Dremel et al. 2017; Lau et al. 2021; Svahn et al. 2017), the empirical data in Study 3 demonstrate that digital innovation units are far from a solely European phenomenon.

In conclusion, the dissertation investigates the increasing impact of digital innovations and their inherent digital technologies on organizational forms (Yoo et al. 2012). It contributes by revealing a co-evolution that is triggered by the advent of digital technologies. By providing a dynamic, multilevel co-evolutionary transformation framework, the dissertation has valuable implications for information systems research as it underlines digital technologies' impact and provides deeper knowledge on possible organizational effects and responses. Applying the lens of co-evolution enables a holistic and ongoing perspective on this transformation (Hanelt et al. 2021a), which can aid in understanding and investigating contemporary digital phenomena.

Finally, the dissertation contributes to Yoo and colleagues' decade-old effort to investigate "organizing for innovation in the digitized world" (Yoo et al. 2012, p. 1398) and the call to embed "a new organizational form that departs dramatically from traditional industrial production" (Berente 2020, p. 92) to prepare for digital innovation by shedding detailed light on one contemporary way of organizing for digital innovation (i.e., establishing digital innovation units).

Organizational Science

This dissertation has two implications for the organization science field. It provides in-depth information on organizational pitfalls in industrial-age incumbents and reveals that organizational challenges and tensions can result from the characteristics of digital innovation and lead to co-evolutionary alterations.

First, by pointing out how information systems in general (Hsu and Hannan 2005) and digital innovations and technologies in particular (Yoo et al. 2012) alter traditional bureaucratic organizational forms, this thesis provides novel detailed knowledge about this enabler and trigger of organizational adaptation (Bailey et al. 2022). It thus contributes to research on changing organizational forms, following Hanelt et al. (2021a), who observe a "shift towards malleable organizational designs which enable continuous adaptation" (Hanelt et al. 2021a, p. 1161). It therefore fits another piece into the jigsaw puzzle of recent organizational designs and transformations (Bailey et al. 2022). The dissertation highlights that digital innovations and their inherent digital technologies cause organizational challenges and tensions.

Second, applying the theoretical lens of co-evolution to organizational transformation expands the understanding of its application in this field (Breslin 2016; Hodgson 2013). Using this theory as a foundation, this dissertation derives a dynamic, multilevel co-evolutionary framework that can lead to a dynamic equilibrium. This theoretical framework contributes to the field of organization science by enhancing the established notion of punctuated equilibrium (Romanelli and Tushman 1994) and enables its adaption to today's digital environments (Fischer and Baskerville 2022; Hanelt et al. 2021a). In conclusion, this dissertation highlights that contemporary co-evolutionary organizational transformations lead to dynamic equilibria which can enhance and extend the existing concept of a punctuated equilibrium.

Additionally, by investigating digital innovation units as one distinct organizational alteration in response to rising digital tensions, the dissertation shows that applying the lens of paradox can aid in overcoming paradoxical organizational tensions in ambidextrous contexts.

First, by applying the paradox perspective on ambidexterity (Gregory et al. 2015; Papachroni et al. 2014), the dissertation sheds light on specific tensions in hybrid forms of organizing triggered by the adoption of digital technologies (Schumm and Hanelt 2021). Thus, adopting a paradoxical perspective on ambidexterity can move our understanding beyond the dominant separation-oriented prescriptions and can aid in situating a nested paradox in hybrid forms of organizing (Papachroni et al. 2014; Smith and Beretta 2021; Smith and Lewis 2011). In conclusion, this dissertation highlights that the application of the paradoxical perspective of ambidexterity can aid the investigation of contemporary hybrid organizational forms by situating paradoxical tensions.

Second, the dissertation's findings underscore the assertion by Andriopolous and Lewis (2009) "that integration and differentiation offer powerful, complementary tactics for fostering ambidexterity, [as] this combination helps reduce the anxiety and defensiveness that tensions spark and that can spur vicious, rather than virtuous, cycles" (Andriopoulos and Lewis 2009, p. 708). The paradoxical perspective may also create and contribute significantly to contemporary organizational research, since, as Gregory et al. (2015) argue, resolving paradoxical-ambidextrous tensions has become especially critical in the digital age. In conclusion, this dissertation highlights that approaches of transcendence and synthesis can overcome paradoxical tensions and foster the successful realization of ambidexterity to embed novel digital organizational units and overcome paradoxical tensions.

Strategic Management

This dissertation contributes to the strategic management field by investigating digital innovation units serve as a coping strategy for challenges in the digitized world (Chanias et al. 2019; Jöhnk et al. 2022; Matt et al. 2015).

First, by providing novel insights into this digital innovation and transformation strategy (Chanias et al. 2019), the thesis enhances current coping strategies for a digitized world (Fischer et al. 2020). As Study 3 shows, the strategic decision to establish digital innovation units can help firms produce digital patents and other unique outcomes. This dissertation contributes to the strategic challenge of finding opportunities to create new digital businesses (Dutra et al. 2018) or modify existing ones (Berman 2012). In addition, digital innovation units stimulate and expedite digital transformation strategies (Chanias et al. 2019), a topic that is further explored in this dissertation (see Study 3). Digital innovation units could further be utilized as an organizational vehicle to enable and trigger the "interaction of digital transformation strategies with business development and business models" (Matt et al. 2015, p. 342) as they accelerate and incorporate digital transformation strategies, while simultaneously developing novel digital businesses and business models (Jöhnk et al. 2022; Raabe et al. 2020a). In conclusion, this dissertation highlights that digital innovation units enhance digital innovation and can accelerate digital transformation strategies.

