DOCTORAL THESIS

Innovating Digital Business Models

Empirical Insights from Industry

Linus Thomson

Entrepreneurship and Innovation

LULEÅ UNIVERSITY OF TECHNOLOGY

Innovating Digital Business Models

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Abstract

"When digital transformation is done right, it's like a caterpillar turning into a butterfly, but when done wrong, all you have is a really fast caterpillar." George Westerman, MIT Initiative on the Digital Economy.

Industrial firms face unprecedented change due to the disruptive effects of novel digital technologies presenting radically new opportunities for value creation, delivery, and capture. Indeed, leveraging value from digital technologies is often viewed as a strategic imperative for industrial firms seeking new forms of competitive advantage. But advancing beyond the really fast caterpillar to the fully fledged butterfly requires a business model capable of leveraging the potential of digital technologies. This presents numerous uncertainties and challenges because it remains unclear how industrial firms can innovate business models to effectively leverage value from digital technologies. Recognising and seeking to account for the significance of this technological shift, academics and practitioners alike can increasingly be found referring to the concept of *digital* business models. Yet, despite arguments for their utility, few researchers have explored what makes digital business models conceptually distinct and worthy of further investigation. As a result, the term "digital" often seems to add little to our existing understanding of business models, raising concerns about buzzword misuse. Consequently, the purpose of this thesis is to *conceptualize what a digital business model is, and to explain how it can be innovated by exploring the intersection with digital affordances.*

The thesis contends that digital business models and their innovation can be better understood by considering the underlying digital affordances that shape them. This argument is supported by findings from four papers containing empirical insights from the innovation of advanced industrial solutions. Three of the papers consist of multiple case studies, and one is a secondary data study of industrial firms and their suppliers/partners. Paper 1 explores how industrial firms approach digital business model innovation by aligning technology development, ecosystem configuration, and business model design across various maturity levels in autonomous solutions development. Paper 2 demonstrates how industrial firms manage the complexity of digital business model innovation of autonomous solutions through business model piloting. Paper 3 unveils how new technology-based firms leverage digital technologies in a combined business model approach to harness both efficiency and novelty value drivers. Paper 4 explains how industrial firms capitalize on digitalization by orchestrating their resources to develop the firm-specific capabilities required for digital transformation.

Through a synthesis of earlier research findings and by drawing on digital affordance literature, this thesis proposes a conceptual digital business model innovation framework. The framework uncovers the underlying mechanisms that support digital business model innovation, offering valuable insights into how industrial firms can effectively innovate in the digital age. Specifically, the framework explicitly links the digital affordances of disintermediation, decoupling, and generativity to the digital business model dimensions of digital value creation, digital value delivery, and digital value capture. Empirical insights from the thesis's four papers are used to theorize the mechanism between each digital business model dimension and its

corresponding affordance. Alongside a proposed definition of digital business models, the framework contributes to fulfilling the purpose of this thesis.

This thesis contributes to the growing literature on digital business models, particularly in the context of industrial firms. Through the development of a conceptual digital business model innovation framework and a tentative definition, the thesis bridges gaps in the existing literature and offers a more rigorous approach to conceptualizing digital business models. Crucially, by theorizing the mechanisms that interconnect digital affordances with business models, the thesis provides a deeper understanding of how value from digital technologies is leveraged across the business model. Besides its theoretical contributions, the thesis presents valuable empirical insights that can support practitioners working with digital business model innovation.

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Linus Thomson
Luleå, June 2023

Appended Papers

Paper 1	**Thomson, L.**, Kamalaldin, A., Sjödin, D., & Parida, V. (2021). A maturity framework for autonomous solutions in manufacturing firms: The interplay of technology, ecosystem, and business model. *International Entrepreneurship and Management Journal,* DOI:10.1007/s11365-020-00717-3
Paper 2	**Thomson, L.**, Sjödin, D., Parida, V., & Jovanovic, M. (202X). Business model piloting for autonomous solutions: An experiential learning process for business model innovation. *(Second round of review at a peer-reviewed academic journal)*
Paper 3	**Thomson, L.** (2022). Leveraging the value from digitalization: A business model exploration of new technology-based firms in vertical farming. *Journal of Manufacturing Technology Management,* DOI: 10.1108/JMTM-10-2021-0422
Paper 4	**Thomson, L.**, Sjödin, D., & Parida, V. (202X). Resource orchestration to realize the potential of industrial digital transformation: Leveraging capability configurations. *(Submitted for peer-review at an academic journal)*

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Part 1

1. Introduction

The introductory chapter presents an overview of the research context, establishing the motivation for undertaking this study. It includes a background section which delves into the specific area of investigation for this thesis and provides a discussion of the research problems. Following this, the overall purpose of the thesis is presented.

1.1. Background

Industrial firms are experiencing unprecedented change due to the disruptive effects of digital technologies (Verhoef et al., 2021; Warner & Wäger, 2019). Digitalization, which involves employing digital technologies, such as the Internet of things (IoT), cloud computing, and artificial intelligence to enact business changes (Buer et al., 2021; Verhoef et al., 2021), is impacting nearly all industries (Trischler & Li-Ying, 2022) and reshaping established market structures (Porter & Heppelmann, 2014). Indeed, industrial firms[1] are increasingly leveraging digitalization to enable significant improvements in both their internal processes and customer offerings (Büchi et al., 2020; Fitzgerald et al., 2013; Tronvoll et al., 2020). These enhancements are driving the digital transformation of industry (Berman, 2012; Björkdahl, 2020; Rachinger et al., 2019), which represents the most pervasive level of organizational change resulting from the application of digital technologies (Verhoef et al., 2021). Rather than simply converting analogue information into digital (digitization) or altering the conduct of a business process (digitalization), digital transformation facilitates a radically new business logic through business model innovation (BMI), leading to company-wide effects (Verhoef et al., 2021). For instance, manufacturers of industrial vehicles are integrating digital technologies into their physical products, thereby delivering new forms of customer value through monitoring, optimization, and remote control of their machinery fleets (Caterpillar, 2021; Porter & Heppelmann, 2015). Consequently, digitally enabled products and services are propelling an industrial shift with transformative effects on industrial firms' ability to deliver increased value[2] (Barras, 1986; Björkdahl, 2009; Porter & Heppelmann, 2015; Tronvoll et al., 2020). This includes the radical transformation of industrial products, services and operations (Yoo et al., 2012), which are opening up new and uncertain possibilities for creating value (Baden-Fuller & Haefliger, 2013; Björkdahl, 2020; Rachinger et al., 2019).

However, despite their transformative potential, digital technologies possess no intrinsic value on their own. Instead, they must be complemented by the innovation of viable business models (BMs) capable of harnessing their potential (Berman, 2012; Björkdahl, 2009; Rask & Günzel-Jensen, 2019; Sabatier et al., 2012; Veit et al., 2014; Vial, 2019). The success of industrial firms

[1] Industrial firms refer to organizations engaged in the processing of raw materials, and/or manufacture of goods in factories.

[2] In this thesis, value refers to the "technical, economic, service, and social benefits a customer company receives" from a market offering (Anderson & Narus, 1998).

pursuing a strategy of digital transformation is therefore intrinsically linked to their ability to leverage the value of digital technologies through BMI (Baden-Fuller & Haefliger, 2013; Berman, 2012; Klos et al., 2023; Rachinger et al., 2019; Sambamurthy et al., 2003). BMI involves "designed, novel, and nontrivial changes to the key elements of a firm's BM and/or architecture linking these elements" (Foss & Saebi, 2016, p. 216), requiring industrial firms to address the BM as a whole (Foss & Saebi, 2018). Autonomous solutions, such as self-driving industrial vehicles, exemplify this need because industrial firms must combine emerging digital technologies with significant changes to their value creation, delivery, and capture components (Thomson et al., 2021). For example, product-centric customer-supplier relationships are typically reconfigured for providing digital services and solutions, with manufacturers assuming greater responsibility for operational performance (Sandvik et al., 2021; Sjödin et al., 2020). Connectedly, scholars have more recently begun to conceptualize digital transformation as the process leading to the innovation of digital business models (DBMs) (Broekhuizen et al., 2021; Klos et al., 2023; Verhoef et al., 2021; Verhoef & Bijmolt, 2019). DBMs are considered a distinct category of BM due to their exploitation of digital technologies (Bock & Wiener, 2018; Veit et al., 2014; Weill & Woerner, 2013), with autonomous-solution BMs broadly aligning with existing definitions and classifications (Bock & Wiener, 2018; Remané et al., 2022; Vendrell-Herrero et al., 2018). However, the relevance and significance of digital technologies in DBMs remain poorly understood (Trischler & Li-Ying, 2022), and the literature is characterized by numerous definitions and vague conceptualizations (Bock & Wiener, 2018; Remané et al., 2022). This not only challenges the cumulativeness of research but also risks undermining the concept.

To advance understanding of the innovation of DBMs, the unique affordances offered by digital technologies can be considered. Affordances are defined as the action potential provided by a specific object to a specific user (Nambisan et al., 2019). Examples of affordances offered by digital technologies include reduced communication and coordination costs (Yoo et al., 2012), disintermediation of value chains (Autio et al., 2018), reduced asset specificity through decoupling (Autio et al., 2018), and increased customer, partnering, and operational agility (Sambamurthy et al., 2003). These digital affordances are evident in the inherent re-programmability and flexibility of digital technologies (Yoo et al., 2010), which enable a wide range of functions to be performed by various underlying digital infrastructures (Autio et al., 2018). Examples of this can be found in smart connected products within agriculture (Porter & Heppelmann, 2015, 2014) and mining (Thomson et al., 2021). However, despite a growing number of research contributions providing valuable insights into the business impacts of digitalization (Kohtamäki et al., 2020; Sjödin et al., 2021; Teece & Linden, 2017), numerous uncertainties and challenges persist for industrial firms pursuing digital transformation.

1.2. Research problematization

The digital transformation of industrial firms is a critical topic because it enables companies to enhance efficiency, reduce costs, and secure a competitive advantage (Büchi et al., 2020; Rachinger et al., 2019). However, the full potential of this transformation can only be realized if firms can innovate their business BMs to leverage value from digital technologies (Chen, Liu,

et al., 2021; Klos et al., 2023). Indeed, when used to improve efficiencies (faster, better, cheaper), digital technologies tend to lock in established ways of doing business (Pentland et al., 2022). Overcoming this necessitates a shift in focus from using digital technologies for internal improvements to driving revenue growth and innovation (Björkdahl, 2020). Consequently, understanding how digital transformation impacts BMs and managing the complex relationships between technology and value creation are crucial for the continued survival and success of industrial firms (Klos et al., 2023; Verhoef et al., 2021; Warner & Wäger, 2019). However, research on this topic is scarce, particularly from the perspective of industrial firms (Remane et al., 2017; Yoo et al., 2010). Indeed, DBMs are more often examined from the standpoint of digitally-native enterprises (Bock & Wiener, 2018), such as e-business in B2C contexts (Demil & Lecocq, 2010) and venture-funded start-ups (Remané et al., 2022). Unlike industrial firms, these enterprises typically have digital technologies as a central feature of their BMs, as exemplified by Uber's digital platform for transportation services (Vendrell-Herrero et al., 2018). Empirical insights on the digital transformation of industrial firms in B2B settings can therefore address important gaps in understanding related to their digital transformation.

First, despite significant practitioner and academic interest, there is a lack of conceptual clarity regarding *what constitutes a DBM*. Notably, the relevance and significance of digital technologies in DBMs remain poorly understood (Bock & Wiener, 2018; Broekhuizen et al., 2021), with the literature frequently relying on existing BM conceptualizations (Trischler & Li-Ying, 2022). To address this issue and develop a clearer understanding of DBMs, researchers have concentrated on formulating DBM taxonomies (Bock & Wiener, 2018; Remané et al., 2022; Vendrell-Herrero et al., 2018). While these endeavors contribute to consolidating knowledge and offering practical guidance, taxonomies based on established examples may inadvertently exclude undiscovered alternative DBMs (Remané et al., 2022). Furthermore, existing definitions and classifications of DBMs vary (Luz Martín-Peña et al., 2018) and tend to be context specific (Bock & Wiener, 2018), with examples ranging from blockchain technology platforms (Kramer et al., 2021), sharing economy digital platforms, such as Airbnb (Schiavone et al., 2021), to e-business extensions (Luz Martín-Peña et al., 2018). This context specificity challenges the development of a more inclusive DBM definition that emphasizes the salient features of DBMs. To promote the cumulative development of DBM research and avoid the potential of buzzword misuse (Bock & Wiener, 2018), scholars have called for a clearer conceptual understanding of DBMs (Broekhuizen et al., 2021; Trischler & Li-Ying, 2022). This thesis contends that shifting the focus to the underlying digital affordances could help clarify existing conceptualizations and expand our understanding of what makes the "digital" of DBMs unique.

Second, there is limited understanding of *how industrial firms leverage the affordances of digital technologies across their DBMs.* While the importance of innovating BMs to leverage value from digital technologies is increasingly recognized (Rachinger et al., 2019), the mechanisms by which digital affordances are leveraged in the value creation, delivery, and capture dimensions remain underexplored (Klos et al., 2023; Remané et al., 2022). In essence, innovating DBMs requires industrial firms to address the increasingly uncertain, complex, and

dynamic relationships between novel digital technologies (Baden-Fuller & Haefliger, 2013) and the business-model dimensions of value creation, delivery, and capture (Foss & Saebi, 2016). These dimensions must be aligned (Ritter & Lettl, 2018) and serve a specific customer need (Lerch & Gotsch, 2015). However, it remains unclear how industrial firms should manage these complex BM relationships (Metallo et al., 2018; Rachinger et al., 2019) in an increasingly digital landscape (Remane et al., 2017). Gaining deeper insights into the interplay between digital affordances and the BM dimensions could uncover new opportunities for innovation. Consequently, this thesis seeks to investigate and shed light on the mechanisms employed by firms to effectively leverage affordances in their DBM.

1.3. Research purpose

This thesis addresses the uncertainties and challenges inherent in the innovation of DBMs, by building upon four separate studies that include empirical insights of industrial firms in advanced digital settings. In fact, prior research has stressed the importance of researching DBMs in complex settings (Remané et al., 2022) in order to uncover the patterns and mechanisms behind their innovation. Consequently, to address the arguments presented in the introduction concerning the phenomenon of DBMI, the following purpose has been formulated:

The purpose of this thesis is to *conceptualize what a digital business model is, and to explain how it can be innovated by exploring the intersection with digital affordances.*

The thesis is divided into two main parts. The first part, the kappa, serves as an introduction to the second part, which consists of four appended papers. The purpose of the kappa is to integrate the key insights and implications from the research papers into a coherent narrative extending beyond the findings and contributions of the individual papers. The following chapters begin with a review of the theoretical background that informs the PhD area of study. After the theoretical background, the research methodology is presented, including a summary of the methods adopted for the four manuscripts. Chapter 4 presents a summary of the manuscripts included as appended papers. Subsequently, in chapter 5, the thesis introduces a proposed framework for the innovation of DBMs as well as a DBM definition, drawing on a synthesis of the findings from the four studies reported in this thesis. Finally, theoretical, and managerial contributions are outlined, along with reflections on the limitations and opportunities for future research.

2. Theoretical Background

This chapter provides the theoretical foundation for the thesis. It begins with an overview of digital business models, followed by a review of digital business model innovation. Next, the background delves into the current understanding of digital affordances. Lastly, a theoretical framework synthesizes the key insights gleaned from the theoretical background, serving as a guide for the subsequent development of the thesis.

2.1. Digital business models

The literature on BMs has experienced a surge since the late 1990s (Demil & Lecocq, 2010; Massa et al., 2017), attracting significant interest from researchers and practitioners alike (Wirtz et al., 2016). BMs can be conceptualized as describing the "design or architecture of the value creation, delivery, and capture mechanisms" of a firm (Teece, 2010, p. 191). *Value creation* pertains to the customer value generated through transactions, resulting from a firm's value proposition, which encompasses products and services (Zott & Amit, 2010). *Value delivery* describes the ways in which the firm organizes to deliver value to the customer (Zott & Amit, 2010). *Value capture* encompasses the process of value appropriation, closely linked to the firm's revenue models (Teece, 2010).

