THESIS FOR THE DEGREE OF LICENTIATE OF ENGINEERING

Digital transformation of a manufacturing firm: A matter of combining resources and strategizing in business networks

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ABSTRACT

Manufacturing firms are gradually undergoing digital transformation through starting to implement new digital technologies, and creating new offerings to meet customer needs. As no business is an island, the process of creating new digital offerings and selling these to customers involves collaboration with other actors. These actors need to develop and combine resources to successfully create value in the business network. Under these circumstances, manufacturing firms develop strategic actions to access and combine such resources.

The purpose of this thesis is to understand resource combining and strategizing in business networks, as part of the process of digital transformation, from the perspective of a focal manufacturing firm interacting with customers and suppliers. This thesis relies on the Industrial Network Approach (INA), and more specifically literature on resources and strategizing, to study business relationships with regard to digital transformation and reveal the nuances and effects of characteristics of digital resources during resource combining and value creation. A single case study of a manufacturing firm undergoing the process of digital transformation, and its related business network, was conducted. By applying the case study method, details about different business relationships within the context of digital transformation were captured and analysed.

The findings of this thesis show that a focal firm needs to take a variety of strategic actions when interacting with other actors, creating and consolidating elements of the business relationships. Focal firms also strive to access and combine key digital and non-digital resources. As a result of this resource combining, value can be created in the forms of flexibility, efficiency, novelty and functioning digital solutions.

This thesis advances the understanding of the interplay between creating/consolidating elements of business relationships to access and combine digital resources during the process of digital transformation. Based on the intrinsic characteristics of digital resources, the forms of resource combining provided in this study offer a perspective on the opportunities, values and challenges that digitalisation presents in the ever-evolving digital business landscape

Keywords: digitalization, digital transformation, business network, resource combining, strategizing, manufacturing firm

List of appended papers

Paper I

Ferreira, C.C. and Lind, F. (2023) "Supplier interfaces in digital transformation: An exploratory case study of a manufacturing firm and IoT suppliers", *Journal of Business & Industrial Marketing*, Vol. 38 No. 6, pp. 1332-1344.

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Author contribution: The two authors planned and framed the study and performed the data collection. Lind supported with theoretical considerations. Ferreira performed the analysis and developed the typology for interfaces with Internet of Things (IoT) suppliers. The two authors were involved in the writing, reviewing and editing process.

Paper II

Ferreira, C.C., Jonsson, P., and Lind, F. (2023), "Strategizing in business relationships to cope with uncertainties in digital servitization". Submitted to a scientific journal in February 2023. An early version of this paper was presented at the 2020 PLAN Research and Application Conference, Södertälje/Online.

Author contribution: All three authors participated equally in the planning and framing of the study as well as the data collection, results analysis, writing, reviewing and editing processes. Lind and Ferreira provided theoretical considerations.

Paper III

Ferreira, C.C., Lind, F., and Pedersen, A. (2022), "Value creation from combining digital and non-digital resources: The case of 'smart products'". Presented in September 2022 at the IMP conference in Florence, Italy.

Author contribution: Ferreira performed the planning and framing of the study. The three authors provided theoretical considerations and participated in the analysis of results and the review process. Ferreira and Lind performed the data collection and contributed to the writing and editing processes.

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"Você não sabe o quanto eu caminhei pra chegar até aqui.
Percorri milhas e milhas antes de dormir. Eu não cochilei…"
In "Estrada", Cidade Negra

Deciding to change my career path towards the academic world, after many years working in the industry, was a brave decision. It was the topic "Digitalization and Business networks" that attracted me the most. And of course, the fact that the program was held by Chalmers University of Technology. Being a faithful Chalmerist, I did not hesitate in applying for this PhD position back in 2019.

The admission to the Graduate School was profoundly celebrated with my family and friends. In this journey, so far, I have learnt a lot in terms of different theories, theory development, and how to produce original research to expand the boundaries of knowledge. The results of this work are presented in this thesis. However, it is also important to say that along this way, as a person, I have had the pleasure to experience unforgettable moments, such as… I jumped in a frozen lake for the first time in my life in Härryda in the company of my dear colleagues from the Supply and Operations Management (SOM) division. I was a chairperson when attending to my very first conference. I joined the Nobel Banquet in 2022 in Stockholm (yes, I did!). Together with some PhD students, I stole a diamond from a bank in a scape room in Gothenburg. I witnessed the Northern lights for the first time in Riksgränsen, when taking a PhD course… What an adventure this PhD program has been!

Writing this thesis provided me a valuable lesson: we, similarly to the companies in the business market, need others to succeed in life. Collaborations and interactions are worthful resources for us, human beings, both in the business and in our private sphere. Following this line of thought, the accomplishment of this licentiate degree could not have been possible without the collaboration, interaction, support and guidance of many people and organizations.

First, I would like to express my gratitude to my supervisor Frida Lind. Thank for always encouraging and believing in me. Thank you for unquestionable support, for your time and effort reviewing my work, and your patience to let me, in my own pace, get into the academic world of concepts, models and theories. Special thanks go to Patrik Jonsson and Ann-Charlott Pedersen, my co-supervisors. Thank you for your constructive comments and feedback that have helped me to take this research to the next level. I also appreciate all the support that I have got from the participants of the IMA seminars, who have directly helped me with the development of this research.