Second, by focusing on the performance implications of this strategic initiative, the dissertation provides measurable data on its actual benefits. It therefore responds to a contemporary research question posed by Hanelt and colleagues- "How do digital transformation-induced changes in the organizational setup influence firm performance?" (Hanelt et al. 2021a, p. 1181) and contributes by providing valuable insights into how firms can accelerate performance in the digital age through strategic initiatives (El Sawy and Pereira 2013). By applying the lens of dynamic capabilities to firm performance, the dissertation provides valuable insights into how digital innovation units can serve as a foundation for this strategy-related topic (Hellmich et al. 2021). The dissertation contributes to this stream, as digital innovation units may be thought of as foundations on which dynamic capabilities can be developed, built and realized (Hellmich et al. 2021), since they can provide the structural, processual and entrepreneurial framework that is essential for the emergence of dynamic capabilities (Teece 2007). In conclusion, this dissertation highlights that digital innovation units lead to beneficial performance implications and are associated with dynamic capabilities.

II.2 Implications for Practice

This dissertation provides several valuable implications for managerial practice. On the one hand, it provides general insights on organizing for digital innovation; on the other, it provides detailed guidance on digital innovation units, which comprise one possible strategic initiative to organize for digital innovation.

As Study 1 demonstrates, organizational forms change over time and under the influence of information systems (e.g., Brynjolfsson et al. 1994; Chwelos et al. 2010). Therefore, it is possible to look into the past to be inspired by earlier concepts of transformation and to cultivate a more mindful perspective on contemporary changes. In this regard, practice should question whether current fashions and the excitement surrounding ostensibly "new" digital technologies are actually that new, since many concepts and ideas today are surprisingly similar to those of past periods. For example, the current trend of holocratic organizational forms has a long history in the 1980s (Mintzberg 1983). The difference with contemporary times is based on the evolution of information systems and their effects on organizations, as the value assigned to technology in organizations has also evolved over time (Yoo 2010). Thus, a simple copy of past transformation projects is unlikely to be viable in a real-world implementation. As direct advice for managers, the use of managerial best practices and success stories promoted by so-called experts and strategy consultants should be questioned due to the context-specific nature of every transformation. Today's pressure for change extends beyond the changes of previous information system implementations, both in IT-related and non-IT-related organizations (Wessel et al. 2021). Moreover, a digital transformation requires a change in perspective from an episodic to a continuous change approach that is triggered by digital technologies (Hanelt et al. 2021a). Therefore, as a piece of advice for managers, transformational initiatives should not be squeezed into a discrete project, which is by definition an endeavor with a predetermined conclusion; rather, they should be an ongoing topic of strategic and operational consideration.

In conclusion, however, it is advisable in all current forms of digital transformation to examine previous developments as an inspiration and situate them in the current technological context and dynamics, such as decentralization in context of digital platform ecosystems. In line with Puranam et al. (2014) a (re-)combination of existing ideas and methods can create a new organizational form suitable for the digital age. To implement the findings in real-world contexts, this dissertation recommends the following. First, organizations need to be aware of information systems' contemporary influence on co-evolutionary development. While information systems have long served as the enabler of planned (organizational) transformations, they are now the driving

factor behind those changes. Second, it is essential that an organization is able to constantly learn, adapt and change. While the changes to bureaucratic organizations wrought by technologies have already been intensively investigated for a considerable period of time, the current digital environment is quite different in character, which is why the today's changes should not be dismissed as merely a repetition. However, it cannot be denied that similar problems have already been described.

This leads to the second managerial implication. It is crucial to strategically establish digital (innovation) initiatives to address today's digitally induced challenges. One prominent example is the establishment of digital innovation units. Managers seeking viable initiatives to alleviate related issues and achieve digital success may indeed explore establishing such units, especially in physical product industries with high tangible assets and in environments with a high concentration of digital ventures. The dissertation helps enable the collaborative and sustainable integration of applicable digital outcomes of digital innovation units. Managers who work in or collaborate with digital innovation units can use the prioritized list of key factors (Study 4) as quick wins to strengthen existing relationships. Additionally, managers who are responsible for digital innovation units should consider the need to leave sufficient breathing room for innovation, joint strategies and the formation of a shared top management team board and mutual operational value creation through, for example, joint innovation projects to accelerate and improve collaboration between the digital innovation units and their main organization. Further, managers and organizations that are unsure about how to target their digital innovation units' objectives may discover direction in terms of sensing for digital patents, seizing new digital market offerings and transforming the main organization.

In conclusion, this dissertation can aid managers confronting a digital innovation unit greenfield (building a digital innovation unit from the scratch) or brownfield (optimizing an existing unit).

The dissertation can help those deploying a novel digital innovation unit by providing the following:

- an overview of digital innovation units' benefits and implications (derived from Studies 2 and 3);
- an overview of possible fields of action (derived from Studies 2 and 3);
- a quantifiable justification to make the investment in a digital innovation unit (derived from Study 3);
- measurable goals and objectives (derived from Study 3);

- a characterization of how to integrate a digital innovation unit into an existing organizational structure (derived from Study 4);
- a plan to develop digital innovation units from small and explorative playgrounds to professional product centers (derived from Study 2);
- a blueprint to develop intersections with the main organization (derived from Study 4).