More recently, the interrelated concept of DBMs has emerged in the academic literature (Remané et al., 2022). DBMs are considered a distinct category of BM, primarily due to their exploitation of digital technologies (Bock & Wiener, 2018; Veit et al., 2014; Weill & Woerner, 2013). Indeed, previous research demonstrates that digital technologies are transforming BMs (Verhoef & Bijmolt, 2019) and impacting each dimension of value creation, delivery, and capture (Remané et al., 2022). Firms initiate BM changes to harness the value derived from digital technologies, recognizing that these technologies themselves do not possess intrinsic value (Berman, 2012; Veit et al., 2014; Vial, 2019). However, despite this recognition, the DBM literature has often built upon established BM theories without explicitly considering the digital component's relevance (Trischler & Li-Ying, 2022). Consequently, the term "digital" in relation to BMs has been likened to a "buzzword" that, in most cases, fails to adequately explain the unique aspects of digital (Bock & Wiener, 2018). This has led to a lack of construct clarity within the DBM literature (Bican & Brem, 2020), where any BM incorporating a digital element could be considered a DBM (Bock & Wiener, 2018). To address this issue and promote the cumulative development of DBM research, scholars have called for a clearer conceptual understanding (Broekhuizen et al., 2021; Trischler & Li-Ying, 2022). Some initial efforts have been made in this direction.

Efforts to enhance our understanding of DBMs include the development of taxonomies. One such taxonomy outlines generic DBM building blocks across five dimensions: digital offering, digital experience, digital platform, data analytics, and digital pricing (Bock & Wiener, 2018). Each dimension is further divided into sub-characteristics, illustrating the primary ways digital

technologies can be incorporated into DBMs. This marks an important step towards clarifying the uniqueness of DBMs. However, the taxonomy does not consider the underlying digital affordances that support various DBM characteristics, which is problematic. DBM taxonomies that overlook digital affordances risk excluding alternative DBM characteristics yet to be discovered (Remané et al., 2022). In other words, digital affordances can be leveraged through DBMs in countless combinations with outcomes that cannot be classified in a taxonomy based on known DBM examples. Similar attempts to develop DBM taxonomies have de-lineated them according to the supply chain position of the focal actor (producer or intermediary), across three distinct sub-fields: digital servitization of incumbents (digital non-native), digital innovation of incumbents (digital native), and digital entrepreneurship of new entrants (Vendrell-Herrero et al., 2018). Although this taxonomy helps categorize DBM research contributions, it likewise falls short in explaining what is unique about DBMs and how digital affordances shape them. A more recent contribution aimed at advancing our understanding of DBMs has classified them into 49 different types within three broader categories: 1) offering digitally enabled products and services, 2) the provision of resources and capabilities for digital business, and 3) the facilitation of intermediation (Remané et al., 2022). While this classification offers valuable guidance on the BM typologies made possible by digital technologies, it is "by no means an exhaustive list" due to the infinite number of ways digital technologies can be combined for DBM innovation (Remané et al., 2022, p. 22). Indeed, similar to earlier taxonomies (Bock & Wiener, 2018), the researchers have classified known DBM variants without investigating the underlying affordances that shape those variants.

To gain a deeper understanding of the historical development and increasing popularity of the DBM literature stream, a Scopus document search and review were conducted, as illustrated in Figure 1. A total of 178 publications reference "digital business model," with the majority published within the past five years. The search revealed contributions to the growth of DBM publications from various disciplines, including engineering (Alcácer & Cruz-Machado, 2019), marketing (Hasselblatt et al., 2018; Vendrell-Herrero et al., 2017; Verhoef & Bijmolt, 2019), information systems (Benlian, 2015; Oestreicher-Singer & Zalmanson, 2013; Veit et al., 2014), strategy (Luz Martín-Peña et al., 2018; Remane et al., 2017), management (Bouncken et al., 2021; Kraus, Roig-Tierno, et al., 2019; Weill & Woerner, 2013), and economics (Minter, 2017; Sahut et al., 2021). However, despite its growing popularity, research on DBMs remains in its nascent stage and suffers from a lack of construct clarity (Broekhuizen et al., 2021; Remané et al., 2022; Trischler & Li-Ying, 2022). Indeed, the scattered nature of the DBM literature leads to varying applications and definitions of the DBM concept.

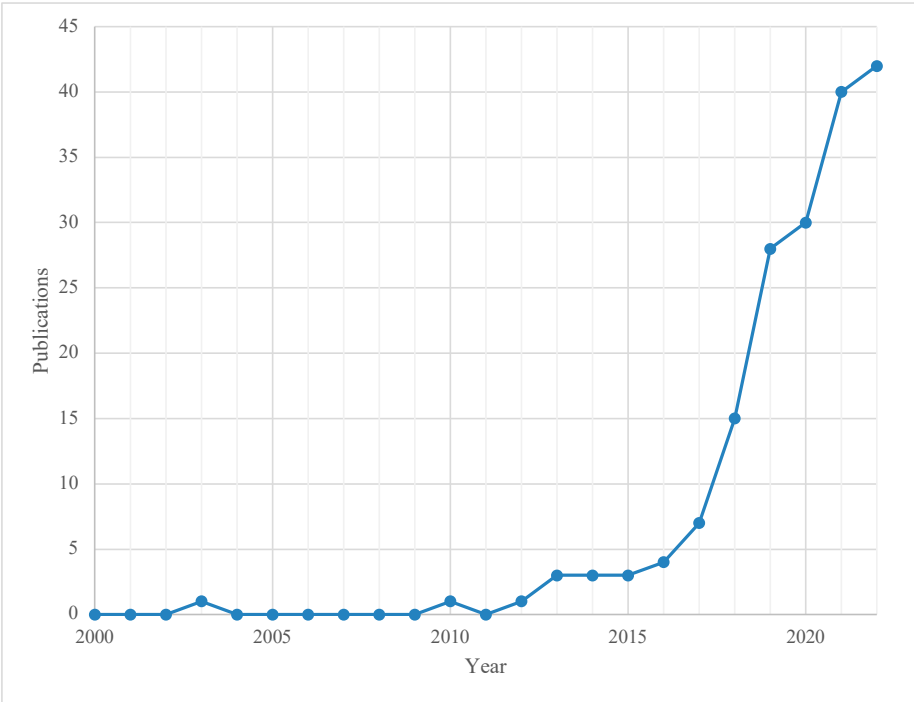

Figure 1: Published research on digital business models

Source: Author, based on Scopus search results for the term "digital business model" in the search field "article title, abstract, keywords" within the subject areas "business, management and accounting", "computer science", "engineering", "decision sciences", "economics, econometrics and finance", and "social sciences", and limited to publications in journals in English, published up to and including the year 2022. (In total: 178 hits)

Table 1 presents the definitions provided for DBMs in the 40 most-cited articles with the term "digital business model" in the title, abstract, or keywords. Notably, 28 out of 40 articles do not explicitly define what a DBM is. Instead, the authors depict DBMs as a consequence of digitalization (e.g., Kraus et al., 2019a; Bouncken et al., 2021; Chong et al., 2019), servitization (e.g., Vendrell-Herrero et al., 2017; Hasselblatt et al., 2018; Baird and Raghu, 2015), specific digital technologies such as blockchain (Kramer et al., 2021), big data (Trabucchi & Buganza, 2019), industry 4.0 (Alcácer & Cruz-Machado, 2019), and equate DBMs with digital platforms such as Air BnB and WhatsApp (Nooren et al., 2018; Standing & Mattsson, 2018). Although the BM concept has been subject to varying definitions and applications (Demil & Lecocq, 2010; Massa et al., 2017; Teece, 2010), a variety of DBM definitions is not necessarily problematic. However, a reliance on implicit definitions and vague connections to digital technologies risks turning the concept into a buzzword that adds little to no value (Bock & Wiener, 2018). Indeed, existing definitions of DBMs often fail to highlight what distinguishes them from non-digital BMs (Remané et al., 2022). Despite some initial progress in conceptualizing DBMs, researchers face challenges in clearly defining what makes DBMs

novel and distinguishable from non-digital BMs (Bock & Wiener, 2018; Remané et al., 2022; Veit et al., 2014). To add value beyond the more generic BMs, the "digital" aspect of DBMs needs to be more clearly defined. Indeed, the utility of the DBM concept will improve as a more formalized understanding is developed (Veit et al., 2014).

Among the 12 articles that explicitly define DBMs, the most frequently cited definition posits that “a business model is digital if changes in digital technologies trigger fundamental changes in the way business is carried out and revenues are generated” (Veit et al., 2014, p. 48). Although this definition provides a useful starting point, it does not explain how digital technologies might change the BM or which specific components of the BM they might alter (e.g., value creation, value delivery, and value capture). Furthermore, the characterization of these changes as "fundamental" raises questions about the scope of the changes and whether they are sufficient to classify the BM as digital. An alternative definition suggests that "digital business models are in fact representations of how a new venture plans to process and distribute value by leveraging affordances provided by digital and non-digital technologies" (Sahut et al., 2021, p. 1163). By referring to affordances, the authors more specifically address the unique attributes of "digital" and their impact on the BM. However, as with other DBM definitions from this review, it remains unclear which BM dimensions are affected by digital technologies, how they are affected, and the extent to which they need to be influenced to be classified as a DBM. Addressing the above shortfalls calls for a new definition of DBMs.

Table 1: Digital Business Model Definitions

Authors, Year	Scopus Citations	Digital Business Model Definition	Comment
(Alcácer & Cruz-Machado, 2019)	480	Not explicitly defined	The authors imply that the enabling technologies of Industry 4.0 lead to the development of digital business models.
(Vendrell-Herrero et al., 2017)	320	Not explicitly defined	The implication is that digital technologies lead to increased servitization of traditional product-centric business models, and result in digital business models - such as the e-book business model in the publishing industry.
(Oestreicher-Singer & Zalmanson, 2013)	264	Not explicitly defined	The implication is that digital business models are representative of the shift from physical to digital content generation (in the content industry).
(Veit et al., 2014)	261	"A business model is digital if changes in digital technologies trigger fundamental changes in the way business is carried out and revenues are generated" (Veit et al., 2014, p. 48)	The authors expand on their definition by stating that "The majority of business models are digital in the media industry, the retail industry, the financial services industry, and in logistics" (Veit et al., 2014, p. 48).
(Kraus, Palmer, et al., 2019)	242	Not explicitly defined	Increased digitalization is posited to lead to digital business models. Examples of digital business models are provided, such as “platform strategies” and “social digital entrepreneurship”.
(Remane et al., 2017)	103	Reference the definition of Viet et al. (2014)	Authors stress that the characteristics of digital business models are different to normal ones.
(Weill & Woerner, 2013)	97	"digital business models - how they (enterprises) engage their customers digitally to create value, via mechanisms such as websites and mobile devices" (Weill & Woerner, 2013, p. 71)	Focused on B2C business models.
(Bouncken et al., 2021)	84	Not explicitly defined	Digitalization is seen as a driver of digital business models.

Authors, Year	Scopus Citations	Digital Business Model Definition	Comment
(Kraus, Roig-Tierno, et al., 2019)	79	Not explicitly defined	Digital business models are equated with the digitalization of entrepreneurship.
(Benlian, 2015)	79	Not explicitly defined	A digital business model is considered to be one that is present online.
(Luz Martín-Peña et al., 2018)	74	Reference the definition of Veit et al. (2014)	The authors propose that digital business models are an extension of the concept of e-business.
(Steininger, 2019)	71	"Business logic that uses entirely IT-mediated processes and digital products or services for value creation and transfer" (Steininger, 2019, p. 380)	The author states that the value must be created through a "completely digitized product or service, digitally sold and delivered" (Steininger, 2019, p. 381).
(Bican & Brem, 2020)	64	"Enhanced resource optimization, characterized by intangibility, businesses' uniqueness, and core values, centering around experience, platform, and content" (Bican & Brem, 2020, p. 10)	Also references the definition of Veit et al (2014).
(Hasselblatt et al., 2018)	63	Not explicitly defined	The authors frame the discussion of digital business models in the context of servitization using IoT technologies.
(Cezarino et al., 2019)	60	Not explicitly defined	Digital business models are framed as a mediator between IoT technologies and a circular economy.
(Minter, 2017)	57	Not explicitly defined	Digital business models are equated with platform business models.
(Chong et al., 2019)	56	Not explicitly defined	Digital business models are connected to increased digitalization and the pursuit of sustainable competitive advantage.
(Sahut et al., 2021)	54	"Digital business models are in fact representations of how a new venture plans to process and distribute value by leveraging affordances provided by digital and non-digital technologies" (Sahut et al., 2021, p. 1163)	Study situated in digital entrepreneurship.
(Verhoef & Bijmolt, 2019)	52	"Digital business models are situations where digital technologies have fundamentally affected the way a firm structures and carries out its business and thereby creates value for customers, the firm itself, and its partners" (Verhoef & Bijmolt, 2019, p. 343)	Focus of the article is on B2C firms.
(Trabucchi & Buganza, 2019)	47	Not explicitly defined	Big data is posited as a reason why firms may pursue digital business models.
(Dellermann et al., 2017)	46	Not explicitly defined	The authors allude to digital business models arising from "various devices and IT infrastructures allow(ing) multiple actors to interoperate and distribute value creation across companies within the ecosystem" (Dellermann et al., 2017, p. 36).
(Bourreau et al., 2012)	43	Not explicitly defined	Five typologies of emerging digital business models in the music industry are provided.
(Bijmolt et al., 2021)	41	Not explicitly defined	Digital business models considered from the perspective of multi-sided platforms - developed due to the increased proliferation of information technologies.
(Voigt & Hinz, 2016)	39	Not explicitly defined	Digital business models framed from the perspective of freemium models utilized in online games or social applications.
(Soluk et al., 2021)	37	Digital business model innovation defined as: "a significantly new way of creating and capturing business value that is embodied in or enabled	

Authors, Year	Scopus Citations	Digital Business Model Definition	Comment
		by digital technologies and in which digital technologies are an essential element of the generated business value" (Soluk et al., 2021, p. 868)	
(Coyle, 2017)	36	Not explicitly defined	Digital platforms such as those used by UBER and Airbnb are equated with the term of digital business model.
(Standing & Mattsson, 2018)	35	"In this paper we use the 'label' digital in relation to business models to denote businesses that rely substantially on the internet to deliver services and products" (Standing & Mattsson, 2018, p. 386)	Study set in the context of B2C digital platforms (e.g., Airbnb, GoCarShare, TravelApp).
(Wiesböck & Hess, 2020)	34	Reference the definition of Veit et al (2014)	The authors contend that the emergence of digital products, services, and processes leads to digital business models.
(Jovanović et al., 2018)	34	Not explicitly defined	The authors posit that digitalization is acting as impetus for the development of digital business models.
(Nooren et al., 2018)	34	Not explicitly defined	Digital business models equated with B2C platform-based business models, such as WhatsApp and Google Play.
(Baird & Raghu, 2015)	33	Not explicitly defined	The authors seem to imply that the digitization of services is leading to the development of digital business models.
(Ansong & Boateng, 2019)	31	Not explicitly defined	The authors frame digital business models in the context of the digital economy, where the economic output results from the application of digital technologies via a business model.
(König et al., 2019)	30	Not explicitly defined	The authors seem to equate digital business models with digital ventures, defined as "ventures attempting to implement an intangible software tool at the core of their business model" (König et al., 2019, p. 847).
(Vendrell-Herrero et al., 2018)	30	Not explicitly defined	The authors begin by positioning digital business models as the outcome of increased digitization. Subsequently, a taxonomy of digital business models (without defining digital business models) is provided: connecting digital business model with digital servitization, digital innovation, and digital entrepreneurship.
(Clemons & Madhani, 2010)	28	Not explicitly defined	Digital business models equated with digital platforms and online business models, with the example of Google provided.
(Schiavone et al., 2021)	27	"A business model, thus, can be categorized as digital if digital technologies trigger fundamental changes in these value dimensions (value creation, and value capture)" (Schiavone et al., 2021, p. 2) - the authors also reference Veit et al (2014)	The authors examine digital business models in the context of the sharing economy, in particular B2C digital platforms such as Uber and Airbnb.
(Kramer et al., 2021)	27	Not explicitly defined	Digital business models equated with choices of blockchain technology platform types.
(Chen, Visnjic, et al., 2021)	27	Not explicitly defined	The authors imply that digital servitization is leading to the creation of digital business models.
(Volberda et al., 2021)	26	Not explicitly defined	The authors imply that the increased prevalence of digital technologies is leading to the development of digital business models.
(Ananyin et al., 2018)	26	Not explicitly defined	Although the authors do not explicitly define digital business models, they do comment on its characteristics: "Digital business models require not only a profound digitalization of the internal links of the enterprise's value creation (design,

Authors, Year	Scopus Citations	Digital Business Model Definition	Comment
			production, logistics, technical support and maintenance of products), but also the building of close partnership relationships between the business and all its contractors. The most important element of such a profound partnership is the creation of an overall integrated information and communication space." (Ananyin et al., 2018, p. 50).