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To all of you I will be forever grateful!

Gothenburg, June 2023

Carla Cleri Ferreira

TABLE OF CONTENTS

1 INTRODUCTION

Digital transformation has broad connotations and can refer to anything from IT modernization (for example cloud computing) and digital optimization to the invention of new digital business models (Gartner, 2022). As a result of digital transformation, people are increasingly connected, businesses have changed and supply chains have become more reliable and effective. Additionally, the amount of data generated every day is increasing, mainly due to the growth of the Internet of Things (IoT) (Forbes, 2018). It is also noted that digital firms have become more powerful and valuable in the market over the last decade, e.g. Amazon, Microsoft Corporation, Apple and Facebook (Verhoef et al., 2019).

Firms need to adapt to the use of new digital technologies. While certain firms were quick to undertake the process of digital transformation, for example banks, others, such as those in the manufacturing sector, are still in the early phases. Many manufacturing firms are now gradually embarking on the journey of digital transformation and introducing the use of new digital technologies, creating new offerings to meet customer needs. In this way, the use of digital technologies has started to transform business and create new value. As a result, manufacturing firms are facing new challenges, for example a lack of relevant knowledge, inadequate cyber security, inflexible company structures and resistance to change (Björkdahl, 2020, Albukhitan, 2020).

For manufacturing firms to overcome these will require not only new resources but also collaboration between actors in the business networks of which they are a part (Pagani and Pardo, 2017, Frick et al., 2020, Ritter and Pedersen, 2020). As no business is an island (Håkansson and Snehota, 2006), the process of creating new digital offerings and selling them to customers involves a variety of actors that need to develop and combine key resources to successfully create value. For this reason, the Industrial Network Approach (Håkansson and Snehota, 1995) to business markets will be used as a base. Given the circumstances presented, manufacturing firms need to develop strategic actions to access key resources in business networks.

1.1 Purpose of the thesis

The purpose of the thesis is to understand resource combining and strategizing in business networks during digital transformation from the perspective of a focal manufacturing firm interacting with customers and suppliers.

A focal firm is affected by the actors around it (Ford, 2004). As digital transformation is a relational process (Fremont, 2021), this work will apply the Industrial Network Approach (INA) (Håkansson, 1982, Håkansson and Snehota, 1995) to understand how manufacturing firms combine resources and interact with other actors during digital transformation. The Industrial Network Approach considers the actions of both the 'focal firm', in this case a manufacturing firm, and other firms around it, such as its distributors, suppliers and customers.

While it is not possible to completely predict and understand the potential combinations, development, uses and value of a resource (Forbord, 2003), this study will describe the interactive process through which digital and non-digital resources are combined and developed. By looking at these processes through the conceptual lenses of the Industrial Network Approach, this thesis aims to provide a better understanding of how strategizing and resource combination occur during the early phases of a digital transformation process.

1.2 Outline of the thesis

Chapter 1 presents the introduction and purpose of the thesis. It describes the impact of digital transformation on manufacturing firms and the resulting need to access new resources and collaborate with new actors in their business network. Chapter 2 provides a theoretical framework, including topics related to the Industrial Network Approach and digital transformation. It also presents a discussion of the problem and the research questions. Chapter 3 describes the thesis methodology, presenting the research context, design, process and method as well as providing notes on data collection. The chapter ends with reflections on the research quality. Chapter 4 briefly describes the case of MANUFACTURING FIRM 1, specifically its business network and digital transformation. Chapter 5 presents summaries of the three appended papers. Chapter 6 explains the contribution of the appended papers to each of the research questions as well as the overall purpose of the thesis. Chapter 7 then discusses the results from a broader perspective and provides a framework for resource combining and strategizing in business networks. Finally, Chapter 8 presents the conclusions of the thesis along with theoretical and managerial contributions, limitations and suggestions for future research.

2 THEORETICAL FRAMEWORK

In this chapter, an overview of the Industrial Network Approach will be provided, with a focus on the resources in business networks with regard to interactions, combination, heterogeneity, interfaces and strategizing. Subsequently, an account of digital transformation is provided. Finally, it presents digital transformation from the perspective of the Industrial Network Approach followed by a discussion of the problem and research questions.

2.1 The Industrial Network Approach

According to the Industrial Network Approach, business markets can be conceptualized as business networks based on the existence of long-term relationships between buyers and sellers and their connections (Håkansson and Snehota, 1995). Business relationships are defined as "a result of an interaction process where connections have been developed between two parties that produce a mutual orientation and commitment" (Håkansson and Snehota, 1995 p.26). Relationships are vital as they allow companies to manage increasing technological dependence on other companies and the need to develop and deliver better offerings (Anderson et al., 1994). Organizational relationships facilitate exchange processes with other parties (Håkansson and Snehota, 2006).

The Industrial Network Approach focuses on how business relationships evolve and how actors achieve relational benefits through interactive processes, i.e. resource exchange, social exchange and adaptation (Håkansson and Ford, 2002). The Industrial Network Approach is applied in a wide range of business fields with an emphasis on relationships related to technology development.

The development of a relationship between two companies is influenced by shared past events, learnings from other relationships, the position of the two companies relative to each other and other actors, the companies' expectations of their future interactions and wider network conditions (Håkansson and Ford, 2002, Abrahamsen and Håkansson, 2012).