For those managers who already established a digital innovation unit, this dissertation can contribute by providing the following:

- a quantifiable justification to continue investing in the digital innovation unit (derived from Study 3);
- measures to steer the digital innovation unit (derived from Study 3);
- a roadmap for possible next evolutionary steps to improve the existing digital innovation unit and to be prepared for changes (derived from Study 2);
- mechanisms to overcome pervasive tensions when creating digital innovations in industrial-age incumbents (derived from Study 4);
- mechanisms to establish sustainable cooperation and collaboration between digital innovation units and their main organizations (derived from Study 4).

Although all these contributions are built on empirical results and may be valuable for managers, they all need to be carefully placed into the concrete context of a given firm's digital transformation.

Finally, the dissertation should serve as something of a warning sign. Changing the course of organizing for digital innovation is not like switching on a light. It does not follow a clear plan; nor can it be built on a list of best practices or a deck of elegant PowerPoint slides. Every transformation is different and necessitates a lengthy and evolutionary process of reconciling and ambiguity, a process that is neither predictable nor linear. As soon as is feasible, managers should begin to develop additional forms of organizing and embed them into their existing context to create novel digital innovation paths and build a more resilient organization. Managers should expect to have to endure and handle paradoxical environments where no simple answer exists. Organizing for digital innovation within industrial-age incumbents may well be the most challenging managerial task of our time.

III Limitations and Future Research

This dissertation is not without limitations; in addition to those outlined in each of the four studies, the dissertation's overall constraints are covered in Chapter C.III.1. However, those limitations may also pave the way for future research. Future research avenues emerging from this dissertation's limitations and from the studies' findings are described in Chapter C.II.2.

III.1 Limitations

Each study included in this thesis has its own limitations in terms of methodology or research design, and they are discussed in the various chapters in Part B. However, the aggregated limitations that apply to this thesis are described below. They can each be considered as to the possibility of opening up new avenues for research.

Although the studies in this dissertation aim to adhere to the highest possible research standards, there were certain overarching limitations rooted in the research design, the phenomena under study and the evaluation, all of which could impact the rigor and relevance of the findings.

First, because dissertation employs several qualitative empirical analyses (in Studies 1, 2, and 4) that involve both inductive and deductive coding, the conclusions may have been influenced by the author's subjective ideas and assumptions (Galdas 2017; Thirsk and Clark 2017). This might result in an erroneous or even biased understanding of empirical evidence based on personal beliefs and experiences. To reduce this risk, all interpretations were thoroughly discussed and reviewed with study co-authors and, in some cases, with other researchers and practitioners who were not involved in the studies. Despite the fact that the investigations took place within a single multinational, multi-brand automotive manufacturer, the experts and panelists were diverse in terms of gender, age, nationality, workplace and hierarchical position. In addition, particularly in Studies 2 and 4, information was acquired from a wide range of internal and external sources, including primary and secondary data, as well as national and international study subjects. Lastly, by aligning and comparing the studies' results with the relevant literature, the issue of biased interpretation could be mitigated (Galdas 2017; Thirsk and Clark 2017).

The second issue involves the studied phenomena. The dissertation covers recent relevant literature regarding digital innovation and digital transformation. Due to the pervasiveness and widespread diffusion of these topics in practically every aspect of modern life (Yoo 2010), there is a risk of overlooking key insights and pertinent studies

from the information systems field, not to mention other research disciplines. In addition, while the contemporary relevance of these phenomena increases opportunities for research, that gain comes with a trade-off between a particular level of detail and broad comparisons. By investigating three funneled research perspectives, this dissertation was conceived as contributing to both the big picture and to more granular perspectives. However, this ambition does not preclude the possibility having overlooked vital topics. Additionally, with regard to the developed framework of multilevel co-evolution, the tension between detail and generality entails a further limitation. As Hanelt et al. (2021a) observed, "a study following the holistic co-evolution perspective might illustrate the 'big picture'" (p. 1176) but still miss a detailed view on distinct and punctuated influences that trigger the transformation (Hanelt et al. 2021a). This constraint may be alleviated since the proposed framework for multilevel co-evolution not only considers the broad environment but also co-evolutionary transformations on multiple levels.

Third, as to digital innovation units, this dissertation faces an additional limitation beyond those indicated in the studies. Since digital innovation units are a relatively recent phenomenon, no standardized term or concrete and established archetypes have yet been coined to describe them. While German research is slowly adopting the term used here (e.g., Barthel et al. 2020; Haskamp et al. 2021a; Raabe et al. 2020a), internationally a wide range of digital innovation unit terms occur in the search queries (digital innovation lab, digital lab, digilab, X-Lab, etc.). Additionally, when investigating digital innovation units in the field, the majority of companies include the corporate name in describing those units (see for a German example, Lau et al. 2021). This plethora of terms and the description of multiple but only slightly different archetypes may, on the one hand, limit the ability to recognize all studies on this phenomenon and, on the other, make it more difficult to compare results. This dissertation seeks to circumvent this constraint by employing numerous terms throughout its literature searches and empirical investigations. In addition, this dissertation takes a broad and generalized perspective on digital transformation units, since it defines them without distinguishing between diverse archetypes. Once research on digital innovation units has progressed further, it will be more suitable to differentiate between distinct archetypes.