2.2. Digital business model innovation

A significant challenge for industrial firms is innovating their BMs (Demil & Lecocq, 2010; Foss & Saebi, 2016, 2018) – a process often considered an "art" requiring difficult-to-transfer tacit knowledge (Teece, 2010, p. 190). BMI is defined as the “designed, novel, and nontrivial changes to the key elements of a firm’s BM and/or architecture linking these elements” (Foss & Saebi, 2016, p. 216). Although this definition shares similarities with that of BMs, it crucially incorporates the term “innovation” (Foss & Saebi, 2016), highlighting the importance of change within the BM to complement product and service innovation (Teece, 2010). Scholars use BMI in various lines of inquiry, adopting different conceptual dimensions and boundary conditions (Foss & Saebi, 2016). For instance, BMI can be seen as a static concept representing a new type of venture or as a dynamic concept reflecting processes of organizational change (Foss & Saebi, 2016). The literature on BMI is less understood than that of BMs due to its relatively recent emergence (Foss & Saebi, 2016). Consequently, even though BMI is recognized as a distinct unit of analysis, research on the topic has been criticized for receiving insufficient attention (Berends et al., 2016). Existing research suggests that BMs can change due to both internal and external factors (Demil & Lecocq, 2010). Internal factors for change can stem from an “increase in the firm’s knowledge about the efficient use of its resources, or the discovery of new uses (or combinations of uses)” that subsequently can lead to the development of new value propositions (Demil & Lecocq, 2010, pp. 236–237). External factors include environmental changes, such as market disruptions that alter demand and supply, the emergence of new competitors, and the availability of new technologies.

Advancements in digital technologies are viewed as key drivers to increase opportunities for organizations to fundamentally change the way they conduct business (Klos et al., 2023). These advancements open up new ways to collaborate internally and externally to the firm, as well as enabling new ways to create, capture, and deliver value (McGrath, 2010; Teece, 2010; Zott et al., 2011). Incumbent firms recognize that digitalization plays a “fundamental role in their ability to enhance their business performance through continual innovations in product, services, channels, and customer segments” (Sambamurthy et al., 2003, p. 255). Indeed, the impact of digital technologies is pressurizing incumbent firms to adapt (Veit et al., 2014) through digital business model innovation (DBMI) (Trischler & Li-Ying, 2022).

Earlier studies have highlighted the need to consider DBMI separately from non-digital BMI (Nambisan et al., 2017; Trischler & Li-Ying, 2022; Volberda et al., 2021). Building on the concept of DBMs, DBMI has also been criticized for a lack of construct clarity (Trischler & Li-

Ying, 2022). Recent efforts have been made to review the literature on DBMI and propose a more useful and parsimonious definition that is able to support both academic and practitioner endeavors (Trischler & Li-Ying, 2022). A prominent definition considers DBMI as the "*purposeful, non-trivial, dynamic changes made to the key elements of the business model by transforming analog, physical objects, processes, or content into primarily (or entirely) digital formats*" (Trischler & Li-Ying, 2022, p. 17). However, this definition does not fully convey how the unique characteristics of digital technologies afford firms new BM options. Building on this work by exploring the opportunities provided by digital affordances will help advance a much-needed multidisciplinary approach to DBMI (Trischler & Li-Ying, 2022).

2.3. Digital affordances

Affordances are defined as the action potential offered by a specific object for a specific user (Nambisan et al., 2019). The unique affordances of digital technologies are driving a radical transformation in business activity through digital transformation (Autio et al., 2018). This transformation encompasses products, services, and operations (Yoo et al., 2012), which are opening up new possibilities for creating customer value (Baden-Fuller & Haefliger, 2013; Björkdahl, 2020; Rachinger et al., 2019). For instance, digital technologies have significantly reduced transaction and communication costs, resulting in business model innovation (BMI) shifting from being solely within the firm to increasingly distributed and occurring across firm boundaries (Yoo et al., 2012). This means innovation is taking place across multiple organizations (Jovanovic et al., 2021; De Reuver et al., 2018; Sklyar et al., 2019) and through new methods of organizing, such as online communities (Yoo et al., 2012). Moreover, digitalization is also altering the materiality of products, transforming them from purely physical entities to ones with digital components (Yoo et al., 2012). Incorporating the unique affordances offered by digital components into physical products creates "new possibilities for creating experiences, relationships, processes, and organizational forms" (Yoo et al., 2012, p. 1399). Moreover, digital technologies accelerate the pace of innovation (Yoo et al., 2012), with pace referring to the "rate at which change is happening within the innovation space" (Yoo et al., 2012, p. 1405). The affordances provided by digital technologies enable incumbents to rapidly and relatively easily transform their operations (Warner & Wäger, 2019). The increased pace is due to the regenerative and programmable nature of digital technologies, which subsequently requires that innovation is "continuous, relentless, and fast" (Yoo et al., 2012, p. 1405). This presents both threats and opportunities for industrial firms, challenging them to become more entrepreneurial by leveraging the affordances of digital technologies (Warner & Wäger, 2019).

Digital technologies are posited to give rise to several affordances, including: *decoupling*, *disintermediation*, and *generativity* (Autio et al., 2018; Yoo et al., 2012). These affordances fundamentally change the ways in which organizations can create, capture, and deliver value, potentially leading to the innovation of new BMs (Autio et al., 2018). *Decoupling* pertains to the reduced asset specificity of digital technologies (Autio et al., 2018). Unlike physical technologies, where form and function are intimately connected to perform a specific activity, digital technologies are inherently reprogrammable and can be adapted to fit a wide variety of

functions (Autio et al., 2018; Yoo et al., 2010). For instance, Sandvik's autonomous platform AutoMine is used to retrofit and automate a broad range of Sandvik and non-Sandvik mining equipment (Sandvik, 2021). This inherent flexibility of digital technologies enables a vast range of different functions to be performed by diverse, underlying digital infrastructures (Autio et al., 2018).

Disintermediation refers to the reduced "dependency on location-specific value chain assets and resources" (Autio et al., 2018, p. 76). This affordance enables "producers and suppliers greater control over material flows and activities within the value chain and reduces their dependency on location-specific intermediaries as sources of information necessary to co-ordinate their operations" (Autio et al., 2018, p. 76). A particularly relevant example involves industrial equipment manufacturers who can monitor, control, and even remotely operate connected machinery. For instance, digital technologies have allowed mining operators, such as Rio Tinto, to establish off-site remote control centers for managing autonomous vehicle operations thousands of miles away from the actual area of operations (Bellamy & Pravica, 2011; McKinsey, 2021; RioTinto, 2021). Disintermediation, therefore, has led to new ways of flexibly configuring and coordinating activity systems (Autio et al., 2018), fundamentally changing how BMs can be designed (Foss & Saebi, 2018; Teece, 2010).

Generativity refers to "the capacity of digital technologies to produce unpromoted change by large, varied, unrelated, unaccredited and uncoordinated entities" (Nambisan et al., 2019, p. 3). It is considered an emergent property of digital technologies which is dependent upon how the technology is used in practice (Pentland et al., 2022) – for example, as digital platforms (Autio et al., 2018). In essence, generativity is associated with the affordances provided by digital technologies due to architectural features that enable reduced transaction costs for large and geographically decoupled audiences (Autio et al., 2018; Yoo et al., 2012). For instance, industrial vehicle manufacturers in mining have opened up their autonomous platforms through access APIs, allowing third-party developers to create derivative innovations (Thomson et al., 2021). These innovations "add new layers of affordances to those digital products and services" (Yoo et al., 2012, p. 1400). Another feature of innovations influenced by digital technologies, closely related to generativity, is the propensity for combinatorial innovation (Nambisan et al., 2019; Yoo et al., 2012). Combinatorial innovation refers to a modular approach where existing modules are combined in new ways to create value (Yoo et al., 2012). However, unlike physical modularity that represents an active and pre-designed decomposition, such as the Scania design and manufacturing process (Nilsson & Dernroth, 1995), digital modularity is designed without knowing the end product (Yoo et al., 2012). Collaborative innovation using APIs, for example, can result in entirely new combinations, such as digital services utilizing the Google Maps API in innovative ways (Yoo et al., 2012). The diffusion of digital innovations, therefore, challenges the implicit assumption that, as innovations spread, they remain static (Yoo et al., 2012). Instead, digital innovations continually evolve in new combinatorial ways (Yoo et al., 2012).

Affordances are valuable for understanding DBMs because they provide the foundation for DBM expressions and benefits. Within the scope of this thesis, expressions refer to the various ways digital affordances are realized or implemented in the BM. In other words, expressions

can be considered the realized paths emerging from several potential paths made available by digital affordances (Pentland et al., 2022). Benefits denote the positive outcomes resulting from the expression of these affordances. Table 2 presents the three affordances – decoupling, disintermediation, and generativity – and, based on the literature review, illustrates potential expressions or benefits that may emerge from them. The objective of Table 2 is to highlight the distinctions between these three terms and demonstrate the logical progression from affordances to expressions, and ultimately to benefits.

Table 2: Connecting affordances, expressions, and benefits

Digital Affordance *Action potential offered by digital technologies*	**Expression** *Examples of how the affordance is realized or implemented*	**Benefit** *Examples of the positive outcomes that arise from the expression of that affordance*
Decoupling *Reduced asset specificity of digital technologies*	• Modular manufacturing systems • Reconfigurable product service systems	• Greater customization options • Increased flexibility • Improved serviceability
Disintermediation *Reduced dependency on location specific assets*	• Digital platform that connects customers and suppliers directly (direct to consumer marketing approach) • Customer co-location connecting the point of supply with the point of demand	• Enhanced control • Improved customer experience • Increased revenues
Generativity *The ability to produce unprompted change*	• Digital platform collaboration between suppliers and customers on product development • Using machine learning algorithms to improve production processes	• Enhanced product quality • Faster time to market • Improved customer engagement

In a practical sense, industrial firms do not necessarily need to know which affordance underlies a specific DBM expression. For instance, they can establish remote monitoring and control of industrial machinery without knowing that this is due to the affordance of disintermediation. However, having visibility and comprehension of digital affordances can help industrial firms develop previously unknown DBM expressions with positive impacts. This addresses one of the limitations of DBM taxonomies, which do not account for yet-to-be-discovered expressions of digital affordances. Gaining a deeper understanding of the connections between digital affordances, expressions, and benefits is crucial for fulfilling the purpose of this thesis.

2.4 Conceptualizing a theoretical framework for digital business model innovation

Despite widespread academic and industrial interest, as well as a seemingly unshakeable consensus on the merits of digital transformation (Furr et al., 2022), research on the innovation of DBMs remains in its early stages (Broekhuizen et al., 2021; Remané et al., 2022; Trischler & Li-Ying, 2022). This is unsurprising given that the focus of digital transformation efforts often progress sequentially, starting with digitization, then digitalization, and finally digital transformation towards DBMs (Verhoef et al., 2021; Verhoef & Bijmolt, 2019). Nevertheless, the relatively recent emergence of B2C digital platform BMs, such as those employed by UBER and Airbnb (Coyle, 2017; Standing & Mattsson, 2018), has coincided with a surge in DBM research publications. In other words, an emerging and expanding body of research is now addressing the most advanced conceptualization of digital transformation (Verhoef et al., 2021; Verhoef & Bijmolt, 2019).

Researchers examining industrial firms in B2B contexts have adopted the terminology of DBMs (e.g., Linde et al., 2020), often to elucidate how digital technologies are promoting the increased servitization of traditional product-centric BMs (e.g., Vendrell-Herrero et al., 2017; Chen et al., 2021b). However, despite the growing body of knowledge, numerous industrial challenges and theoretical gaps persist in our understanding of DBM innovation. For instance, while it is acknowledged that the unique characteristics of digital technologies are transforming BMs (Verhoef & Bijmolt, 2019), there is still limited understanding of the mechanisms that facilitate this change (Del Giudice et al., 2021).

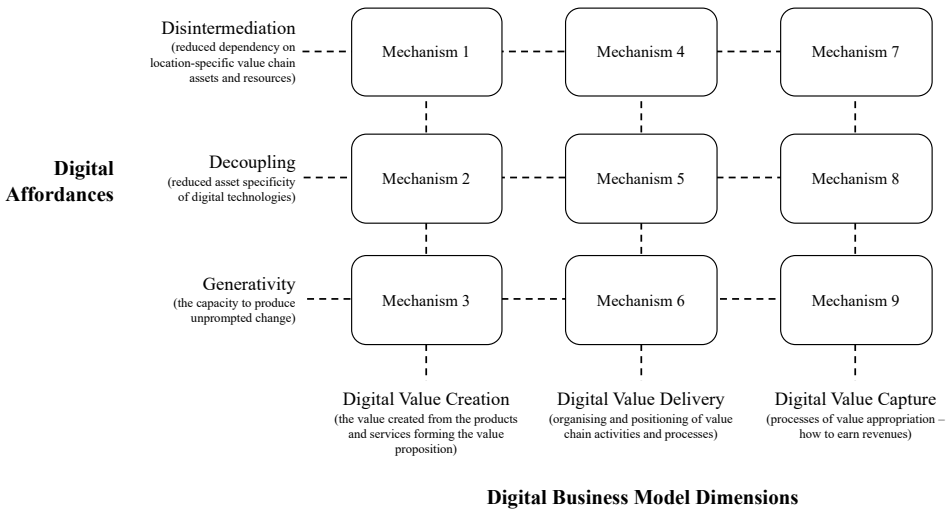

Figure 2: A theoretical framework for digital business model innovation

Drawing on the review of literature above, Figure 2 presents a theoretical framework for DBM innovation that will be employed to address the purpose of this thesis. The framework links the DBM dimensions of digital value creation, delivery, and capture to the three digital affordances: disintermediation, decoupling, and generativity. The decision to emphasize the "digital" of each DBM dimension reflects the shift from a non-digital to digital focus. The interconnection between each digital affordance and the respective DBM dimension is denoted as a *mechanism*. The DBM mechanisms relate to the enaction of digital affordances and reveal potential expressions available to industrial firms seeking to leverage digital affordances in their DBM. In the following two chapters, the methods and a summary of the appended papers conducted as part of this thesis are presented. In chapter 5, insights gleaned from the four appended papers are utilized to theorize each mechanism to address the thesis' purpose and present a conceptual framework for DBMI.

3. Research Methods

This chapter presents an overview and discussion of the research methods employed in this thesis. The chapter starts by outlining my research journey and the research context, including a description of the research project that formed the empirical foundation. Following this, supplementary research activities conducted as part of the research project and PhD education are presented. Thereafter, the philosophical positioning and approach to theory development are outlined. This is followed by an explanation of the research design, as well as case selection and data collection. The chapter finishes with a description of the data analysis and reflections on research quality.