2.1.1 The ARA model

Håkansson (1987) developed the ARA model, or network model, for investigating business networks by looking at three analytical dimensions: actors, resources and activities (see Figure 1). The ARA model (Håkansson, 1987) is a key element of the toolbox provided by the Industrial Network Approach.

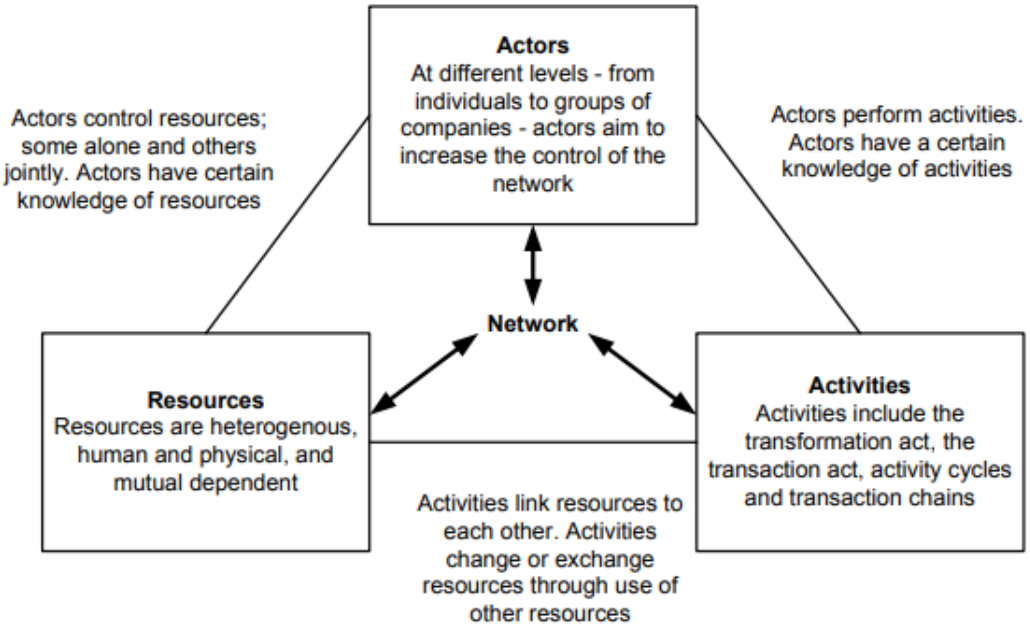

Figure 1: The network model (Håkansson, 1987 p.17)

The three dimensions of the ARA model, actors, resources and activities, are considered the substantive elements of business relationships, and they can vary depending on their effects (Håkansson and Snehota, 1995). Some aspects of each dimension are presented below. However, it is vital to point out that these dimensions are closely related.

The first dimension is actors. Actors perform activities and/or control resources. Actors can be individuals, departments, companies or even groups of companies. Each actor can be described according to the activities it performs or controls, the resources it controls and the knowledge it possess in relation to activities, resources and the business network (Håkansson, 1987).

In general, actors aim to increase their control in a business network. There are usually a number of different actors involved in technical development projects with a focal firm. Each actor controls certain resources that can be combined with those of other actors through collaborative partnerships (Håkansson, 1987). Actor bonds connect actors and influence their perceptions of each other, forming their identities (Håkansson and Snehota, 1995). Business relationships can also influence the roles of actors in the network. In this context, actors will take on new roles depending on the relationships that are necessary for their position in the network, value creation and their involvement in the business exchange (Bankvall et al., 2017, Jocevski et al., 2020).

The second dimension is activities. It is noted that actors are the ones that perform activities, meaning they combine, develop or exchange resources. Activity links refer to different types of activities (e.g. technical, administrative, commercial) performed by a company that can be variously connected to those performed by another company during the development of a business relationship. Activities are linked in various ways. While some activities are closely connected, others are only loosely so. Actors and activities are interdependent. Over time, actors become more efficient at performing activities (Håkansson, 1987).

The third dimension is resources. Resources can be physical, financial or human assets (labour, knowledge, relationships). The value of a resource is always dependent on how it is combined with other resources and vice versa. By combining resources, new knowledge can emerge, presenting possibilities for new and improved combinations. Resource ties connect the various resources of two companies. These resource ties are a result of how a business relationship has developed. It is important to note that business relationships can be considered resources in themselves (Håkansson and Snehota, 1995).

Hence, as stated above, the substance of business relationships have been conceptualized in terms of how activities are linked, resource ties and actor bonds (Håkansson and Snehota, 1995). At the network level, tied resources form resource constellations, linked activities shape activity patterns and actor bonds form webs of actors. Håkansson and Snehota (1995) also explain the functions of business relationships. A relationship between two companies can impact and be impacted by other parties/relationships, hence it has functions for: 1) the dyad, 2) the single actor and 3) the network.