Lastly, when evaluating the results of the findings, this dissertation faces additional limitations. Multiple novel and pertinent contributions are made, including distinct roadmaps and characterizations for organizational transformations in general, implications for the establishment, survival and growth of digital innovation units, concrete mechanisms on how to integrate those units, detailed information on their performance implications, and a multilevel framework on dynamic co-evolution.

However, none of these has been intensively tested or evaluated in further studies or practice. In order to alleviate this limitation and better evaluate the outcomes, the empirical findings of Studies 2 and 4 have been presented to and debated with industry experts as to their relevance. This effort, however, cannot fully compensate for these shortcomings. Consequently, this dissertation still faces limitations in terms of the applicability of its findings and conclusions. Nonetheless, those limitations afford clear opportunities for future research.

III.2 Future Research Opportunities

This dissertation contributes to the current state of knowledge with novel findings and implications; additionally, it opens up future research opportunities. Besides those described in the studies, which are not repeated here, three major avenues for future research are presented in this chapter. They represent a more general view than those from the studies and are presented using the three funneled research perspectives.

With regard to the broadest research perspective, understanding digital technologies' and innovations' impact on organizational forms, this dissertation implies the following opportunities for future research. The observed multilevel, dynamic co-evolutionary transformation offers a foundation for future investigation. Future research should assess and test the suggested framework. Investigating what further levels of co-evolution could be revealed and how dynamic this transformation may become could be a valuable topic of inquiry. Additionally, the changed role of digital technologies with regard to this co-evolution – from an enabling dynamic to a triggering dynamic – should be further investigated. On the basis of this dissertation and other recent research (Hanelt et al. 2021a; Wessel et al. 2021), the specifics of digital transformation, compared to previously studied IT-enabled organizational transformations, should be investigated to better prepare for the already pervasive and still accelerating impact of digital innovations and their inherent digital technologies on organizational forms. It is also necessary to examine commonalities and evaluate their adaptation to the digitized world to help avoid having future researchers, managers and consultants seek to reinvent the wheel. In addition, the first research perspective reveals a continuous decentralization and a shift to more distributed organizational archetypes, such as networks or digital platform ecosystems. Hence, this dissertation presents valuable implications for future research by examining this notion in general and by defining digital innovation units as one potential organizational foundation in particular. Future research may expand on this by examining how digital innovation units might assist incumbents to adapt their organizational forms to engage in digital ecosystems (Verhoef et al. 2021). Lastly, research should investigate how strategic initiatives other than

digital innovation units may lead to more hybrid and malleable organizational forms (Hanelt et al. 2021a) and what further organizational adaptations are applicable. Hence, this dissertation can provide a solid base for future research endeavors with regard to understanding digital technologies' and innovations' impact on organizational forms.

With regard to the second perspective of investigation, establishing digital innovation units, this dissertation provides several future research opportunities. It offers broad information on digital innovation units and their ability to foster digital innovation in industrial-age incumbents. These distinct insights can provide the foundation for further research in this area. It opens future research opportunities to provide more data on distinct digital innovation unit outcomes and their direct implications on firm performance. These findings could help measure whether the positive influence continues to be stable, rises over time or declines. With regard to the development of digital innovations units, the findings provide a three-stage co-evolutionary model. Those stages can serve as bases to further investigate the development of digital innovation units and should be evaluated with regard to their generality. Future research could develop distinct enhancements on a more granular level or look inside digital innovation units with other objectives. In addition, the noteworthy tendency toward greater standardization and professionalization deserves additional research and may be linked to organization science and its broader notions of standardization (Thompson and Bates 1957). Future research might also assess the hypothesis on the role of digital innovation units as a foundation for dynamic capabilities and investigate which specific requirements or activities lead to their emergence. This dissertation supplies solid evidence on where to look for this foundation (i.e., digital innovation units) and offers implications for this research avenue. Lastly, the link between digital innovation units and external digital ventures should be further investigated. This dissertation provides a first starting point to bridge the gap between these two phenomena and their associated research streams.

With regard to the third research perspective, managing digital innovation units to overcome digital innovation tensions, the dissertation provides several further research opportunities. First, by describing and characterizing the nested paradoxes in the modular-layered product architecture and their implications for organizational forms, the thesis opens future research avenues on this important issue. Since it is vital for industrial-age incumbents to overcome physical–digital tensions to be successful in the digital age (Hanelt et al. 2021b; Piccinini 2015), further research should investigate this timely topic, despite the inherent complexity of nested paradoxical tensions. Another future research avenue is the practical application of the paradoxical perspective on ambidexterity and the derivation of concrete coping strategies for paradoxical tensions,

as this is a nascent part of the information systems field (Agarwal et al. 2022; Ciriello et al. 2018; Hund et al. 2021). This dissertation engages further studies to build on the derived meta-patterns and add clarifying details from practical investigations. Moreover, establishing and managing digital innovation units to overcome digital innovation-related tensions in industrial-age incumbents is only one of numerous possible initiatives (Jöhnk et al. 2022). This research encourages future research to examine more subjects, perhaps by examining the implications derived from this dissertation. Lastly, the dynamic, multilevel co-evolution framework provides a potential opportunity to address these and other paradoxical tensions. Future research might expand on this to examine the framework's ability to overcome tensions and to further link co-evolutionary notions and paradoxes.