3.1. Research journey and research context

My academic journey as a PhD candidate in the subject of Entrepreneurship and Innovation at Luleå University of Technology (LTU) began in November 2019. Several lucky orientations and reorientations between academia and industry led me here. I was initially destined for a career in aviation, having completed a Master of Aeronautical Engineering at Loughborough University in the UK. Instead, I had the good fortune of landing in a career as an engineer working with the maintenance and upkeep of nuclear submarines. However, following five formative years in various roles, I decided the time was right to upgrade my pencil case and get back to school. So, I joined a two-year Master of Industrial Management and Innovation at Uppsala University. This was nothing short of an enlightening experience that opened my eyes to many new perspectives and ideas, one being a firm belief that doing a PhD would never be for me! Instead, after two years in Uppsala I took a step into the IT industry and joined an exciting company in Stockholm where I worked as a consultant. The projects that I worked on, and environments that I worked in, fueled my interest in understanding the intersection of technology and management. Having racked up an educational and professional background in both, I had the serendipity to discover the perfect professional fit in a previously discounted place, went back on my word, and started a position as a PhD student in the DigIn (Digital Innovation of Business Models) project at LTU.

The DigIn project (part of a challenge-driven innovation program funded by Vinnova) bridges the gap between the development of novel and often advanced technology with a complementary focus on management for successful commercialization. The project aims to *develop, test, disseminate, and commercialize digital business model innovation methods in Swedish and global industrial ecosystems*. This provided the perfect opportunity for me to leverage my technical and management background from industry, alongside knowledge from my academic studies, to engage in research seeking to address contemporary industrial challenges. The DigIn project research consortium includes participation from over 50 industrial actors representing customer, provider, service partner, and digital actor perspectives from diverse industries, such as forestry, mining, and manufacturing, and it includes representation from various government authorities. Most of the industrial actors are regarded

as leaders within their industry and, in addition to being in Sweden, typically have a large international presence too. Access to and participation in this project have enabled the collection of rich data from numerous partner organizations and their business ecosystems.

From the outset of my research process, I have been engaging with industrial firms to better understand their DBMI challenges. Shaped by the ambitions of the DigIn project, initial data gathering was focused on business challenges related to industrial applications of autonomous solutions. This has formed the basis for Paper 1 and Paper 2. The first of these papers addresses the "what" in relation to DBMs and conceptualized autonomous solutions according to a business-focused maturity framework. The second paper addresses the "how", exploring the underlying processes of DBMI. Both papers take a solution provider perspective, focusing on industrial equipment manufacturers and how they innovate autonomous solutions. For example, a prominent case informing Paper 2 was the piloting of autonomous vehicles in an Australian underground mine. Despite technical successes, the provider faced challenges in scaling the BM beyond a single trial to other use cases and customers. This was a particularly interesting case opening for interviews with company representatives in different global areas of operations. I took an active role in developing the overarching concept of each of the papers together with my co-authors. I was also the lead in writing the original drafts of the manuscripts, was heavily involved in data collection activities as part of conducting the investigation, and I led the formal analysis of data and visualization of results. Finally, I was responsible and took the lead in writing the reviewed versions of the manuscripts and conducting the final editing. Paper 1 was presented at the Spring Servitization Conference in 2020. Paper 2 was presented at the same conference, but in 2021.

In the spring of 2021, I began working on Paper 3. This is a sole authored paper that was borne out of a desire to manage the entirety of the research process independently, explore the utility of podcasts as a secondary source of data, and pursue a personal curiosity of vertical farming. The paper explores the ways in which new technology-based firms (NTBFs) – in this case vertical farming producers – leverage the value from digital technologies in their BMs. Exploring this alternative type of organization and the ways in which they engage in DBMI was not only interesting on a personal level but also provided valuable insights from what can be considered digital frontrunners. Opting for the use of secondary data in the form of podcasts enabled me to conduct my own data collection in parallel to the DigIn project activities and resolved the issue of not having my own funding. Despite being the sole author of this paper, I benefitted from contacts internally within the research group that connected me to a local vertical farming start-up in Luleå. Furthermore, I received valuable support and feedback from one of my colleagues in the process of developing the manuscript. Drafts of the manuscript were presented at the NORSI (Nordic Research School in Innovation and Entrepreneurship) annual conference in Oslo in 2022, as well as an ScAIEM (Scandinavian Academy of Industrial Engineering Management) workshop in Uppsala in 2022.

Paper 4 includes customers of firms from Paper 1 and Paper 2 and studies digital transformation from a resource orchestration perspective. A consistent theme throughout many of the interviews that I have conducted as part of this thesis is the development of firm-specific digital

platforms as part of efforts to digitally transform. The industrial challenges associated with the development and implementation of digital platforms, therefore informed the framing of the study. A personal motivation behind this choice was to learn more about the ways in which industrial firms manage their resources in support of digital transformation, something that has typically been overlooked in earlier studies. One of the cases informing the study centers on an international mining company developing a common and enterprise-wide digital platform. The intent of the platform is to connect different areas of the mining operations in support of a digital transformation towards increased data-driven decision making and mine site automation. Gaining a better understanding of both the technical and organizational challenges in supporting this transformation was particularly interesting, revealing path dependencies and politics to be important factors shaping transformation efforts. Similar to paper 1 and paper 2, I took a leading role in shaping the conceptual development of the paper together with my co-authors. I was also the lead in writing the original drafts submitted for review, data collection activities, formal analysis of data, and visualization of results. I have also been responsible for writing the reviewed version of the manuscript including the final editing. In total, I have conducted 72 interviews across 15 organizations as part of the data collection efforts for Papers 1, 2, and 4.

The final step on my PhD journey has consisted of producing this kappa. The positioning of it to focus on DBMI is driven by the experiences and insights gained from working together with the DigIn project industrial partners, the perceived shortcomings of the extant literature dealing with DBMs, and a personal interest in exploring this nascent topic. Instead of pursuing a more conventional synthesis of my research findings, which would have led to a broader thesis encompassing BM piloting and resource orchestration for digital transformation, I have striven to create a more focused "meta-article". This approach draws on my earlier studies and the literature on digital affordances, with the purpose of contributing a novel conceptual framework and understanding of DBMI. Seeking to contribute new insights has undoubtedly increased the complexity and challenge of producing this kappa. However, the opportunity to reflect on the experiences and insights gained over the past three years and using these to theorize novel concepts and relationships has been an enjoyable and fitting conclusion to my PhD studies.

3.2. Supplementary research activities

Alongside typically expected research activities, such as engaging in the writing and publishing of papers, conducting a PhD involves numerous other tasks. This is especially the case when conducting research as part of a challenge-driven innovation project such as DigIn. A key responsibility which I have had as part of the DigIn project has included engagement with the partner organizations, extending over and above more typical data collection activities. A central aim of this engagement has been to report back academic insights to the participating companies from the interviews that have been conducted, thereby shedding light on the industrial cases being investigated. This mutual exchange of value – interview data from the companies, insights from us – has been an important dynamic contributing to the success of the DigIn project. Academic insights have typically been delivered via a PPT report and presentation defining the industrial challenge being investigated, the reflections of the interviewees regarding this challenge, and our own insights and reflections for better

understanding them. The reports could extend from 10 to 50 slides long, with each taking somewhere between 10 to 80 hours to prepare. In total, I was the lead in preparing six academic insight reports for five different partner organizations. These reports were presented by me and the DigIn project leader to key contacts at the companies, and where requested, a broader group of representatives. For example, in collaboration with the vice president of Digital Business at an industrial equipment manufacturer, we engaged in an extensive research study exploring the innovation of autonomous solutions. The study included interviews with 26 senior representatives from the case company and partner organizations and focused on the challenges of BM scaling. Following completion of the study interviews and development of an academic insight report, I presented the study findings to the Vice President of Digital Business. Deemed relevant for the broader organization, we were subsequently asked to conduct a strategic dissemination to other senior managers at the industrial equipment manufacturer. Consequently, I presented a condensed version of the study findings to 15 senior managers with the aim of stimulating further engagement in the topic, sharing of knowledge, and feedback on our insights. Alongside the intent of establishing effective working relationships and supporting the research project aims, the delivery of academic insights has served as a sensemaking exercise, and it has supported validation of the frameworks developed for Papers 1, 2, as well as key ideas related to Paper 4.

In addition to the academic insight reports described above, I hosted an online webinar titled "Making sense of business models in the era of digitalization – a webinar for practitioners" in November 2020. This webinar was delivered in parallel to the development of Paper 1 and 2. The webinar was intended to be less company specific than the more typical academic insight reports and to extract more general insights related to the work of the DigIn project. The webinar concept and material were developed by a PhD colleague and me. In total, 69 people attended the webinar, including representatives from Vinnova, LTU Business, senior industry representatives, academia, and Regeringskansliet.

Somewhere in-between the production of Paper 3 and Paper 4, I become involved in planning activities for a DigIn project process industry workshop held in May 2022 at Fotografiska in Stockholm. The purpose of the workshop was to explore the theme of transforming towards a data-driven organization in the process industries. My responsibilities included managing workshop logistics, designing workshop themes, external and internal communication, and supporting facilitation on the day. The workshop included representation from 18 different organizations with approximately 42 participants. Bringing together a diverse range of process industry actors sharing insights on becoming a data-driven organization supported valuable discussions between participants and attending researchers. Overall, the workshop was regarded as a success and supported the intent of the academic insight reports and online webinar in strengthening co-operation between the DigIn project and industrial partners.

Despite taking a prominent position due to the challenge-driven nature of the DigIn research project, industrial firm deliverables account for only one part of the activities completed in my PhD. Over the course of 3.5 years, I have had an average teaching load of 20% – or 1,174 hours. This has included being jointly responsible with a PhD student colleague for the development

of a new course in *Industrial Organization*. We designed the course from the ground up and, for the past two years, I have had a leading role in delivering and further improving the course. I have had joint development responsibility for a new course titled *Artificial Intelligence and Business Development.* I have lectured and led seminars for the past two years in *Organisation och Ledning* (Organization and Management), hosted seminars in *Innovation & Strategic Business Development*, and more recently delivered guest lectures in *Introduction to AI*.

The PhD includes a total of 80 credits, which I have read across subject specific, methodological, pedagogical, ethics and philosophy of science courses. I was elected PhD student representative for the department of Social Sciences, Technology, and Arts, and held this position for the duration of the spring term 2020 with a commitment of 10% of my time. I have also been involved in two rounds of PhD student recruitment. In the first round, I developed and coordinated the position announcement, filtered candidates, coordinated administrative documents, and presented a shortlist to the subject chair. In the second round, I took a more active role by, in addition, designing and facilitating a recruitment day with various assessment activities.

In summary, completion of research and supplementary activities described above have been an important component in meeting the targets for the degree of doctor. In the sections which follow, I describe the research methods employed in this thesis.

3.3. Philosophical positioning and approach to theory development

Despite the central importance of research philosophy in determining what represents "truth" (Easton, 2010) or "practical adequacy" (Sayer, 1992), it's selection is rarely a deliberate and pre-informed choice but rather something that happens by default (Hughes & Albers, 2011; Saunders et al., 2016; Sayer, 1992). However, there is a need to be able to reflect upon and articulate a position on the research philosophy that is followed. Regardless of whether it is intentionally followed or not, research philosophy has important implications for the methodological techniques employed in collecting and interpreting information (Sayer, 1992).

This thesis follows the philosophical positioning of critical realism. In doing so, it adds to a large body of qualitative research that has adopted critical realism's underlying assumptions and methods but that often do so without making explicit statements for their positioning (Hughes & Albers, 2011). Critical realism takes "an ontological position of realism (there is a world that exists independently of our perceptions, theories, and constructions) while accepting a form of epistemological constructivism and relativism (our understanding of this world is inevitably a construction from our own perspectives and standpoint)" (Hughes & Albers, 2011, p. 5). As a consequence, critical realism straddles seemingly contradictory views by simultaneously accepting existence of an objective reality independent of our knowledge of it but also accepting that this reality is, at least in part, socially constructed (Easton, 2010; Sayer, 1992). Critical realism, therefore offers a philosophical middle ground between the law-like generalizations of positivism, and the general rejections of interpretivism to determine causality (Easton, 2010). This middle-ground position reflects a generally accepted and commonly held

understanding of the world, both in everyday life and within the social sciences (Easton, 2010; Sayer, 2000).

There are several implications for this thesis in following critical realism. First, critical realism is recognized as being compatible with a range of different research methods (Easton, 2010; Sayer, 2000). For example, researchers can engage in either intensive (situated in a specific context e.g., ethnography) or extensive (seeking regularities and patterns across populations e.g., large scale surveys) inquiries (Sayer, 2000). Of particular importance for this thesis, critical realism has been identified as being well suited to the conduct of case study research (Easton, 2010). Critical realism is suitable for case study research because it "justifies the study of any situation, regardless of the numbers of research units involved, but only if the process involves thoughtful in depth research with the objective of understanding why things are as they are" (Easton, 2010, p. 119). Second, the critical realist perspective recognizes that the collection and analysis of data will always be imperfect and flawed with inherently biased researchers (Saunders et al., 2016; Sekaran & Bougie, 2013). However, attempts should be made to strive towards the ideal of truth through good research practice whilst, at the same time, recognizing this is ultimately an unobtainable ideal. Researchers following a critical realist perspective would, therefore, typically seek to use "triangulation across multiple flawed and erroneous methods, observations, and researchers" (Sekaran & Bougie, 2013, p. 30), as is commonly done in case studies (Yin, 2018). Finally, critical realism is *critical* of the ability of researchers to understand the external world with certainty (Sekaran & Bougie, 2013). Indeed, realists recognize that certain or "objective" knowledge of the world is not possible, and that there is the potential for alternative accounts of the same phenomena (Hughes & Albers, 2011). To develop analytical generalizability of theory, critical realists, therefore seek to establish a deep understanding of the phenomena under study and develop explanations that are consistent with the data (Easton, 2010).

The thesis adopts an abductive approach to theory development. This is closely aligned with the critical realist mode of inference, retroduction (Easton, 2010). Retroduction moves iteratively between theory and data and employs both deductive and inductive cycles of data collection (Easton, 2010), as with abduction (Dubois & Gadde, 2002). An abductive approach is well suited to address the purpose of this thesis, supporting in the identification of themes and explaining patterns in search of new theory, or the modification of existing theory (Saunders et al., 2016).

3.4. Research design

"The key to good research lies not in choosing the right method, but rather in asking the right question and picking the most powerful method for answering that particular question" (Bouchard T. J., 1976, p. 402).

This thesis adopts a qualitative approach in addressing the overarching research purpose to *conceptualize the innovation of digital business models.* Qualitative approaches are typically favored over quantitative when studying relatively new topics that lack established theorizing (Hair et al., 2007), as is the case with the relatively nascent theoretical stage of research on DBMs and digital transformation (Broekhuizen et al., 2021; Remané et al., 2022; Trischler & Li-Ying, 2022). Indeed, despite a growing number of research contributions, it is still unclear how industrial firms digitally transform (Warner & Wäger, 2019; Verhoef et al., 2021), or how they engage in DBMI (Foss & Saebi, 2018; Trischler & Li-Ying, 2022).

Closely connected to the choice of pursuing a qualitative or quantitative research approach is the decision whether to adopt an exploratory, descriptive, or causal design (Hair et al., 2007). In the context of this thesis, a qualitative exploratory research approach is determined as being most suitable. The intent of exploratory research is to discover new relationships or ideas, rather than test pre-existing hypotheses (Hair et al., 2007). This is compatible with the overarching purpose of this thesis to explore a novel topic that lacks theorizing. Exploratory designs are typically characterized by research questions that seek to address the "what" or "how" of some issue or phenomenon (Saunders et al., 2016). This corresponds well with the intent of this thesis to *conceptualize the innovation of digital business models,* and it can also be seen in the research questions guiding the four appended papers. For example, "*How can industrial equipment manufacturers align the development of technology, business models and ecosystem relationships for the advancement of autonomous solutions?*" (Paper 1), "*How do manufacturers engage in business model piloting for autonomous solutions"* (Paper 2), "*How can NTBFs innovate their business models to leverage the value from digitalization?*" (Paper 3), and "*How do industrial firms orchestrate resources and leverage capabilities for the digital transformation of production operations?"* (Paper 4). Seeking to address questions of "what" and "how" related to DBMI, a nascent literature stream with limited prior insight lends itself to a qualitative and exploratory research approach as the most promising way to increase understanding of this area (Stebbins, 2001).