Even though the ARA model provides different dimensions and layers, it is worth highlighting that they are all interdependent, the existence of actor bonds being a requirement for the development of activity links and resource ties. Actors, resources and activities can be considered to be embedded in larger network structures. For example, activity links may prevent or reduce the need for resource adaptations, and actor bonds may increase the possibilities of developing activity and resource links. Moreover, major relationships tend to be ‘thicker’ and more complex (Håkansson and Snehota, 1995). While there are some business relationships that are mainly characterized by actor bonds, others result in the development of both actor bonds and resource ties. There are also relationships characterized by strong activity links and weak actor bonds and resources ties. Differences in relationships are usually related to the type of industry they exist in or company-specific circumstances.

Relationship links, ties and bonds are also useful for capturing changes in content and other developments in business relationships (Abrahamsen and Håkansson, 2012, Laage-Hellman et al., 2020). This includes shifts towards more collaborative relationships, requiring extensive resource adaptations, e.g. joint projects, or towards more distant relationships through delinking activities or ending business relationships, e.g., due to sudden changes in actor bonds.

In summary, a business relationship between two companies can be characterized in terms of the three dimensions of the ARA model (activities, resources and actors), and this analytical tool can be useful to assess, predict or explain the importance and role of a relationship (Håkansson and Snehota, 1995).

2.2 Resources, resource combining, strategizing and value creation

Resources have a known or a potential use value to a certain actor (Håkansson and Snehota, 1995), and the value of a single resource depends on how it is used. The actual or potential use of a resource changes when its features are modified or when a combination of resources of which it is a part is altered. Resource development occurs when the use of the resource changes (Håkansson and Snehota, 1995, Holmen, 2001). In this section, different concepts related to resources and resource combinations are presented.

2.2.1 Heterogeneity and resource combination

In the 50s, Penrose (1959) highlighted that the value of a specific resource depends on the services it provides when combined with other resources. According to Penrose, "it is never resources themselves that are the 'inputs' in the production process, but only the services that the resources can render" (Penrose, 1959 p.22). The same resource can be used in different contexts, combined in different ways and provide different services, and this is the basis for the argument that resources can be regarded as heterogeneous. Every resource consists in a bundle of services, and firms combine heterogeneous resources that render the services offered to customers (Penrose, 1959). Several scholars have applied the Industrial Network Approach and the assumption of resource heterogeneity to investigate resource development in interactive business networks (Baraldi, 2003, Lind, 2006, Håkansson and Waluszewski, 2002a).

Assuming resources are heterogeneous, the value of a resource is a question of combination. Combining resources can in principle be done in two ways: first, by combining existing features of the resource in new ways with those of other resources, and second, by identifying and apply new features of an existing resource (Holmen, 2001, Forbord, 2003).

It is through business relatships that two companies interact and combine their resources (Gadde et al., 2012). When a single resource is combined and connected with other resources, it takes on new characteristics (Håkansson and Waluszewski, 2002b). The results of these interactions and resource combinations are also used for further combinations and resource development with the same and/or other business partners (Ford et al., 2003, Håkansson et al., 2009). When seeking new development and tailored solutions, it is observed that there is a need for resource combination and adaptation on both sides, as well as to establish a connection between technologies of production and technologies of use (Gadde et al., 2012).

Considering an industrial product as a resource, from a relational view of resources, flows are not unidirectional and resources are double faced. This means that those resources can be seen as outputs and inputs. From an interactive approach, selling and buying are therefore part of the same process (Håkansson, 1982), and the combination of selling and buying can lead to resource combination and development. As resources have both a provision and a use side, only analysing one side will limit understanding of the potential use of the resource. In fact, many changes and developments in industrial products occur as a result of interactions between buyers and sellers (Håkansson and Snehota, 1995). Interactions facilitate knowledge creation and transfer, which are necessary to discover new economic uses for a resource (Forbord, 2003).

Gadde et al. (2012) point out two critical aspects that can be identified when a resource is connected and combined with other resources. First, new resources have to function in relation to existing resources, as resources do not operate in isolation. For example, a new product or service must fit and work in combination with connected products and services. Second, every resource exists in two settings: production and use. Resources therefore need to function well in both of these settings (Alderson, 1965).

In new business relationships, in which necessary interactions between products and their environments are complex and difficult to predict, several uncertainties emerge. One way to cope with these uncertainties is through experimentation, rather than strategic planning (Gadde et al., 2012). Experimentation can be implemented by developing small-scale projects that involve a number of actors and different forms of interaction. Uncertainty regarding the outcomes of experimental resource development should not be considered wholly negative. In fact, uncertainty can result in outcomes varying from threats, unexpected events and irrelevant consequences to opportunities (Cleden, 2017).

The use of a resource can be improved through resource development when connected actors interact and question knowledge about its features and combinations. Along these lines, new ways of relating a resource to new and existing ones have emerged, resulting in new resource combinations (Forbord, 2003).

2.2.2 Resource interfaces

Resource interfaces are zones where different resources meet and have an impact on each other. In other words, resource interfaces are "the contact points along a shared boundary between at least two specific resources. These contact points influence the technical, economic and social characteristics of the involved resources" (Prenkert et al., 2019 p.141). The characteristics of any resource are determined by its interfaces with other resources. These characteristics determine the way a resource is used, as well as how it can be combined with other resources (Håkansson and Waluszewski, 2002a). It is important to note that not all resource interactions create adaptations or imprints in resource interfaces. For example, a pure exchange does not constitute the creation of a resource interface despite being an example of resource interaction (Prenkert et al., 2019).