IV Conclusion

"Organizing for innovation in the digitized world" (Yoo et al. 2012, p. 1398) is as relevant today as it was a decade ago. Pervasive digital innovations and their underlying digital technologies exert continued pressure on organizing, particularly in industrial-age incumbents. The initiatives that have arisen in response ultimately result in an ongoing primacy of transition and necessitate the incorporation of post-bureaucratic forms of organizing to achieve malleability and enable swift reactions to digital threats. One attempt to adapt to these dynamics is the establishment of digital innovation units. While they serve as an organizational foundation for novel digital capabilities and help bridge innovation gaps in the digitized world, they are simultaneously required to consider the traditional, physical world to ensure integrability and applicability in an industrial-age incumbent context. The increasing (paradoxical) tensions caused by these contradicting demands necessitate synthesis and transcendence as opposed to separation and local optima, as similarly shown in the derived dynamic, multilevel co-evolutionary framework of transformation. Co-evolution is sparked and intensified by the dynamics of digital innovations and their inherent digital technologies. It emerges in a constantly accelerated, swinging pendulum of adaptation that is continuously and inherently triggered by pervasive digital innovations and culminates in a state of dynamic equilibrium, which sets the tone for contemporary organizational transformations in an inherently turbulent and dynamic environment (Hanelt et al. 2021a; Wessel et al. 2021). A fundamental rethinking of ideas, strategies and organizational responsiveness is required to shape an updated organizing for innovation in the digitized world.

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Appendix

Appendices to Study 2

Appendix A – Semi-Structured Interview Guideline

Introduction

- Please introduce yourself and your position and role inside the company.

Digital Innovation Unit – General Information

- What is the current task of the DL?
- How is the DL currently connected to the head organization in terms of the processes and its geographical position?
- Which changes regarding the connection between DL and the head organization have occurred so far?

History & Changes inside the DIU

- What was the reason for founding the DIU, and which internal changes have been taking place so far?
- What have been major changes in the DIU regarding employees (size / origin [head organization / DIU]), business model, connection to the head organization and role?
- What was the decisive factor?
- How has the collaboration with the head organization changed over time?

Phases – variation, selection, retention

Previous information to this chapter:
According to the evolutionary theory, organizational changes are established via three phases – variation, selection, and retention. We hypothesize that these three phases can be transferred to innovations created inside a DIU. We see variation as promoting and allowing alternative behaviors, workflows, routines, and collaboration models – in short, organizational structures. After that, these structures are tested and selected in their business environment – effective structures will be maintained, and non-effective ones canceled. Effective organizational forms will be spread and transferred to the head organization. These three phases will now be discussed in more detail.

1. Innovation requires variations in terms of behavior, workflow, and routines.

- What are the labor practices of your DIU that contribute to variations?
- Are there differences between your DIU and the head organization?
- What is the current focus on increasing variations of work practices, and (how) has it changed over time since the foundation of the DIU?

2. Different variations must be selected and tested in practice for their benefit.

- How and with whom do you test the variations in terms of their added value and their chances of viability?
- Internally / externally, with partners / customers, randomly / structurally, implicitly / explicitly?
- What is the current focus on this topic, and (how) has it changed over time since the foundation of the DL?

3. Successfully approved variations in work practices, routines and collaboration models can be transferred to the head organization.

- How are the selected variants of step 2 transferred to the head organization?
- Regarding the processes, opposite pole in the head organization, frequency of contact, success.
- What is the current focus on this topic, and (how) has it changed over time since the foundation of the DIU?

Appendix B – List of Codes

List of Codes	Frequency
Code System	1720
General Environmental & Contextual Conditions	1
Method-Dilemma	9
Social Changes	1
COVID	5
Automotive Specific	3
Digitization	2
Main Organization	2
(Digital) Transformation	8
"Historically Grown" Structures	15
Department Description	7
Committee Top Management Team	16
Restrictions & General Conditions due to MO	6
Decision-Making / Pace (Committees, Steering Committees)	2
Cultural Restrictions	4
Technological Restrictions	10
MO Procedural Restrictions	7
Funding Restrictions	6

Structural Restrictions	5
Formal Leadership Restrictions	7
Employee Development Restrictions	16
Acceptance of the MO	0
Change In Acceptance Due to	18
Positive Acceptance	7
Critical Acceptance	15
Connection through / to MO	7
Cooperation Model with the MO	13
Communication (Channels) with MO	5
Technical Framework	5
IT-Security	4
IT-Cloud	6
IT-Hardware	4
"Legitimacy" through Work-Results	12
Employee "Exchange"	19
Best Practices / Practices of Cooperation	12
Communication & Meetings	6
Design Thinking	0
Agility	15

User Centricity	7
Decent Project Description	18
Different Ways of Working in "Conflict	19
DIU Location	24
Description of the Premises	6
Spatial Delimitation	13
General Darwinism	3
Procedure / Sequence - Meta Level	11
Retention	3
Components	0
Structure & Enablement	11
Alignment of working Methods	4
Acceptance	0
Organizational Framework for Retention	2
Contribution to the Transformation of the MO	3
Technical Products	9
Working Methods	5
Methods	9
Culture	12
Impact	5