Having determined a qualitative exploratory research approach as being the most coherent way to address the thesis purpose, the next methodological decision relates to the selection of an appropriate research strategy. A research strategy is defined as the plan for how a researcher intends to answer the chosen research question (Saunders et al., 2016). There are various research strategies to choose from, including but not limited to: experiments, surveys, archival and documentary searches, case studies, ethnographies, action research, and narrative enquiry (Saunders et al., 2016). The choice of research strategy is guided by the pursuit of coherence with the particular research question or overarching purpose being addressed, as well as practical considerations, such as access to potential participants, other forms of data, and the

available time (Saunders et al., 2016). The first two strategies listed above – experiments and surveys – were not considered for this thesis due to their predominant usage in quantitative research design. Of the remaining strategies, the usage of case studies has been determined as the most coherent and suitable choice for Papers 1, 2, and 4. Furthermore, multiple case studies were chosen over single case studies for each of these papers. This was not with the intent to conduct formal cross-case analyses but rather to aggregate insights and support comparisons between the journeys taken by different firms. Case studies were selected because they are particularly suited to the conduct of exploratory research seeking to gain in-depth insights of theoretically novel and contemporary phenomena where the boundaries to the surrounding context are unclear (Edmondson & Mcmanus, 2007; Eisenhardt & Graebner, 2007; Yin, 2018), making it particularly suited to studying the innovation of DBMs. However, a case study research strategy also has some disadvantages. Case studies provide the researcher with a large quantity of empirical evidence, rooted in an attempt to observe and understand the specific context of the case. This has the potential to inundate the researchers and lead them to develop overly complex theories, or establish inconsequential relationships that only relate to the particular case being studied (Eisenhardt, 1989). Another perceived weakness of case study research is the lack of thoroughness when applying the methodology, with a risk of sloppiness, unsystematic procedures, and ambiguous evidence leading to a perceived lack of rigor (Yin, 2018). Mitigating these weaknesses involves the application of a rigorous data analysis, which is outlined later in this chapter.

Paper 3 takes an alternative approach to the other three papers, opting for a research strategy of archival and documentary search (Saunders et al., 2016). As a sole-authored paper, the change in research strategy was guided principally by practical considerations. Producing a sole-authored paper without having access to an independent research project required an alternative strategy that could be realized outside the bounds of DigIn. Opting for the strategy of archival and documentary search prioritized access to and analysis of publicly available information. The ease and speed of access to the empirical material of study – in this case, podcast episodes – was the key factor in selecting this strategy (Glaser & Strauss, 1967; Saunders et al., 2016). Although being efficient, a weakness of this strategy is that the sourced documents were not created for the purpose of addressing the research study aims (Saunders et al., 2016).

In terms of the time horizon, a choice needed to be made on whether to perform cross-sectional or longitudinal studies (Saunders et al., 2016). Despite the benefit of longitudinal studies supporting a time-based analysis of development, a cross-sectional study approach has been adopted for each of the thesis papers principally for two reasons. First, the overarching purpose of the thesis does not explicitly seek to explore a process view of DBMI. This is reflected in the research questions for each of the papers relating to the study of a particular phenomenon whilst being agnostic to time (Saunders et al., 2016). For example, the research question in Paper 2, "*How do manufacturers engage in business model piloting for autonomous solutions",* does not make explicit reference to time as something that needs to be addressed in the study. Second, although not impossible, the nature of working within a challenge-driven innovation project, requiring engagement with numerous firms on firm specific studies, did not lend itself to the employment of a longitudinal study. Instead, engagement with fewer firms over a longer period

would have been more conducive to the development of studies exploring a longitudinal perspective.

In summary, the research approach for each of the papers can be subdivided into two groups. This thesis includes three qualitative, exploratory, cross-sectional, multiple case studies (Papers 1, 2, and 4), and a qualitative, exploratory, cross-sectional, archival, and documentary search (Paper 3).

3.5. Case selection and data collection

Papers 1, 2 and 4 are situated within the bounds of the Vinnova-funded DigIn research project. The aim of the project is to *develop, test, disseminate, and commercialize digital business model innovation methods in Swedish and global industrial ecosystems*. The participation of over 50 industrial actors in this project provided a large pool of willing and committed representatives where relevant cases for study could be identified. This provided several advantages. Firstly, being the third and final stage of the DigIn research project, working relationships with key contacts at each of the companies had already been established. This greatly simplified the identification and contact with key individuals in support of each of the studies. Furthermore, the company contacts were committed to the DigIn project and were often already aware of its intended aims. Communicating the intent of subsequent interviews and convincing them of their relevance was, therefore, made easier. Finally, selection of industrial actors for inclusion in the DigIn project acted as a pre-filter on the suitability of their inclusion in the studies conducted as part of this thesis.

Cases were selected from the DigIn consortium of industrial actors through theoretical sampling to align as closely as possible with the purpose of each study (Eisenhardt & Graebner, 2007). The reason for selecting theoretical sampling over alternatives such as critical case, or typical case sampling, is that it is better suited to informing emergent theory (Eisenhardt & Graebner, 2007; Saunders et al., 2016). This is because cases are specifically chosen as illuminating examples (Eisenhardt & Graebner, 2007). The case selection criteria were informed by the purpose of the research study, including the associated research questions. The methods sections of the papers provide further detail on the selection criteria, and the cases that were selected.

Data collection for Papers 1, 2 and 4 was principally conducted through individual semi-structured interviews with informants from the selected case companies and their ecosystem partners. Semi-structured interviews provide several important advantages that led to their selection. Firstly, they cohere with the overarching purpose of the thesis and the exploratory research approach, where there are complex and open-ended questions that need to be answered (Saunders et al., 2016). Indeed, the complexity and abstract nature of the issues being covered in each of the papers strengthens the case for conducting interviews that are better able to address questions of "why" or "how" (Yin, 2018). Observations, for example, would not be the most effective way to gather data capable of addressing conceptual questions such as "How would you describe the impact of digitalization on your business model?". Additionally,

structured interviews relying on questionnaires lack the flexibility required to adapt the order or type of interview question based on the interviewee's response. For example, when I was conducting interviews on the theme of digital transformation with senior managers at a process industry actor, several respondents raised trust as being an important factor in supporting change. Using semi-structured interviews as the data collection approach supported deviation from the pre-prepared interview questions to further explore trust as a relevant theme to the study.

For each of the papers, lead contacts at the industrial firms provided the entry point for data gathering, assisting in the identification of additional informants actively involved in the object of study. Supporting the development of a broad and multifaceted view of the area of study, the selection of informants was made to include various functional roles and different levels of seniority within the firms. Interviewing a functionally diverse group of individuals provided an opportunity to explore the intricacies of DBMI from differing perspectives and provide alternative views on the area of research. The semi-structured interviews were supported through the development of interview protocols. The interview protocols were updated as the interviews progressed for each of the studies, enabling us to pursue interesting deviations to the originally intended lines of questioning and complement our data (Eisenhardt, 1989). Initial questioning tended to focus on establishing a more general understanding of the case under study, asking the interviewee questions such as, *How are you involved in the delivery of...? What do you perceive to be the greatest challenge...?* When it became clear that a certain feature of the case was particularly important and relevant in advancing our understanding, the interview protocol would be updated. For example, an iteration between the first and second versions of a protocol used in Paper 2 shifted the focus from developing a more general understanding of autonomous solution BMs (e.g., *How would you define the value proposition that you are offering?*) to seeking a better understanding of how the firms engage in BMI (e.g., *How do you work within the organization to conceptualize and test new BM opportunities?*). Asking open-ended questions was an important aspect that helped to uncover and reveal novel and unexplained relationships (Edmondson & Mcmanus, 2007). This is advantageous for studying novel and contemporary phenomena, such as industrial firms engaging in advanced instances of DBMI, where there is little prior insight (Stebbins, 2001). In all instances, the interviews were recorded and professionally transcribed for analysis. To develop a deeper case understanding, the semi-structured interviews were complemented by secondary data sources, such as company presentations and publicly available online material (Yin, 2018).

Paper 3 diverges from the research approach of the other papers. The study relies on a novel source of data collection by drawing on publicly available interviews originating from podcast episodes. Despite being unconventional, secondary data represent one of the numerous and under-valued sources of data that researchers can use (Bryman & Bell, 2015; Corbin & Strauss, 1990; Glaser & Strauss, 1967). Selecting podcasts as a secondary source of data provided several important advantages. In addition to ease and speed of access (Saunders et al., 2016), podcast data had the additional benefit of providing access to globally diverse insights from leading industry experts, academia, founders, and executive management from a broad range of organizations in the vertical farming industry. This provided a functionally diverse group of

individuals presenting different perspectives on the topic of study, enabling the analysis of alternative views related to the area of research. Finally, a unique feature of using podcast episodes is that the podcast host often embodied the role of a well-informed research assistant who was well read on the subject and supported insightful discussions. This provided a rich source of secondary data to analyze.

Data was selected in accordance with its theoretical utility in answering the research question (Glaser & Strauss, 1967). The podcast episodes were selected from online searches of podcasts containing the terms “vertical farm”, “indoor agriculture”, and “urban agriculture”. For each of the producers and suppliers identified from the podcast search, data were principally collected from podcast episodes from which they were sampled and supplemented by data obtained from company websites and news articles. The podcasts covered themes such as manufacturing processes employing the Industrial Internet of Things (IIoT), and new approaches to value delivery enabled by vertical farming BMs. Themes such as these were relevant to the study’s research question because they revealed how the value from digital technologies are leveraged through the innovation of DBMs. In total, 50 podcast episodes were included as part of the data collection for this study with an average duration of 49 minutes.

Table 3 provides an overview of the papers and a summary of the research methods for each.

Table 3: Overview of the four papers and their research methodology

	Paper 1	Paper 2	Paper 3	Paper 4
Title	A maturity framework for autonomous solutions in manufacturing firms: The interplay of technology, ecosystem, and business model.	Business model piloting for autonomous solutions: An experiential learning process for business model innovation.	Leveraging the value from digitalization: A business model exploration of new technology-based firms in vertical farming.	Resource orchestration to realize the potential of industrial digital transformation: Leveraging capability configurations.
Status	*Published*. International Entrepreneurship and Management Journal.	*Working paper.* Second round of review at a peer-reviewed academic journal.	*Published*. Journal of Manufacturing Technology Management.	*Working paper.* Submitted for peer-review at an academic journal.
Purpose	To investigate how industrial equipment manufacturers can align the development of technology, business models, and ecosystem relationships for the innovation of autonomous solutions.	To advance understanding of how industrial manufacturers engage in business model piloting for autonomous solutions.	To explore how new technology-based firms (NTBFs) can overcome established notions of scale and scope through business model innovation, which leverages the value from digitalization.	To explore how industrial firms manage their resources to create cross-functional capabilities for digital transformation.
Research approach	Qualitative, explorative, cross-sectional, multiple case study.	Qualitative, explorative, cross-sectional, multiple case study.	Qualitative, explorative, cross-sectional, archival, and documentary search.	Qualitative, explorative, cross-sectional, multiple case study.
Case(s)	4 industrial equipment manufacturers and ecosystem partners.	2 industrial equipment manufacturers.	16 vertical farming producers, 21 vertical farming suppliers.	3 process industry actors and 3 digital suppliers.
No. of interviews	32	32	50	42
Data sources	Semi-structured interviews, supplementary secondary data.	Semi-structured interviews, supplementary secondary data.	Secondary interviews (podcast episodes), supplementary secondary data.	Semi-structured interviews, supplementary secondary data.

3.6. Data analysis

The data analysis for the papers followed a similar approach where the collected data was coded for themes via a thematic analysis (Braun & Clarke, 2006). Thematic analysis was chosen due to its ability to support analysis of large quantities of data from different sources in the development of new theory (Saunders et al., 2016). This aligns well with the overarching purpose of this thesis to *conceptualize the innovation of digital business models*. Supporting the thematic analysis, a data structure inspired by Gioia and colleagues consisting of first-order codes, second-order categories, and aggregate dimensions was produced for each of the papers (Gioia et al., 2013). The Gioia approach to data analysis is particularly relevant for exploratory research as it supports originality in theorizing by departing from existing constructs and developing new concepts (Gioia et al., 2013). By treating industrial firm informants as "knowledgeable agents" and placing value on their interpretations and understanding of organizational reality, the potential development of novel insights and concepts is improved

(Gioia et al., 2013). Aided by an analytical approach of systematic combining, moving back and forth between empirics and theory to converge on a model of best fit (Dubois & Gadde, 2014), the adopted research approach supported identification of novel and interesting patterns in large and complex data sets (Gioia et al., 2013). The data analysis broadly followed a three-step process.

The first step of the analysis began with an in-depth review of the study data (e.g., transcripts from interviews). The intent of this first step was to become familiar with the data (Saunders et al., 2016). To do this, I read and re-read the interview transcripts thoroughly, and highlighted key terms, phrases, and initial ideas that were interesting in the text. Each highlighted segment was provided with a coded description to symbolize or extract the segment's meaning (Saunders et al., 2016). For example, the statement, "*We are so driven by machines. It's very hard to conceptualize and think about anything else*" from an interview supporting Paper 2, was coded "challenge to conceptualize". Thereafter, similar data were provided with the same code, or alternatively a new one if the meaning of the data was different. The coding exercise established first-order categories reflecting the views of the informants in their own words. Microsoft Excel, and later MAXQDA coding software, was utilized to support the review and analysis of data when generating the first-order codes. In parallel to the coding, existing literature connected to the area of study was reviewed to support the discovery of new insights (Gioia et al., 2013). This is representative of the back-and-forth movement between empirics and theory characterized as systematic combining (Dubois & Gadde, 2014). The next step included a review of the first-order categories to detect links and patterns. The large number of first-order codes (typically numbering into the hundreds) are then distilled into a more manageable number (typically numbering between 10 and 30) of abstracted first-order codes by looking for similarities and differences. Following the development of first-order codes, second-order themes that represent theoretically distinct concepts to bridge first-order empirics with theory were developed. Second-order themes are, therefore, connected to the empirics of the study whilst, at the same time, connected to theory. Finally, aggregate dimensions building on the second-order themes were theorized. Aggregate dimensions represent the highest level of abstraction and build on the second-order themes developed in the preceding step. At the end of this process, a data structure explicating the first-order codes, second-order themes, and aggregate dimensions is produced. Figure 3 taken from Paper 2 shows a typical example of a data structure. The intention of the data structure is to facilitate and demonstrate rigor in the data analysis by making explicit connections between the first-order empirics and the aggregate dimensions, which, in part, represent the findings of the study.