The type of interaction pattern impacts how challenges and opportunities related to resource interfaces are handled. Resource interfaces can provide both efficiency and effectiveness depending on their interaction pattern (Waluszewski and Johanson, 2008). There are different types of interaction patterns to which a company can be subject: first, the indirect interaction pattern, which is built on the hierarchy between companies (this can be seen in the economic system in relation to governments or in networks dominated by large national or multinational companies); second, 'thin' interactions, based on traditional market theory and third, 'thick' interactions, which can lead to resource combination (Waluszewski and Johanson, 2008).

Dubois and Araujo (2006) distinguish between technical interfaces, which relate to products and facilities and organizational interfaces, which relate to organizational units and relationships. There are also mixed interfaces, which are those between organizational and technical resources (Jahre et al., 2006). An example of a mixed interface is a relationship developed to establish a connection between a product and a suppliers' expertise (Jahre et al., 2006, Baraldi et al., 2012).

2.2.3 Strategizing and resource combination

Strategizing is about how a company manoeuvres to achieve a favourable position in the business network based on both new and existing relationships. The desire to gain access to resources and achieve a certain network position drives actors' behaviours and strategizing. A network position encloses a firm's relationships and the activity links, resource ties and actor bonds that arise from them (Ford et al., 2003). From this point of view, the position of a firm is determined by external influences. In the context of the Industrial Network Approach, the network position is more important than the market position (Baraldi et al., 2007). However, a network position is only considered to exist if it is perceived and recognized by other actors in the given context (Håkansson and Snehota, 1989).

From the perspective of a focal firm, strategizing requires simultaneous consideration for the heterogeneity of resources and interdependencies between activities across company boundaries as well as organized collaboration between the companies involved (Gadde et al., 2003). Strategizing can be decisive to a firm's opportunities to develop its own capability by drawing on the capacity of others (Håkansson and Snehota, 1995). Strategizing "is demanding but necessary for managers to anticipate future change and identify opportunities for strategic action, since the outcomes of acting are strongly contingent on other firms' actions and reactions in the network" (Abrahamsen et al., 2023 p.1). Strategizing is always an interactive process, for instance acquiring a position in a network requires the creation of new solutions and relationships. This is a relational process, and thus the business strategy of a new firm depends on what its counterparts are willing to concede (La Rocca and Perna, 2014). In this vein, there are several studies in the literature about strategizing and networking that use and/or reference the Industrial Network Approach (Gadde et al., 2003, Holmen and Pedersen, 2003, Baraldi et al., 2007, Harrison and Prenkert, 2009, Ford and Mouzas, 2010, Harrison et al., 2010, Abrahamsen et al., 2012, Aaboen et al., 2013, La Rocca and Perna, 2014, Ritter and Andersen, 2014, Abrahamsen et al., 2016, Öberg et al., 2016, Mosch et al., 2022, Abrahamsen et al., 2023).

One key strategizing task is to identify the scope for action within existing and potential relationships (Gadde et al., 2003). When interacting in business networks, firms make conscious attempts to influence business relationships (see the interaction model in Ford and Mouzas (2010 p. 957)), and these attempts are considered networking (Ford et al., 2003). Firms need to make network choices between different relationships when interacting in a business network. For example, managers need to decide whether to focus on creating new relationships

or consolidating existing ones (Ford and Mouzas, 2010, Ford et al., 2003, Håkansson et al., 2009). Some managers have many relationships in their 'portfolio', and this usually has a collective importance. In this context, managers can take actions that lead to consolidating existing relationships or try to change the structure of existing or new relationships. For example, managers need to decide on either increasing sales and interactions with existing counterparts or prospecting for new customers or suppliers. While it can be challenging, it is sometimes necessary for firms to develop new relationships and/or change the nature of the problems addressed within existing ones (Ford and Mouzas, 2010), such as when starting the process of digital transformation that brings new technologies into play.

According to Gadde et al. (2003), a strategic issue for companies related to the resource dimension is to identify and establish appropriate levels of involvement in their relationships with individual partners. The level of involvement impacts resource combinations, and collaboration becomes essential to create new resource combinations, technical and business solutions and market offerings (Håkansson and Snehota, 1995). Moreover, actor behaviours are contextual and embedded in a business network (for an understanding of how business networks can be related to other theoretical framing of complex business environment, see Möller et al. (2020).

2.2.4 Resource combination and value creation

Value is highly dynamic and cannot be universally defined as a concept, as there are different perspectives on value, each relying on a different definition (Forsström, 2005) . Defining the value of a resource is contextual and depends on specific combinations of single resource features and how these relate to features of other resources when used (Prenkert et al., 2022). Value may take different forms, such as knowledge, safety and profits.

In fact, interactions between actors in business networks determine the identification of solutions, and thus value creation (Håkansson et al., 2009). Depending on how resources are combined and developed, interaction can create value for an individual firm (actor) and/or span firm boundaries (Håkansson and Waluszewski, 2002b, Lind et al., 2012). Hence, relationships with other actors can influence, configure and sustain the value creation process (La Rocca and Snehota, 2014).

Actors all perceive value differently (Cantu et al., 2012) and will assess value differently for themselves and their counterparts. Forsström (2005) makes a distinction between value (i.e. perceived value) and value creation. Perceived value is a subjective assessment of the trade-off

between benefits and sacrifices at a given point in time in a specific context. Value creation is the process through which buyers and sellers make use of each other's resources with the aim of creating value.