Successes / Failures	5
Challenges	7
Failures	6
Success Factors	20
Working Methods	3
Dev Ops.	1
Employee "Exchange”	1
Coaching / Consulting	15
Push Principle	2
Communication / Committees	7
Joint Project Approach	9
Agility	12
Selection	1
Components	0
Restrictions	3
Cooperation	1
Iterative	1
Successes / Failures	1
Failures	1
Challenges	9

Success Factors	12
Working Methods	0
Early Phase	5
"Fail Fast"	3
Pitch / Presentation	7
(Strategic) Priorities	4
Economic Efficiency	4
Testing / Customer Interviews	13
Iterative Procedure	14
Prototyping	2
Dev. Ops.	1
Joint Project Approach	13
Agility	5
Variation	1
Components	0
Focus Digital	2
Alternative Mode of Operation	0
User-Centric	3
Awareness of Impact / Innovation	3
Organizational Influence	5

Products	12
Successes / Failures	1
Failures	3
Challenges	11
Success Factors	11
Ways of Working / Methods	12
Coaching	2
Try Outs	5
Research	9
Joint Action	6
Communication	6
Start Up Scouting	10
Interviews / Customer Centered	11
Prototyping	19
Design Thinking	10
Agility	15
DIU Development	0
Meta-Phases	2
Product Center	10
Business Model	19

Continuing to Promote Innovation	12
Place of Innovation	9
"Greater Effort"	6
Challenges	6
Targeted Innovations According to Orders	16
Research	4
Specific Products	11
Perception of the DIU	9
Labs Scaling	21
Form of Organization & Cooperation	4
Cooperation With MO	9
Description Collaboration	5
Culture	14
Methods	8
XP	3
Safe	3
Agility	10
Pairing & Dev Ops.	3
Leadership	19
Employee Development	9

Structure	14
Ambidexterity inside Labs	19
Self-Organization	7
Product Line	8
Rollers	4
Flat Hierarchy	4
Matrix	15
Distinct Teams	11
Composition	12
Outlook	10
Formalization / Specialization	4
Through Growth	5
Change In the Way of Working / Structure	0
Mode of Operation / Processes	9
Culture / Mindset	13
Structure	11
Less Flexibility / Stronger Focus	24
Professionalization of Processes	12
Strategic Transition to Product Center	11
Transfer of Innovations into Products	4

Driven by Product Thinking	3
Operating Products	14
Product Focus	7
Long-Term Products	8
Customer Proximity	7
Financing Pressure	18
Licensing Income	2
Projects	3
Ideation, Creation & Testing	10
Business Model	6
Project Description	6
Reason For Change	7
Organization of Employees / Work	12
Connectivity	5
Funding	2
Tasks And Purpose	11
Perception of the DIU	6
Form of Organization & Cooperation	10
Methods	6
Design Thinking	1

Coaching	2
Agility	8
Leadership	10
Employee Development	2
Structure	4
Flat Hierarchy	5
Self-Organization	7
Introduction Teams	4
Composition	1
Culture	7
Growth	19
Foundation Phase - Self-Organization	5
Business Model	3
Employees	2
Perception of the DIU	12
Form of Organization & Cooperation	4
Description Collaboration	1
Culture	5
Methods	3
Agility	2

Leadership	15
Structure	2
Self-Organization	6
Foundation	3
First Steps	7
Hard Facts	4
Contact MO	5
Purpose / Purpose	3
Start Up Scouting	2
Ideas Scouting / Ideation	3
Transformation	8
Products / Digitization	14
Innovation	9
Funding	2
Employees	5
Changes In General	8
DIU Information	3
Role	1
Organizational Structure & Processes (Focus DIU-Internal)	0
Leadership	4

Employee Development	11
Mindset & Culture	8
Legal Form	17
DIU Ecosystem	36

Appendices to Study 4

Appendix C – Delphi Survey 1

Digital Labs, Hubs & Units - A look into the future

Delphi Study - Background Information

Thank you for supporting me in my research!

I want to deepen the existing results in the context of my research and elaborate concrete approaches and recommendations for action for a successful contribution of the DIUs to the transformation. For this, I ask for your contribution to the question:

What factors will sustainably contribute to effective collaboration between DIUs and the main organization?

The Delphi study proceeds in three steps:

1. name 5 factors that will sustainably lead to effective collaboration with the main organization - today.
2. prioritization of the consolidated results (top 5 statements) - in about 3-4 weeks
3. ranking of the most relevant points - in approx. 4-6 weeks

I am very pleased that you are participating as a Lab expert. Your data will be anonymized.

First of all, I need four short details about yourself.

1. how many years of work experience do you have?

- 1-5 years
- 5-10 years
- 11-15 years
- 16 or more years

2. how many years of experience have you already gained in the Lab context?

- 1-3 years
- 4-6 years
- 7 or more years

3. what is your current role?

- Project management / product responsibility
- Sub-department management
- Department management
- Lab management
- C-Level
- Other

4. what is your highest academic qualification?

- Education
- Bachelor
- Diploma / Master
- PhD
- Other

Delphi Question:

5. *What factors will contribute to effective and symbiotic collaboration between DIUs and the main organization in the long term?*

Please list 5-8 factors, including an optional brief description.

Example: Factor ABC - Means XYZ to me.

Appendix D – Complete List of Factors

(The following list was formulated by German experts and correspondingly translated into English without any contextual modifications. The order of the list is randomized. The list includes 123 factors. These factors were composed of the question in the survey presented in Appendix C).