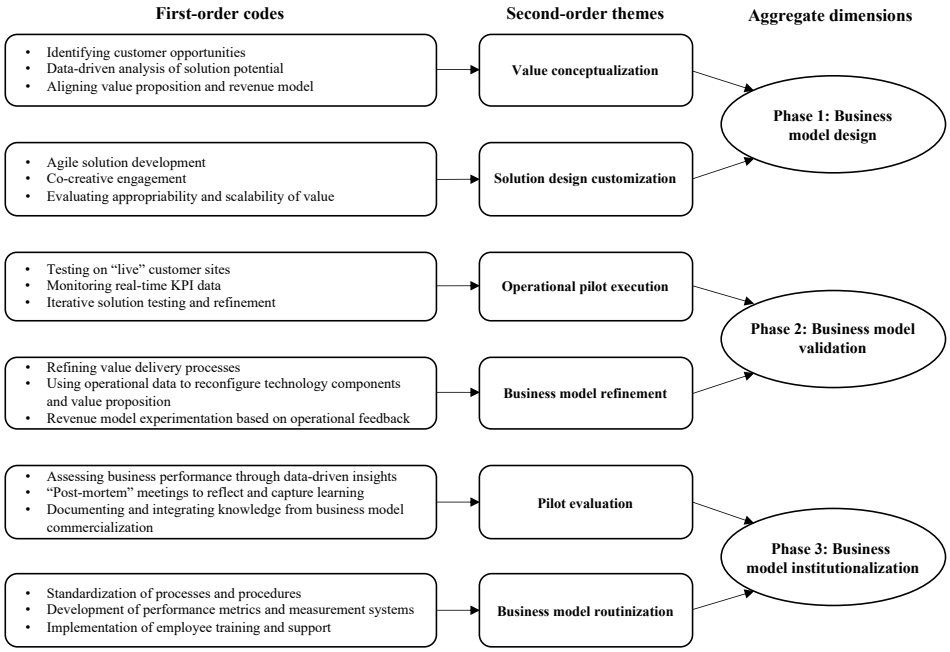

Figure 3: Data Structure Example

3.7. Reflections on research quality

Research quality is often assessed against four criteria; reliability, construct validity, internal validity, and external validity (Yin, 2018). Whilst originating from quantitative research, adaptation of the measures to make them less rigid and more applicable to qualitative work is recognized as an effective way of assessing research quality (Saunders et al., 2016; Yin, 2018).

Reliability relates to the replication or repeatability of a study. Studies deemed reliable should in theory achieve the same results if performed by another researcher following the same steps and procedures as detailed in the methodology (Yin, 2018). In practice, this is recognized as being difficult to achieve, yet good documentation that makes the research methodology explicit is seen as an important way of improving reliability (Yin, 2018). Attempts to strengthen the reliability of the four studies include step-by-step explanations of the research approaches. This is aided by the inclusion of a data structure detailing the connections between first-order empirics and aggregate dimensions. Indeed, one of the driving forces behind the development of the approach of Gioia and colleagues was criticism from reviewers that qualitative research failed to meet the required standards and rigor more typically associated with quantitative work (Gioia et al., 2013). Inclusion of a data structure, and description of the development of its different stages, provides a more structured approach and improves reliability. An additional measure to improve reliability included the development of interview protocols (Yin, 2018).

These measures aid in providing a thorough description of the research and improve the repeatability of the study (Saunders et al., 2016).

Construct validity has been referred to as the trustworthiness of research (Yin, 2018). The major issue which construct validity seeks to address is the potential for value-laden judgements of researchers when collecting and analyzing data (Yin, 2018). The principal way in which construct validity has been addressed is through the collection of multiple sources of data (Yin, 2018). For example, instead of solely relying on interviews, secondary data in the form of company reports or presentations have been included in the studies. This has supported triangulation of the findings across different data sources (Miles & Huberman, 1994). Moreover, construct validity has also been addressed by attempting to establish clear chains of evidence, which enable the reader to see how the results of the study have been reached from the data (Yin, 2018). Additionally, all the authors were involved in the analysis of data for Papers 1,2, and 4, improving construct validity through back-and-forth discussions of the most suitable concepts and measures related to the data.

Internal validity is about attempting to establish causal relationships between different variables and is, therefore, only used in explanatory or causal studies (Yin, 2018). As the studies included in this thesis are exploratory, this form of validity does not apply.

External validity relates to the generalizability of a study's findings beyond the context of the study (Yin, 2018). One of the principal tactics for enhancing external validity is through a replication logic using multiple case studies (Yin, 2018). This approach was adopted in three of the four papers included in this thesis. However, generalizing a study's findings to a broader population is challenging. This thesis instead focuses on analytical generalization, which refers to the ability to generalize from data to theory. Analytical generalization goes beyond the specific context of the case to focus instead on what can be learned at a more abstract level from the case, and how this relates to theory, rather than attempting to draw conclusions at the level of a population (Yin, 2018). For example, analytical generalizations on the leveraging of digital value drivers from Paper 3 can benefit industries other than vertical farming where the characteristics of the setting are similar (Saunders et al., 2016). However, the small sample size means that no generalization on a statistical basis can be made to a broader population (Yin, 2018).

4. Summaries of Appended Papers

This chapter summarizes the four appended papers. Together, the findings of the papers contribute to fulfilling the overall purpose of the thesis. The chapter briefly presents the research gaps, the research purpose, and the key findings from each paper.

4.1. Paper 1

Thomson, L., Kamalaldin, A., Sjödin, D., & Parida, V. (2021). A maturity framework for autonomous solutions in manufacturing firms: The interplay of technology, ecosystem, and business model. *International Entrepreneurship and Management Journal,* DOI:10.1007/s11365-020-00717-3

Significant advancements within the fields of digitalization, electrification, and automation have enabled the development, testing, and implementation of increasingly advanced autonomous solutions. Current examples of industrial automation promise significant economic and sustainability-oriented benefits for industrial customers. Yet, implemented autonomous solutions have rarely advanced beyond "islands of autonomy". Although the efficiency and effectiveness of specific processes have been improved, the systemic improvements that fully autonomous solutions can achieve have not yet been realized. It is becoming increasingly clear that the major challenges in this shift extend beyond technology to focus on the development of new BMs and ecosystem relationships. Yet, extant research offers few insights into these domains.

Specifically, three research gaps have been identified. Firstly, there is a need to consider all the BM elements for advancing to higher levels of autonomous solution maturity. Prior research has identified the importance of alignment between value capture, value delivery, and value creation. Yet this is under-explored in the context of autonomous solutions. Secondly, there is a need to extend the understanding of autonomous solutions beyond the boundaries of a single firm to incorporate an ecosystem perspective. The increased levels of system integration required to deliver autonomous solutions require an ecosystem approach that leverages the capabilities and resources of different partners. Yet, it is not clear how the ecosystem configuration changes with varying levels of autonomous solution maturity. Finally, there is a need for a maturity framework to advance understanding of how firms can successfully develop and commercialize autonomous solutions, taking into consideration the alignment between technological, ecosystem, and BM perspectives. Current classifications of autonomous solutions in the digital servitization literature fail to capture the significant nuances between solutions at varying levels of technical complexity and purpose of application.

As such, the study investigates how industrial equipment manufacturers can align the development of technology, BMs, and ecosystem relationships for the innovation of autonomous solutions. The paper builds on an exploratory multiple case study with 32

interviews from four industrial equipment manufacturers and their extended ecosystem of partners.

The study contributes by developing a maturity framework for autonomous solutions that captures the dimensions of *technology development*, *ecosystem configuration*, and *business model design* across three levels of maturity (level 1: operator assistance, level 2: semi-autonomous operation, level 3: fully autonomous operation), see Figure 4. By emphasizing the important interplay between these three dimensions for successful commercialization, the study contributes to the literature on digital servitization, and to a business-oriented definition of autonomous solutions.

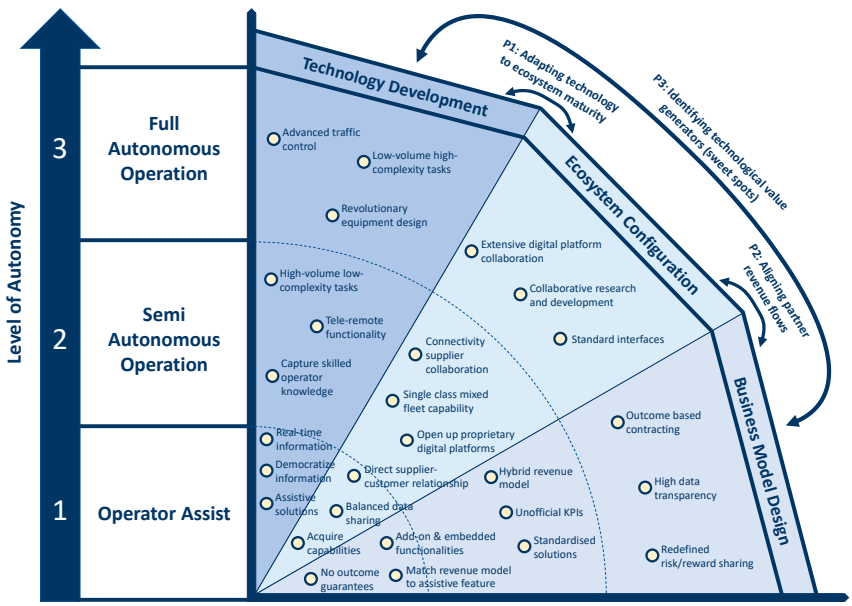

Figure 4: A maturity framework for autonomous solutions

4.2. Paper 2

Thomson, L., Sjödin, D., Parida, V., & Jovanovic, M. (202X). Business model piloting for autonomous solutions: An experiential learning process for business model innovation. *Second round of review in a peer-reviewed academic journal.*

Traditional manufacturers are increasingly adopting digitalization to enhance customer value and gain a competitive edge through business model innovation (BMI) (Hanelt et al., 2021; Opazo-Basáez et al., 2022; Paiola & Gebauer, 2020; Sorescu, 2017). A prominent example of this shift is the development of autonomous solutions, which represent a sophisticated

application of digital technologies in product-centric BMs (Leminen et al., 2022; Sandvik et al., 2021). Nevertheless, industrial manufacturers face significant challenges when innovating BMs for autonomous solutions. First, they must adapt their approaches to create, deliver, and capture value while learning about emerging autonomous solutions (Baines et al., 2017; Sandvik et al., 2021; Schroeder et al., 2020). Second, manufacturers need to configure unique combinations of digital technologies to meet customer requirements, necessitating new coordination strategies within the organization (Desyllas et al., 2022). Last, scaling successful solutions from initial pilot cases demands knowledge sharing across different organizational units (Berends et al., 2016).

Set against this background, the purpose of the study is to advance understanding of *how industrial manufacturers engage in business model piloting for autonomous solutions.* The study is situated in the dynamic context of industrial vehicle manufacturers engaged in digital servitization at the most advanced level to develop and commercialize autonomous solutions (i.e., self-driving industrial vehicles). The study seeks to address this through an exploratory multiple case study including 32 interviews with senior managers from two global industrial equipment manufacturers.

As a contribution to the BM literature, the study presents a BM piloting framework for autonomous solutions, see Figure 5. The framework consists of three phases: business model design, business model validation, and business model institutionalization. In each phase, key activities promote an iterative, incremental, and learning-oriented BMI process. Three critical principles for successful BM piloting are identified: frugal learning, systematic evaluation, and scalability testing.

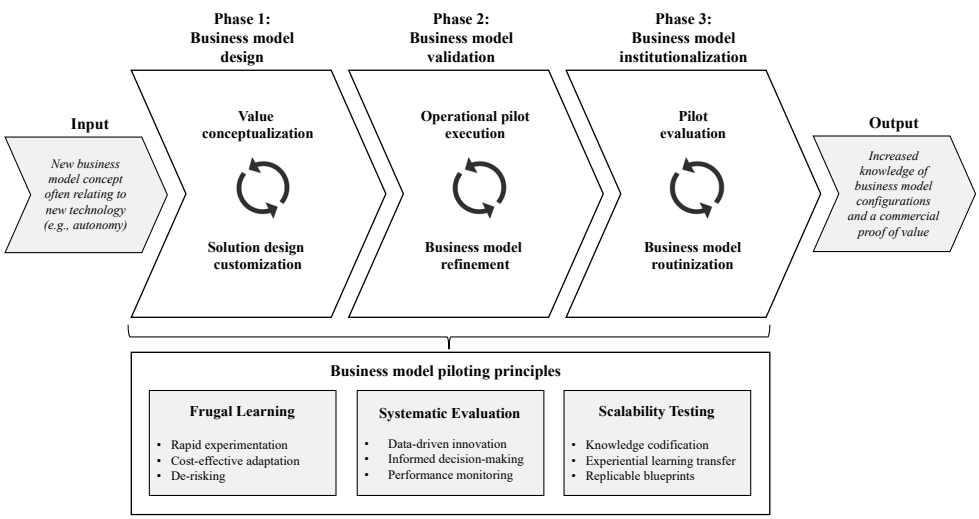

Figure 5: A business model piloting framework for autonomous solutions

4.3. Paper 3

Thomson, L. (2022). Leveraging the value from digitalization: A business model exploration of new technology-based firms in vertical farming. *Journal of Manufacturing Technology Management,* DOI: 10.1108/JMTM-10-2021-0422

Digitalization is leading to a fundamental transformation of industry under the paradigm of Industry 4.0. Manufacturers employing digital technologies (for example, the Internet of things and artificial intelligence) to digitalize their operations are expected to derive significant improvements. However, they face numerous challenges in endeavoring to secure the value from digital technologies. To leverage the full potential of digitalization, manufacturers need to complement a technological focus with innovation of their BM. Yet, the extant research is unclear how this is achieved. Prior literature frames the strategic choice open to manufacturers as being the pursuit of a BM design for efficiency or novelty, but critically not both because this risks "getting stuck in the middle" (Porter, 1985). However, there is some evidence that new technology-based firms (NTBFs) can successfully adopt a hybrid BM, leveraging both efficiency and novelty (Loon & Chik, 2019). Yet, the literature remains scarce on how this can be understood in the light of BMI (Buer et al., 2021; Holzmann et al., 2020; Montes & Olleros, 2020; Müller, 2019; Rachinger et al., 2019; Rask & Günzel-Jensen, 2019).

The purpose of the paper is to provide insights into how new technology-based firms (NTBFs) can overcome established notions of scale and scope through BMI, which leverages the value from digitalization. The study adopts a qualitative, exploratory, archival, and documentary search research approach, drawing on a novel data set of 50 publicly available interviews with vertical farming (VF) industry leaders and insiders who represent 36 different organizations from North America and Europe.

By studying new technology-based firms (NTBFs) in the vertical farming industry, this study reveals how the value from digital technology is leveraged by the BM at the product, process, and system levels, see Figure 6. By identifying digital firm activities across different levels of analysis, the framework provides a comprehensive view of how digitalization is used to innovate the BM as a whole. Critically, the study makes an important contribution by showing how NTBFs innovate their BMs in order to adopt a combined approach to leveraging both efficiency and novelty value drivers from digitalization.

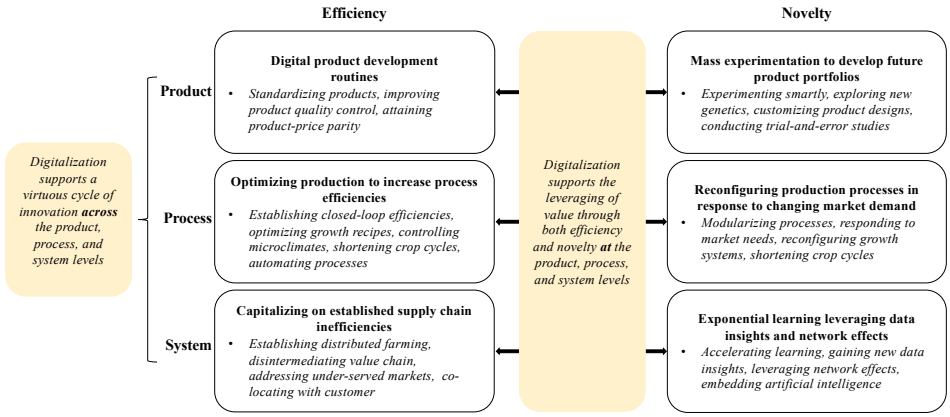

Figure 6: Leveraging the value from digitalization via a combined approach of efficiency and novelty

4.4. Paper 4

Thomson, L., Sjödin, D., & Parida, V., (202X). Resource orchestration to realize the potential from industrial digital transformation: Leveraging capability configurations. *Submitted to a peer-reviewed academic journal.*

The industrial sector is currently confronting an unparalleled transformation driven by various digital technologies, necessitating a shift in the approach to industry operations (Correani et al., 2020; Iansiti & Lakhani, 2014; Sommer et al., 2021; Verhoef et al., 2021; Volberda et al., 2021; Warner & Wäger, 2019). This transformation, fueled by the integration of innovative digital technologies, signifies a wide-reaching level of digitally driven organizational change, offering substantial advancements in business operations (Fitzgerald et al., 2013; Verhoef et al., 2021).