Three forms of value related to customer retention are provided by Flint et al. (1997). First is the abstract perspective of 'value', which consists of implicit beliefs that guide behaviour, hence making value specific to each customer. Second is 'desired value', which is a less abstract view of value and comprises what a customer wants to happen (benefits sought). Third is 'value judgment', an assessment of what has happened (benefits and sacrifices). Value judgment is an overview of trade-offs between benefits and sacrifices in actual terms and relates to the interaction between customers, products/services and a specific use situation.

Ulaga (2001) states that there are three different perspectives on 'customer value': the 'buyer perspective', in which value is created through products and services; the 'seller perspective', in which value is created through customer equity, as the customers are the key assets of a firm; and the 'buyer-seller perspective', in which value is created through networks when buyers and sellers create value jointly through relationships, partnering and alliances.

Borys and Jemison (1989) define value creation as "the process by which the capabilities of the partners are combined so that the competitive advantage of either the hybrid or one or more of the partners is improved" (p. 241). Håkansson and Prenkert (2004) conceptualize a number of types of activity systems involving value-creating processes with different outcomes. They provide a framework with four basic types of business exchange activity systems: buying/selling, producing/using, cooperation and networking. The authors argue that there are two different value-creating processes involved in business exchange: the process for creating exchange value and the process for creating use value. 'Exchange value' is related to how efficiently a transaction or resource exchange is performed, while 'use value' relates to how well the parties make use of each other's resources.

Building on Håkansson and Prenkert (2004), Forsström (2005) explains that value is created by exploiting different types of interdependencies, either to achieve a more efficient exchange or more effective use of each other's resources. She emphasizes that value co-creation in a buyer-seller relationship can only be achieved if there is interdependence between the companies. If there is interdependence, and a positive trade-off between the benefits and costs of involvement, there exists value co-creation potential. This potential is realized through exploiting interdependencies to create exchange value or use value. Hence, exploiting

reciprocal interdependencies is necessary to access and make use of resources and co-create exchange value, in the form of greater efficiency, and use value, in the form of more effective resource use. Interdependence should hence be seen as a key resource that enables value co-creation potential.

Studies of efficiency that have applied the Industrial Network Approach have focused mainly on the activity dimension (Håkansson and Snehota, 1995). Efficiency can be achieved through interlinking activities, creative use of resource heterogeneity and mutuality based on actors' self-interest (Anderson et al., 1994). Efficiency can be considered a result of changes in resource use. When interdependence between activities prevails, resource control is not needed for firms to be efficient. In studies of efficiency, resources are conceptualized in broad terms (for example, relationships, machinery, tools and personnel are all considered resources), and aspects of resource sharing related to activity chains, resource utilization, resource unit, resource improvements and resource development are highlighted (Dubois, 1998).

Innovation can also be seen as value created. The resource dimension is a common focus when studying innovation using the Industrial Network Approach. Innovation has been considered a result of resource interactions and combinations. See for example Lind et al. (2012), Landqvist and Lind (2019) and Ingemansson (2010) Interaction refers to the creation of linkages between resources that are interconnected in a network context. This process can include more or less complex patterns, ranging from simple exchange to mutual adaptations between actors (Håkansson, 1982).

Different types of values can be obtained by a focal firm when resources are used and developed. For instance, in the context of projects, resource combination can create direct value, indirect value, relational potential value and transactional potential value (Lind et al., 2012). Nevertheless, due to the complexity of the network context in most cases, it is not clear for all actors how to capture the value in the network (ibid.).

2.3 Digital transformation

The concept of digital transformation has now been widely used by practitioners and academics from different areas. Several management scholars, such as those in marketing management, strategic management, innovation management and operation management, have also studied, conceptualized and applied the concept of digital transformation in various ways (see Verhoef et al. (2021)).

Due to the wide use of the concept, it is not clearly defined in the literature. Therefore, the author sees a need to clarify how concepts and terms related to digital transformation are applied throughout this thesis and its appended papers, as presented below. Based on a review of the literature and the context and requirements of the present study, Table 1 presents how the terms 'digitization', 'digitalization', 'digital transformation', and 'digital servitization' are used throughout this thesis and in the appended papers.

Table 1 Definitions of digitization, digitalization, digital transformation, and digital servitization in this thesis

Digitization	Digitization is the replacement of processes or tools with digital equivalents. The use of this term in the thesis and appended papers is limited.
Digitalization	Digitalization refers to the combination of different resources, with at least one resource being a digital technology (e.g. cloud platforms, IoT, big data). These combinations allow the creation of new product offerings.
Digital transformation	Digital transformation is a process that changes a business through the application of new digital technologies. Digital transformation creates new value for the actors involved and changes business relationships and business models.
Digital servitization	An empirical phenomenon by which manufacturing companies make use of digital resources to create new services, generate new resources combinations and create value in business networks. It can be seen as one type of digital transformation. The term 'digital servitization' has been used in Paper I and Paper II.

It is noted that these definitions are interwoven, especially 'digitalization' and 'digital transformation'. The above definitions are a guide for the use of these terms in this work. 'Digitalization' is applied mainly when referring to the combination of resources. However, in the case of more radical changes to a business model driven by digital technology, value creation and/or changes in business relationships, the term 'digital transformation' has been preferred. More details about the terminology and concepts related to digitalization are presented below.