- Main organization leadership must understand and value agile ways of working
- Trust: ... of management in employees
- Creativity and innovation - courage to embrace new technologies, processes, methods
- Transparency on both sides
- Personal contact with the "client"
- Consistent processes
- Eye-level - extras in labs and envy/power retention in the main organization
- Transparency on both sides to project requests and each area needs
- Extremely early involvement in the portfolio process (early requirements engineering)
- Funding
- Networking
- Clear objectives and strategies
- Mutual acceptance of "cultural differences"
- Involvement of management
- Real cases: Joint projects in which the Lab contributes the means and methods (the "how") and the main organization provides the challenge/field of application (since "what")
- Flexibility in process adaptations within the main organization
- Willingness to cooperate - this is only given by a few employees of the main organization
- Management commitment to the Lab
- Effectiveness in the company - i.e., productive use of the solutions developed, on which the financing is also essentially dependent
- Free space to find common ground
- Processes - processual integrated into the main organization
- Willingness to share knowledge
- A common understanding of a task
- DIUs must prove that they contribute to the desired goal of the main organization.
- Decentralized responsibility: ... Responsibility must be given "downwards"
- Partnership - working together (without prejudice) on issues
- Compromise between classical and modern ways of working. Both sides must not strictly insist on their model
- Proximity to relevant problems
- Technology standards
- Output - Do the labs help with the core problems, or is it the self-realization of individuals?

- Joint project acquisition - network domain experts and clarify scaling/operation from the beginning
- Refrain from long-term milestone commitments
- Willingness to share (projects & data & code)
- Error culture
- Lab as a temporary stop for employees
- To me, the maturity of LAB products means that the products developed are accepted by customers and, e.g., good operability and scalable.
- Communication to employees
- Inclusion: don't formally separate Lab and MO – otherwise, there's us and them and repulsion
- Understanding prioritization of the need for DIUs specifications from the main organization
- Alignment of portfolio processes –agile way of working and portfolio processes in DIUs do not fit with long-term traditional planning and processes
- Vision aligned with strategic goals and pain points of the main organization
- Organizational adaptability - i.e., the ability to organize as you grow and adapt to the rest of the main organization in a way that works (also breaking dogmas, e.g., how to work only in pairs or only Agile, etc.)
- Don't be afraid of mistakes: don't look for a culprit
- Mission - mission of the "Lab" is closely linked to the main organization
- Networking and regular exchange
- Top management commitment
- The main organization must not control labs
- Authorization by MO: Whoever gets duties must also get decision-making power
- Collaboration - achieving the goals together
- Respectful interaction - the DIUs are not simply suppliers but co-creators
- Showing the successes of the DIUs in real terms in the daily work
- Communities / exchange / transparency
- Financing model - financing the DIUs must not turn them into "service providers”
- Adaptation of processes - scale-based processes that meet the standards of the main organization even for smaller projects (mostly in the lab environment)
- Direct access to customers/users
- Cooperation with other departments
- Cross-departmental projects
- Use labs as labs and not as the development department
- The transition from proof of concept/pilot to product, i.e., Lab resources can be dedicated to new topics and products emerging from PoC, seamlessly transition to the main organization
- Transparency
- Rotation: MAs from DIUs and MO rotate jobs/tasks or meet horizontally (e.g., in WOL groups) for empathy building
- Close networking between decision-makers from the main organization and innovation drivers from DIUs
- The mutual exchange between employees and managers
- Transparency about the Lab's actions to the main organization

- Content adaptability - i.e., address new topics, see what is needed, find gaps in need
- Truly shared understanding of agile values
- Reviews - create an advisory board for the main organization
- Leaders who think holistically
- Distribution of competencies (different competencies in the teams)
- Leaders from the main organization must not become leaders in the labs
- Placement of product mindset in MO: ... the goal must be to make not my work more efficient but that of the user of my work product.
- Trust
- Build long-term relationships
- Work quickly and easily
- Rotation - managers and employees change between organizational forms
- Strengthen communication - knowing each other always helps with collaboration :)
- Collaboration with empowered subject matter experts
- Integration into the group
- Support through leadership
- Clarify beforehand how Lab results will be used
- Embed Lab flexibility into the long-term planning processes of the main organization, i.e., integrate a "3-month planning" in the DIUs into a 5-year planning of the main organization
- Continuous exchange
- Spatial proximity: Shared (physical and digital) event space that brings together topic-specific interested parties from Lab and MO (digitally extended)
- Strong communication skills on the DIUs' part to explain the added value of their innovation to the main organization in a way that is understandable to the target group and thus drives innovation in the main organization.
- Creation of a common mission - the labs currently coexist and cooperate only in exceptional cases.
- A bridge builder is needed who communicates between the units and also "translates" when necessary.
- Adhere to rules or create new rules that meet own goals - e.g., adjust/reduce IT production processes, create regulations together with legal for data protection (e.g., for AI applications)
- Collaboration at eye level
- Focus - Clear focus on delivering Digital products/features for the main organization
- Organizational incentives for collaboration
- Joint budget allocation
- DIUs need concrete goals from the main organization
- Avoidance of sense of superiority and arrogance: labs need to be aware that the MO supports them
- Respect
- Trust - without trust; there is too much affinity for control
- at eye level
- No finger-pointing - share successes AND failures.