However, established industrial process firms, deeply rooted in a pre-digital era, face particular challenges during this digital transformation (Berndtsson et al., 2020; Correani et al., 2020; Sommer et al., 2021; Verhoef et al., 2021). These complexities often result in setbacks and demand a careful balance between digital technology integration and maintaining operational efficiency (Chirumalla, 2021).

To overcome these challenges, industrial process firms need to devise strategies that optimize their resources (Furr et al., 2022; Grant, 1999; Liu et al., 2011; El Sawy et al., 2010; Verhoef et al., 2021). This requires striking a balance between leveraging existing capabilities and cultivating new ones (Svahn et al., 2017). However, a clear understanding of resource management in the context of digital transformation remains elusive (Verhoef et al., 2021). Additionally, further exploration is needed regarding the micro-level managerial processes through which this transformation unfolds (Ghosh et al., 2021; Vial, 2019; Warner & Wäger, 2019).

Drawing on case studies of three industrial firms and their digital suppliers, the study addresses these gaps in understanding by investigating *how industrial firms orchestrate resources and leverage capabilities for the digital transformation of production operations*. The study enhances the digital transformation literature by developing a resource orchestration framework that highlights the multifaceted nature of industrial firms undergoing digital transformation. Specifically, the study demonstrates how combinations of digital resources facilitate the development of distinct capabilities, including digital agency, process digitalization, and digital co-creation capabilities across two phases. Furthermore, the framework shows how these capabilities are leveraged collectively to drive digital transformation, see Figure 7.

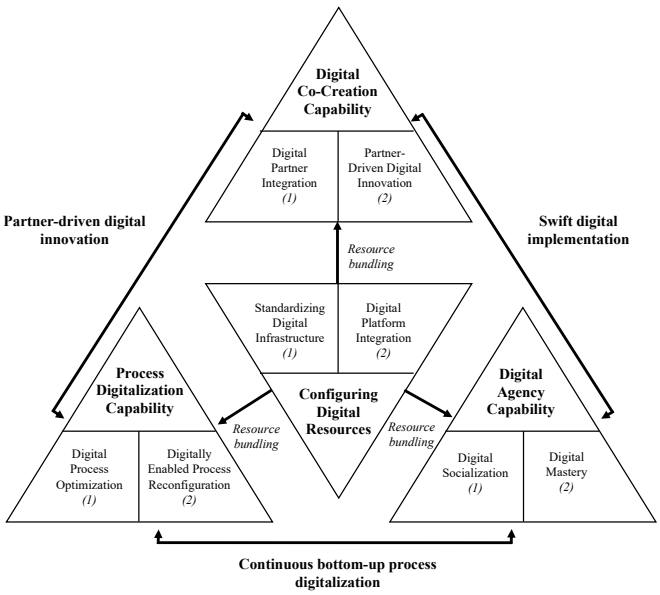

Figure 7: A resource orchestration framework for digital transformation capabilities

5. Towards a Conceptual Framework for Digital Business Model Innovation

This chapter integrates the findings from the four appended papers to develop a conceptual framework for digital business model innovation. In the subsequent chapter, the framework is discussed, including a description of the business model mechanisms for expressing digital affordances. Informed by the framework, a novel definition of digital business models is also proposed.

5.1. Introduction to the framework

The purpose of this thesis is to *conceptualize what a digital business model is, and to explain how it can be innovated by exploring the intersection with digital affordances.* To contribute to the overall thesis purpose, selected findings from the four appended papers are synthesized into a proposed DBMI framework, demonstrating how industrial firms can innovate their BMs to leverage the value from digitalization. Specifically, through the development of mechanisms, the proposed framework explicitly connects the digital affordances of disintermediation, decoupling, and generativity to the DBM dimensions of digital value creation, digital value delivery, and digital value capture. Empirical insights from the four papers in this thesis are employed to theorize the mechanisms between each component of the BM and the associated digital affordance.

Through the development of a proposed DBMI framework that explicitly connects digital affordances to the DBM dimensions of digital value creation, delivery, and capture, this thesis bolsters existing conceptualizations of the unique aspects of DBMs. The purpose of the proposed framework is not to provide definitive guidance on developing a DBM but rather to elucidate how digital affordances could be expressed within the BM. The proposed framework is applicable for the innovation of DBMs by industrial B2B firms, with an emphasis on industrial providers. The reason for this is that many of the insights used to inform the framework are derived from a provider perspective (Paper 1 and Paper 2). However, it is important to note that the relationships outlined in the framework have not been explicitly explored in the four appended papers. For instance, the connection between digital value creation and the digital affordance of decoupling has not been directly examined. However, as an illustrative example, decoupling is evident in how digital technologies afford industrial firms to reduce asset specificity through the development of modular, reconfigurable, and customizable product-service bundles (Paper 3 and Paper 4). Indeed, the framework demonstrates that digital affordances can be considered a unifying theme throughout the papers, supporting the development of an improved understanding of how industrial firms leverage value from digitalization in their BMs. The framework thus provides an initial suggestion for how digital affordances relate to DBMI. Incorporating digital affordances not only serves as a sensemaking tool to organize key findings from the four appended papers but also offers a novel and much-needed foundation upon which future work can build. Figure 8 illustrates the conceptual DBMI framework.

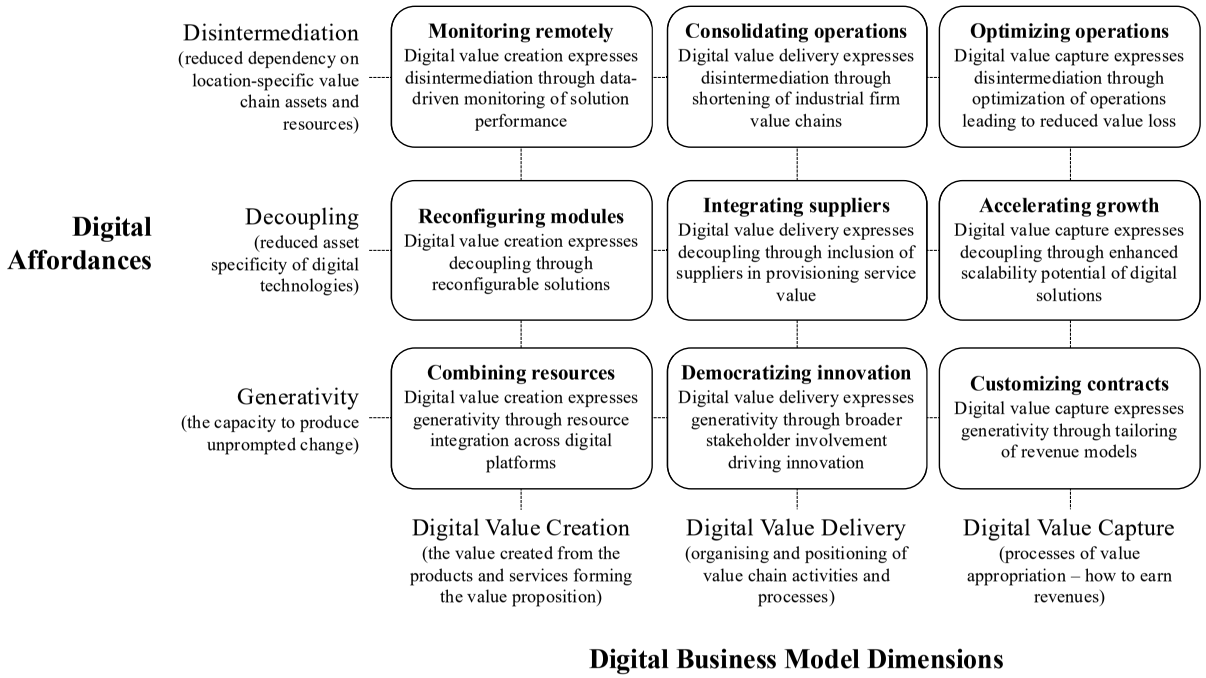

Figure 8: Towards a conceptual digital business model innovation framework

The selection of generativity, decoupling, and disintermediation as the digital affordances for constructing the proposed DBMI framework is not exhaustive but was made due to their explanatory potential. Initial theorizing of the connections between these affordances' specific attributes and DBMI aligned well with the findings of the papers. For instance, disintermediation had clear connections with empirical examples from the four appended papers (e.g., data-driven visibility of solution performance). Furthermore, unlike other affordances, such as reduced communication and coordination costs (Yoo et al., 2012), and increased customer, partnering, and operational agility (Sambamurthy et al., 2003), the affordances of decoupling, disintermediation, and generativity more closely correspond with the definition of an affordance as the action potential offered by a specific object for a specific user (Nambisan et al., 2019; Pentland et al., 2022). This alignment also applies to the logic presented in Table 2, which connects affordances, expressions, and benefits. Section 6.3 on Limitations and suggestions for future research acknowledges that not all affordances fit the presented logic and suggests potential directions for further development. The subsequent sections of this chapter elaborate on the proposed framework in greater detail.

5.2. Mechanisms for expressing digital affordances

The proposed DBMI framework, depicted in Figure 8, connects the digital affordances of disintermediation, decoupling, and generativity to the DBM dimensions of digital value creation, delivery, and capture through the development of interconnecting mechanisms. The mechanisms draw on the insights obtained from the four appended papers to show potential expressions of the digital affordances in DBMs.

5.3.1 Digital Value Creation

Digital value creation expresses the digital affordances of disintermediation, decoupling, and generativity through the mechanisms of *monitoring remotely*, *reconfiguring modules*, and *combining resources*.

Monitoring remotely expresses disintermediation through the establishment of real-time and data-driven observation, and control of a deployed solution[3], regardless of whether the industrial firm has a physical presence at the site. This disintermediated approach, therefore, extends the ability of industrial firms to engage in value-creating activities regardless of their location. For instance, industrial firms leveraging the mechanism of monitoring remotely can create value and benefit in various ways, such as utilizing digital technologies for remote-control operation of industrial machinery to improve safety, efficiency, and reduce the need for on-site personnel (see Paper 1). Furthermore, the development of autonomous solution capabilities improves operational productivity as well as reduces human intervention in

[3] The term *solution* is intentionally abstract, referring to an implementation of resources (including digital and non-digital technologies) in distinct combinations to support the capabilities required for problem solving (Gartner, 2022).

industrial processes (see Papers 1 and 2). Condition monitoring of manufacturing environments supports proactive maintenance and increased uptime (see Paper 3). Finally, by leveraging real-time data and analytics, firms can refine and improve industrial products, processes, and overall performance (see Papers 3 and 4). Through the mechanism of monitoring remotely, digital technologies facilitate disintermediated forms of value creation, providing industrial firms with improved visibility, control, and responsiveness in managing their deployed solutions.

Reconfiguring modules expresses decoupling through the deployment of digital technologies in a diverse range of solutions through adaptable resource combinations. As a result, *reconfiguring modules* drives digital value creation by offering increased flexibility and versatility in meeting market demands and creating value. Digital technologies inherently support decoupling due to their low asset specificity, which allows them to be deployed in various solutions through adjustable resource combinations. For instance, GitHub, the world's largest source code host, empowers software developers to reuse existing code snippets for quicker and easier development of new solutions (GitHub, 2022). In the industrial context of this thesis, reconfiguring modules is evident in how industrial firms deploy flexible manufacturing systems to maximize value creation (see Paper 3). These systems harness digital technologies to enhance adaptability and responsiveness to shifting market needs, enabled by relatively straightforward adjustments in control system software. Vertical farmers, for instance, can efficiently reconfigure their production systems to optimize the growing conditions for different crops that demand specific inputs of light, nutrients, and temperature (Thomson, 2022). Furthermore, digital technologies support greater reconfigurability of firm resources in the development of digital transformation capabilities. For example, industrial process firms carefully analyze different data for the development of firm-specific KPIs (Key Performance Indicators) to develop process digitalization capability (see Paper 4). Finally, the mechanism of reconfiguring modules is evident in the ways in which industrial manufacturers can customize vehicle platforms for different levels of autonomous solution maturity (see Paper 1). For example, the same underground loader platform can be configured for operator assist, semi-autonomous, and fully autonomous functionality through new combinations of digital and non-digital modules (Thomson et al., 2021). Through the mechanism of reconfiguring modules, digital technologies enable decoupled forms of value creation, granting industrial firms with greater ability to develop and implement novel resource configurations that meet the evolving needs of the market.

Combining resources expresses generativity through the value that is derived from resource integration across digital platforms. Essentially, this mechanism supports digital value creation by harnessing the generative potential of shared resources among various actors. While generativity in the B2C context often emerges from spontaneous and uncoordinated interactions among a large number of entities (Nambisan et al., 2019), such as user-generated content on social media platforms, generativity in the B2B context assumes a more controlled and focused form. For instance, the B2B firms from this thesis are found to exercise greater control and coordination over a relatively limited number of digital solution collaborators. The mechanism of combining resources is evident in how, for instance, process industry firms co-create value with equipment suppliers by granting them access to selected information through their digital

platforms. This approach aims to harness supplier resources and capabilities to enhance internal operations, such as improving procurement activities by providing suppliers with direct visibility of inventory levels (see Paper 4). In another example, industrial process firms are opening up their proprietary digital platforms to equipment manufacturers to supports the development of solutions for monitoring mixed fleets of equipment (see Paper 1). Although the number of collaborators is smaller and more controlled, opening up firm boundaries allows industrial firms to augment their resources and capabilities with those of their ecosystem. Consequently, digital value creation through the mechanism of combining resources leverages a subtler form of generativity, emphasizing resource sharing among a select group of actors to create value in an industrial B2B context.

5.3.2 Digital Value Delivery

Digital value delivery expresses the digital affordances of disintermediation, decoupling, and generativity through the mechanisms of *consolidating operations*, *integrating suppliers*, and *democratizing innovation*.

Consolidating operations expresses disintermediation through the restructuring of industrial firm value chains, supporting novel ways of delivering value to customers. For instance, the internet has revolutionized commercial supply chains by disintermediating traditional brick-and-mortar retailers via online sales. Industrial firms can similarly benefit by consolidating their value chain activities. An example of this can be observed in vertical farming, where industrial firms have employed digital technologies to consolidate downstream supply chain activities related to retail and distribution (see Paper 3). Digital technologies have facilitated this transformation by enabling innovative ways of organizing value delivery. For instance, vertical farm producers are strategically co-locating with their customers to compress the supply chain, integrating retail and distribution into their value chain activities. As a result, consolidating operations provides industrial firms with a broader array of opportunities for organizing and enhancing their digital value delivery activities.

Integrating suppliers expresses decoupling through the reconfiguration of industrial firm value delivery to incorporate digital suppliers in the provision of service value. Digital technologies pave the way for a restructured value chain in industrial firms, as they facilitate the decoupled relationship between fit, form, and function. For example, Renault, a traditional car manufacturer, has forged a partnership with Google, the world's leading search engine company, to innovate new mobility solutions (Renault, 2022). The decoupling of form and function enables Google to play a crucial role in value-chain activities associated with delivering digital service value, despite having limited expertise of the automotive hardware. Similarly, in the context of this thesis, industrial equipment manufacturers specializing in mining machinery can collaborate with digital suppliers focused on solution autonomy to deliver enhanced in-use service value (see Paper 2). For example, the autonomous solution provider ASI can serve multiple industrial sectors, such as construction, cleaning, agriculture, and mining, due to the decoupled nature of digital technologies (ASI, 2023). Indeed, insights from the context of this thesis shows that the collaboration between industrial firms and digital

suppliers is made feasible by the separation between the physical machinery and the software that operates it. Thus, digital value delivery through integrating suppliers generates new avenues for industrial firms to improve their value delivery processes by collaborating with digital suppliers.