2.3.1 Digital technology, digitization and digitalization

Digital technologies are those that involve bitstrings (Faulkner and Runde, 2019) and are usually electronic tools, systems and devices that can create, store, transfer and process data. Examples of digital technologies include big data, artificial intelligence (AI), blockchain, IoT, robotics, analytics, cloud platforms, additive manufacturing, drones and digital twins (Wedel and Kannan, 2016, Aryal et al., 2020, Ng and Wakenshaw, 2017, Langley et al., 2020, Paiola and Gebauer, 2020, Rogers et al., 2016, Ivanov et al., 2018).

Rachinger et al. (2019) define digitization as the process of converting analogue data into digital data sets. In this fashion, digitization is the framework for digitalization, which the authors define as the exploitation of digital opportunities. Digitalization often combines multiple digital technologies (e.g. cloud platforms, IoT, big data, 3D printing) and opens up a wide range of opportunities, facilitating the creation of radically new products, services and business models (ibid.). Digitization is considered the first step towards digitalization.

In a similar vein, Holmström et al. (2019) distinguish digitization from digitalization. They describe digitization as the straightforward replacement of discrete processes or tools with digital equivalents. On the other hand, digitalization is defined as the use of digital information to fundamentally revisit intra- and inter-organizational decision-making, processes and architectures (Holmström et al., 2019). Verhoef et al. (2019) define digitization as the action of converting analogue information into digital information, e.g. the use of digital forms in ordering or digital applications for internal financial declarations. Digitalization, in turn, is described as the way in which digital technologies can be used to modify existing business processes, e.g. the creation of a new online communication channel to allow all customers to connect to firms through digital technology. In this example, the implementation of a new communication channel demands the organization of new sociotechnical structures and a digital technology deployment.

While digitization makes data available in a digital format for processing (Iansiti and Lakhani, 2014, Coreynen et al., 2017, Hsu, 2007), digitalization can impact business models by enabling new connections between customers and firms (Pagani and Pardo, 2017), changing relationships (Vendrell-Herrero et al., 2017) and creating new value for customers or new business opportunities. From a process perspective, digitalization can impact business models

by improving business processes (e.g. quality, products; (Li et al., 2016) and enabling the interconnection of products and production systems through global product networks.

2.3.2 Digital transformation and digital servitization

Research on digital transformation has studied its effects not only on organizations but also in relation to ethical, societal, sustainable and regulatory trends (Bounfour, 2016, Gomez-Trujillo and Gonzalez-Perez, 2022). Digital transformation implies changes in key business operations that affect products, processes, organizational structures and management concepts (Matt et al., 2015). Using a literature review, Vial (2021) provides a framework of digital transformation, considering it a process by which "digital technologies create disruptions, triggering strategic responses from organizations that seek to alter their value creation paths, while managing the structural changes and organizational barriers that affect the positive and negative outcomes of this process" (Vial, 2021).

In a broader sense, digital transformation is about the changes that digital technologies have on a whole, i.e. how companies operate, interact and are configured, and how wealth is created within these systems (Reddy and Reinartz, 2017). In the context of digital transformation, company boundaries are constantly evolving and the rate of innovation is increasing due to customer demands and technological opportunities (Reddy and Reinartz, 2017). However, as digital transformation is a complex process, for instance poor strategy may hinder companies starting their digital transformation journey, while security issues become a greater concern for maturing digital companies (Kane et al., 2015).

Internal and external resources and capabilities need to fit the demands of digital transformation (Liu et al., 2011). According to Parviainen et al. (2017), changes brought by digital transformation can occur at four different levels. The process level involves the adoption of new digital tools and streamlining processes by reducing manual steps. The organizational level involves offering new services and discarding obsolete practices, as well as offering existing services in new ways. At the business domain level, digital transformation changes roles and value chains in ecosystems. Finally, at the societal level, it can change social structures (e.g. type of work, means of influencing decision-making; (Parviainen et al., 2017 p.67).

Digital transformation is occurring more rapidly in some industries than others. The travel and publishing industries, for instance, were quick to embrace digitalization and digital sales. However, in the manufacturing industry, which is the focus of this thesis, it has taken longer for companies to master digitalization in the context of their operations and business models

(Björkdahl, 2020) and to turn digital technology into a business advantage (Harbert, 2021, Westerman et al., 2014).

From a marketing perspective, Verhoef et al. (2021 p.899) define digital transformation as "the process of changing the business by using new digital technologies to reshape customer preferences, create new value for customers, change firm relationships, and develop new value propositions". It has become very common for new services based on digital technologies to be created by manufacturing companies that are now selling digital solutions instead of traditional products. In this context, the term 'digital servitization' has been used to describe the process of manufacturing companies transforming their portfolios using digital technologies to shift from product- to service-centric business models and logic. Hence, digital servitization (Luz Martín-Peña et al., 2018, Kohtamäki et al., 2019, Kamalaldin et al., 2020, Sjödin et al., 2020, Tronvoll et al., 2020, Paschou et al., 2020) is treated as a type of digital transformation in this thesis.