- No political power, especially at the management level - the subject matter experts are there to be heard, and accordingly, decisions should be made together
- Iterative budget planning and approvals
- Recruiting
- Connectivity
- Central Lab Budget
- Management understanding: managers in other areas also need to internalize the power and necessity of innovation and new methods
- Create visibility for DIUs results + requirements from the main organization within the main organization
- Lab in self-image as part of the organization, with the goal to be "charmingly" disruptive
- Willingness to integrate - i.e., see itself as Lab offshoot as part of the rest of the organization - e.g., IT Lab is part of IT - to avoid demarcation and exclusion, avoid a sense of entitlement (e.g., IT must deliver "that")
- Start as champion: first present on a small scale with good use cases and then convince the masses
- Organization - structural connection to units of the main organization
- MA acting in the interest of the group instead of seeing it as a brake or even a competitor
- Designation of top issues from the main organization (high-level task)
- Rotations: Targeted enabling of personnel rotations to the DIUs and back - Otherwise, nothing will get through to the MO.
- Speak the language of the departments
- Transparency of Lab ecosystem - Who does what?
- Free funding - DIUs work as mercenaries for the main organization instead of working according to an innovation strategy
- KPIs that are understandable to the client
- Continuing education
- Shared IT landscape (whiteboard , Reallife collab, Sharepoint, Confluence)
- Funding committed to the Lab for the long term
- Good communication and honest marketing
- Degree of freedom to work on the task
- Merge DIUs ecosystem organizationally (virtually) to avoid uncontrolled growth
- Rotation model - training in the DIUs and integration into the main organization (incl. spirit/mindset)
- Willingness for evolutionary product development
- Speediness
- No competition for budget pots
- Balanced governance - how much (own) governance/orchestration does the Lab ecosystem need?
- Trust in the knowledge and skills of internal employees
- Integration with the external tech scene (tech partners, networks, universities, etc.)

Appendix E – Delphi Survey 2

Digital Labs, Hubs & Units - A look into the future

Delphi Study - Phase 2

Thank you for participating in the first phase of the study!

From 22 participations, nearly 130 individual factors have emerged that contribute sustainably to effective collaboration between DIUs and the main organization.

The second phase builds on your findings. It is important to prioritize the factors I summarized and consolidated (result: 36). I am very pleased that you are participating as a Lab expert. Your data will be anonymized and will not be related to your company's context.

Thank you very much

Which factors contributing to effective collaboration between DIUs and the main organization are most important to you?

Please select exactly 10 factors. (The order of the factors was random and different for each panelist; the original German factors were translated for this dissertation)

- Adaptable & flexible organizational structures in DIUs
- Flat hierarchies within the labs
- Rotation principle of employees between Lab & main org.
- Close connection and clearly defined scope of action between lab & MO
- Agile organizational structures in labs
- Physical proximity between lab & MO - Physical & Digital.
- Advisory board in the MO & structural linkage with top management of MO
- Organizational & structural incentives for collaboration between DIUs & main org.
- Structural integration of labs into MO
- Establishment of a Lab ecosystem - close networking between DIUs.
- DIUs act at eye level with MO (mutual understanding and trust)
- Distinct error culture within the DIUs
- Transparent action and knowledge management between Lab & MO
- The bold, visionary, and holistic mindset in DIUs (disruptive)
- Lived agile values and incremental work culture in DIUs.
- Clear leadership and role model between management & experts within DIUs.
- Prevention of personal "power games" between DIUs & main org.
- Top management commitment & support from MO
- Continuous and distinctive communication within the Lab network
- Active communication of added values and successes of the labs to the MO

- Joint, demand-driven portfolio development between DIUs & MO (with end customers)
- Partnership-based and transparent value creation between labs & MO - from idea to operation
- High product maturity & subsequent assurance of operation by DIUs
- Definition of performance indicators to make lab success measurable
- DIUs focus on innovation rather than development & operations
- DIUs' strategy and vision derived from the overall strategy of MO to avoid co-existence
- Focus on short-term milestones with a clear scope rather than long-term planning within DIUs
- Focus on digital products with high added value and high innovation in DIUs
- Integration of external partners (universities, tech scene, partners, startups...) in lab activities
- Operationally coordinated & collaborative partnership between DIUs & MO homogeneous and transparent processes)
- Agile collaboration models and processes within the labs
- Installation of mediation roles between labs & MO
- Uniform technology & IT standards of DIUs with MO
- Synchronization of agile and classical processes between labs & MO
- Long-term financial security for DIUs to focus on innovation.
- Iterative design & reporting of Lab budget plan toward MO

Appendix F – Delphi Survey 3

Digital Labs, Hubs & Units - A look into the future

Delphi Study - Phase 3

Thank you for participating in the first two phases of the study!

From 19 participations in the second phase, 13 prioritized factors have emerged, which sustainably contribute to effective collaboration between DIUs and the main organization.

The third and final phase builds on your findings.

The final phase is to rank the individual factors in order of importance.

Optionally, you can also provide a rationale for your ranking.

I am very pleased that you are participating as a Lab expert. Your data will be anonymized and will not be linked to your company's context.

Which factors contributing to effective collaboration between DIUs and the main organization are most important to you in the long term?

Please rank these factors in order of importance. (Position 1/top = most important)

(See List of Factors and Ranking in Study 4).

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