Democratizing innovation expresses the generative potential of broadened participation from both internal and external to the firm actors in refining and enhancing value delivery processes. In essence, this mechanism supports a more diverse involvement of actors in driving innovation to improve the delivery of value. For instance, industrial firms are leveraging common data platforms to democratize digitalization initiatives, encouraging bottom-up innovation of new processes and technologies that improve value delivery (see Paper 4). This is supported by self-serve reporting tools, such as Power BI, which assist industrial firms in making data-driven decisions for optimizing operations. Furthermore, democratizing innovation also relies on increased engagement with external actors, or platform complementors (see Paper 1). For example, industrial equipment manufacturers that specialize in machinery are partnering with digital suppliers that have the capabilities to support them in innovating autonomous solutions. By actively involving a wide array of internal and external actors, industrial firms can leverage collective expertise and knowledge to drive innovation and enhance value-delivery activities. Digital value delivery through *democratizing innovation* revolves around cultivating a collaborative environment that enables and encourages the involvement of diverse internal and external actors. This fosters continuous improvement and innovation of value-delivery processes.

5.3.3 Digital Value Capture

Digital value capture expresses the digital affordances of disintermediation, decoupling, and generativity through the mechanisms of *optimizing operations*, *accelerating growth*, and *customizing contracts*.

Optimizing operations expresses the affordance of disintermediation using digital technologies to improve the efficiency of industrial firm value chains. Optimizing operations, therefore, supports digital value capture by a reduction in value loss. Digital technologies enable industrial firms to streamline their operations, reduce costs, and secure a larger portion of the overall generated value. For instance, ecommerce enterprises that adopt a direct-to-consumer strategy can cut down on non-value-adding touchpoints within their supply chains, optimizing overall efficiency. Similarly, industrial firms can reap the benefits of optimizing operations. One example is vertical farm producers who use digital technologies to revolutionize their logistics and distribution processes. By adopting distributed manufacturing models and situating their operations closer to customers, these producers can eliminate the need for long-haul logistics, reducing costs, and enhancing value capture (see Paper 3). Digital value capture through optimizing operations emphasizes the potential for minimizing value loss in the value chain. By embracing digital technologies, industrial firms can eliminate inefficiencies, leading to streamlined operations that improve value capture.

Accelerating growth expresses the affordance of decoupling through the enhanced scalability potential of digital solutions. This mechanism supports digital value capture by taking advantage of the decoupling of digital solutions from physical constraints, thereby enabling more accessible scaling. For instance, social media platforms, such as Facebook and WhatsApp, have experienced exponential growth in user numbers with minimal marginal costs, largely due to the inherent scalability of digital technologies. While industrial firms operate in a different context, they can similarly capitalize on the increased scalability offered by digital technologies. For example, industrial firms in vertical farming can rapidly expand their production capacity using digital technologies (see Paper 3). This expansion is made possible by a digital operating system that embodies the core capability of vertical farmers. Once this system is developed, it can be easily scaled and applied to new production facilities, expediting faster growth. Digital value capture through accelerating growth acknowledges that as the business expands, more value can be captured.

Customizing contracts expresses the affordance of generativity to capture value through the tailoring of revenue models that reflect the modularity and generative potential of digital solutions. The generative potential of digital technologies is apparent in their capacity for combinatorial innovation (Nambisan et al., 2019; Yoo et al., 2012), which involves employing a modular approach to combining existing modules in innovative ways, ultimately creating value (Yoo et al., 2012). Examples of this modularity can be found in digital solutions with open APIs, which allow for entirely new combinations, such as digital services that creatively utilize the Google Maps API (Yoo et al., 2012). However, unlike physical modularity which represents an intentional and pre-designed decomposition, such as the Scania design and manufacturing process (Nilsson & Dernroth, 1995), digital modularity is designed without knowing the end product (Yoo et al., 2012). Consequently, industrial firms providing digital solutions need to be flexible in adjusting their revenue models to capture the value being delivered effectively. In the empirical context of this thesis, industrial firms were found to tailor their subscription models based on the specific combination of modules being provided. For instance, assistive autonomous features, such as collision awareness or collision avoidance, are considered as “add-ons” and are charged accordingly in the revenue model (see Paper 1). Customizing contracts, therefore, supports digital value capture by embodying the affordance of generativity, allowing firms to be agile in adapting their revenue models to better align with the modular nature and generative potential of digital solutions.

5.3. Towards a novel digital business model definition

Digital technologies are profoundly impacting industries, driving BMI by reshaping value creation, delivery, and capture processes (Verhoef & Bijmolt, 2019). This transformation has led to the emergence of DBMs (Bock & Wiener, 2018; Veit et al., 2014; Weill & Woerner, 2013), which have become a critical area of study in both academic and practical contexts (Remané et al., 2022). However, despite various proposed definitions, a cohesive and comprehensive understanding of DBMs remains elusive (Broekhuizen et al., 2021). To address this shortcoming, this thesis provides a tentative definition of DBMs, building on prior contributions and a conceptual framework that connects digital affordances with DBM dimensions. The proposed definition is applicable to the innovation of DBMs by industrial B2B firms, and is defined as follows:

> *Digital business models rely on the leveraging of digital affordances for creating, delivering, and capturing value in novel ways.*

The definition is intentionally broad due to the nascent and exploratory stage of DBM research (Sharma & Chrisman, 2007). However, by including digital affordances and greater specificity on the scope of change, it achieves greater comprehensiveness than extant DBM definitions. Indeed, of central importance to this definition is the leveraging of digital affordances, which refers to the ways in which the inherent properties and capabilities of digital technologies can be expressed to achieve specific outcomes. By explicitly including digital affordances, this definition aligns with the reasoning of Sahut et al. (2021) and provides greater clarity regarding the unique aspects of DBMs that distinguish them from traditional, non-digital BMs.

Although the mechanisms from the conceptual framework are not explicitly included in the definition, they play an essential role in construct clarity by informing the action of leveraging. Consequently, the conceptual framework supports a more rigorous and coherent application of the proposed DBM definition. Furthermore, by specifically referring to "creating, delivering, and capturing value," the definition explicitly addresses the dimensions of the BM under consideration. In doing so, it builds on the work of Veit et al. (2014), whose DBM definition is frequently cited in literature, by expanding on the phrase "the way business is carried out" and, in the process of doing so, clarifies the scope of change. The proposed definition, therefore, represents an attempt to balance accuracy (comprehensiveness) with simplicity (parsimony) and generality (Langley, 1999; Suddaby, 2010).

Critically, the definition alludes to the fact that DBMs differ from non-digital ones not in terms of their digital materiality but rather in the extent to which they rely on digital affordances to deliver value in novel ways. Emphasizing the term “novel” means that the distinction between digital and non-digital BMs must be relative to support meaningful comparisons and classifications. This acknowledges that the degree of digitalization may vary across different BMs, industries, and contexts, and that the boundary between digital and non-digital models may not always be clear-cut.

6. Discussion

This chapter presents the main theoretical contributions of the thesis as well as its managerial implications. To conclude, the research limitations are stated and directions for future research are suggested.

6.1. Theoretical contributions

The purpose of this thesis is to *conceptualize what a digital business model is, and to explain how it can be innovated by exploring the intersection with digital affordances*. To achieve this purpose, the thesis combines the four appended papers, the DBMI framework depicted in Figure 8, and the definition proposed in section 5.3. In doing so, the thesis offers the following theoretical contributions.

First, this thesis contributes to the understanding of DBMs through the *development of a novel definition of DBMs rooted in the literature of digital affordances*. In doing so, this thesis enhances the conceptual rigor in applying *digital* in the context of DBM. Previous literature on DBMs has often defined and examined DBMs based on the specific phenomena being studied, such as sharing economy digital platform BMs (for example see: Schiavone et al., 2021), or blockchain technology platforms (Kramer et al., 2021). Although the adaptability of the DBM concept to different contexts can be considered a strength, its varying interpretations – rooted in specific industries or equated with particular technologies – may increase the potential for misinterpretation, especially when comparing DBMs across different contexts. These studies, and others like it, have therefore contributed to a growing list of definitions lacking theoretical foundations (Bock & Wiener, 2018) and that have not adequately captured the essence of *digital* (Bock & Wiener, 2018; Broekhuizen et al., 2021; Trischler & Li-Ying, 2022). This has hindered the development of a consensus on DBMs and limited the cumulative progress of research (Broekhuizen et al., 2021). To address this issue, scholars have called for interdisciplinary work connecting fields such as information systems and business management (Veit et al., 2014). By developing a framework that incorporates insights from both BM and digital affordances literature, this thesis presents a new conceptualization and definition of DBMs. This definition and the associated framework respond to the call for greater interdisciplinary insights to build on existing DBM contributions. Through the development of a DBM definition and a conceptual DBMI framework that explicitly links digital affordances to the DBM dimensions of digital value creation, delivery, and capture, the thesis refines existing conceptualizations of what makes the *digital* aspect of DBMs unique. Shifting the focus from specific digital technologies to the underlying affordances reveals a broader view of potential expressions, or paths (Pentland et al., 2022), that digital technologies can support. Additionally, shifting the focus to affordances enables us to consider combinations of multiple technologies that can be expressed in a BM, which is a more realistic scenario for industrial firms who rarely rely on a single technology (Pentland et al., 2022). This contributes a more comprehensive

conceptualization of the interplay between digital affordances and the various dimensions of BMs.

Second, through the development of a conceptual DBMI framework, this thesis contributes to the understanding of *how industrial firms can approach the innovation of DBMs*. Drawing on the four appended papers and the affordance literature, this thesis theorizes mechanisms that connect the digital affordances of decoupling, disintermediation, and generativity with the DBM dimensions of digital value creation, delivery, and capture. The mechanisms relate to the enaction of digital affordances, exemplifying the ways in which digital affordances have been expressed in industrial firm BMs. Although the insights are limited to the four appended papers of this thesis, the mechanisms and the associated framework contribute to filling a gap in the literature related to understanding how value from digital technologies is leveraged across the DBM (Metallo et al., 2018; Rachinger et al., 2019; Remané et al., 2022). A key strength of the framework is that, instead of placing emphasis on specific expressions of digital technology, such as digital platforms, focusing on DBM mechanisms supports a broader understanding of how digital technologies can change ways of organizing (Pentland et al., 2022). For instance, the digital affordance of decoupling is manifest across each of the BM dimensions through mechanisms that acknowledge a wide range of action potential resulting from digital affordances. Consequently, the mechanisms from the proposed conceptual framework connect a micro-level view of affordances to more extensive changes in how DBMs support new ways of organizing (Pentland et al., 2022). Theorizing these interconnecting mechanisms, therefore, provides valuable theoretical insights into the ways in which industrial firms can leverage digital affordances to innovate their BMs.

Finally, the thesis *contributes empirical insights in the context of industrial firms innovating DBMs.* To date, most research contributions investigating DBMs have focused on B2C settings (Bock & Wiener, 2018; Demil & Lecocq, 2010). However, DBMs are not exclusive to born-digital startups, such as Airbnb or Uber (Vendrell-Herrero et al., 2018), but are also relevant to established industrial firms (Broekhuizen et al., 2021). By providing empirical insights from a B2B context, this thesis offers an alternative perspective on DBMI, which is more applicable to industrial firms. Indeed, B2B industrial firms differ from their B2C counterparts in several ways. For example, the mechanism of combining resources actualizes the affordance of generativity for digital value creation in a less pronounced manner than in typical B2C settings. This is because B2B firms tend to exert greater control over a limited number of digital solution collaborators to co-create value with their ecosystem. Consequently, digital value creation through combining resources leverages a less pronounced type of generativity, based on shared resources between a relatively small number of geographically separated but digitally connected actors. Furthermore, as reflected in the proposed definition of this thesis, DBMs should not be judged solely by their digital materiality but rather by the extent to which they rely on leveraging digital affordances. This consideration is particularly important for understanding the context of industrial firm DBMs, which often combine both digital and physical components. For instance, the innovation of autonomous vehicle solutions represents a combined physical and digital architecture. By exploring the DBMs of industrial firms, this thesis adds greater nuance to what can be considered a defining feature of DBMs.

6.2. Managerial implications

The thesis has implications for managers who are seeking to leverage technologies for the digital transformation of industrial firms.

By offering a clearer understanding of the relationship between digital affordances and DBM dimensions, this thesis supports the development of practical strategies for industrial firms aiming to innovate DBMs. More specifically, the framework developed as part of this thesis can serve as a conceptual tool for managers in industrial firms innovating DBMs. The framework provides managers with an alternative way of conceptualizing DBMs by explicitly linking digital affordances – disintermediation, decoupling, and generativity – with the DBM dimensions of digital value creation, digital value delivery, and digital value capture. Managers can use the framework as a tool to explore how digital affordances can be leveraged through DBMI, supported by a synthesis of empirical observations from the four papers in this thesis when making these connections. For instance, managers wishing to conceptualize how the affordance of decoupling leads to value creation can consider the potential from developing modular and reconfigurable solutions as part of their DBM. While it is possible to innovate DBMs without understanding the underlying digital affordances, managers who draw upon the framework will gain a new way of conceptualizing their actions rooted in the digital domain. Moreover, this understanding enables industrial firms to better comprehend the potential of digital technologies to create previously unknown DBM expressions.

6.3. Limitations and suggestions for future research

Despite providing several contributions to the literature on DBMs, the present thesis has certain limitations that create opportunities for further work.

First, the proposed conceptual framework is based on empirical insights derived from four appended papers, which were not originally designed with the explicit intention of addressing the purpose of this thesis. This creates opportunities for future empirical research to explicitly study the ways in which industrial firms leverage digital affordances across their DBMs. By conducting studies that are purposefully designed to explore this aspect, researchers can further refine the framework and contribute to a more robust understanding of the interplay between digital affordances and DBMs in industrial settings.

Second, while the framework is conceptual, it primarily relies on insights obtained from qualitative, multiple-case studies. Although multiple-case studies offer widely recognized benefits, such as increased generalizability, due to examining a larger number of relationships (Yin, 2018), they have been criticized for sacrificing analytical depth in favor of breadth (Flyvbjerg, 2006; Peattie, 2001). As a result, future research could consider adopting a single case study design to develop dense, detailed, and practitioner-orientated explanations (Flyvbjerg, 2006). Several influential articles referenced in this thesis, such as the study of BMI through trial-and-error learning at Naturhouse (Sosna et al., 2010) and BM evolution at Arsenal FC (Demil & Lecocq, 2010), have utilized single case studies to good effect. These studies

exemplify the enhanced contextual richness and depth of analysis that single-case study investigations can achieve (Dubois & Gadde, 2002, 2014; Thomas, 2011). In the context of this thesis, single-case studies hold the potential to provide greater nuance and contextual detail to the theorized DBM mechanisms for leveraging digital affordances.

Third, future work could seek to refine the logic that connects digital affordances, expressions, and benefits, as illustrated in Table 2. In particular, affordances such as reduced communication and coordination costs (Yoo et al., 2012), and increased customer, partnering, and operational agility (Sambamurthy et al., 2003) seem more appropriately categorized as benefits. While this clarification is beyond the scope of the current thesis, future studies could address this apparent inconsistency by reevaluating the classification of these elements. Furthermore, this situation presents opportunities for additional research to explore alternative digital affordances beyond those included in the existing framework. By investigating a broader range of digital affordances, researchers can develop a more comprehensive understanding of how digital technologies influence DBMs.

Finally, further work could seek to refine and clarify the proposed definition of a DBM. Specifically, terms such as "rely" and "novel," may warrant further elaboration. For instance, the extent of reliance on digital affordances may vary significantly across different DBMs. Indeed, it is unclear whether the presence of a single mechanism or the fulfillment of all mechanisms is necessary for a BM to be classified as "digital". Additionally, the term "novel" may need to be better contextualized with regards to being considered within firms, specific industries, or markets. Refining the proposed definition could support a more robust conceptualization of DBMs.

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