2.4 Digital transformation using the Industrial Network Approach

Studies that apply the Industrial Network Approach have focused not only on technology in broad terms but also on information technology and digital technologies. Two decades ago, scholars started to use the Industrial Network Approach to study the impact of digital technologies in general on business networks and business relationships (Baraldi, 2001, Baraldi, 2003, Salo, 2003, Baraldi and Nadin, 2006, Salo et al., 2010).

More recently, researchers have started to study the digital transformation process using the Industrial Network Approach. Digital changes and business relationships in a B2B context have been conceptualized with the use of the ARA model (Pagani and Pardo, 2017). In the manufacturing industry, changes and value creation achieved through digital transformation in industrial networks have been explored (Fremont, 2021). Other studies have focused on the interplay between digitalization, relationships and networks (Frick et al., 2020, Ritter and Pedersen, 2020), resource interaction and digitalization (Fremont et al., 2019, Kot and Leszczyński, 2020), network dynamics in IoT (Andersson and Mattsson, 2015) and the impacts of digitalization on buyer-seller relationships (Salo et al., 2020). More recently, scholars have focused on understanding network roles and how companies strategize in digitalized business networks (Mosch et al., 2022), how industrial markets can be seen as both business networks and networks of connected things (IoT) (Pardo et al., 2022) and the role of customers in the development of smart products (Sabatini et al., 2023).

Pagani and Pardo (2017) used the ARA model (Håkansson and Snehota, 1995, Håkansson, 1987) as a basis to identify the different types of changes triggered by digitalization on any networked actor. In their study, digitalization refers to companies' adoption of IT-based solutions, mainly using the Internet; they developed a framework that regards digital changes in a B2B context. According to this framework, there are three types of digitalization. The first is 'activity-links-centred digitalization', which represents a condition in which the primary impact of a digital resource is on the links between activities. In this type of digitalization, the digital resource is used to optimize activities performed by existing actors (e.g. Coca Cola's CRM platform). The second type is 'resources-ties-centred digitalization', which is characterized by digital resources that support the creation of new activities performed by existing actors. When actors combine their digital resources, new activities occur between them (e.g. Volvo Construction Equipment's connected objects). The third type is the 'actor-bonds-centred digitalization', by which new bonds are created between actors through a new actor taking a position in the network. New connections between actors are created through the use of the digital system implemented by the new actor (e.g. marketplaces; (Pagani and Pardo, 2017 p.189)).

Fremont (2021) investigates the introduction of digital technologies in the context of manufacturing firms and how this results in a complex technological and organizational structural change process that he refers to as digital transformation. The author points out that the digital transformation process affects many aspects of industrial networks, from single product functionality and production process efficiency to inter-firm business interactions, and consequently affects value creation in the industrial network. Fremont (2021) identified three distinct stages of this complex change process: initial, transitionary and ideal. In the initial stage, small changes may start to drive conflicts or opposition to existing resource structures. In this way, a diverging path is established, which in turn may separate resources from established structures. During the transitional phase, resource structures, the fundamental structures of industrial networks, are deeply and irreversibly changed. They aim to introduce new resource structures that conflict with or replace established resource structures throughout the industrial network. Finally, in the ideal stage, the industrial network reverts to a state of incremental change. However, it is important to notice that the ideal stage is also characterized by preparations for the initial stage of a new cycle of structural changes. As these cycles tend to repeat, incremental changes may eventually lead the network to trigger new structural changes (ibid.).

2.5 Problem discussion and research questions

As mentioned above, digital transformation is a relational process in which collaboration between actors in business networks is key. However, value creation in business networks as a result of digital transformation is a process that cannot be taken for granted. Developing and embedding a new digital technology in existing business networks and resources, formed by existing products, distributors, production lines, customers and suppliers, is far from an easy task for manufacturing firms. It invariably results in significant changes to business relationships, interactions and resources, and a period of instability should be expected by manufacturing firms that are starting or undergoing digital transformation, see Fremont (2021).

The ARA model presented (Håkansson, 1987) has proven to be a useful tool for analysing business relationships in transformation through its three separate analytical dimensions: actors, resources and activities, see Pagani and Pardo (2017). Considering that this study focuses on the early phases of digital transformation, it seems reasonable to assume that the resource and actor dimensions will be heavily affected by new developments that are needed when transitioning through the phases. This is because the development of new offerings and initial phases of transformation usually involve a great deal of resource combination between different actors. Studies that explore resource combination and try to characterize and investigate the interplay between a *digital* resource and other resources are needed. Although digital resources are important building blocks for any digital transformation process, how the intrinsic features of a digital resource can impact combinations and value creation is a topic currently missing from the literature.

It is known that within a firm, the use and development of a resource is limited by the firm's collection of resources (Håkansson and Snehota, 1995). Hence, to expand the development and use of new digital technologies, interaction between actors is a requirement. In this context, companies undergoing a digital transformation need to strategize in business networks (Gadde et al., 2003) and build business relationships to access the other actors' resources (Håkansson and Snehota, 1995), which can be digital or non-digital. By strategizing and accessing new resources, manufacturing companies achieve new network positions. Since digital transformation introduces new dynamics and digital resources to the business setting, manufacturing firms' resources are continuously being exchanged, combined and developed through interaction with other actors in the network during the process. The pursuit of new resource combinations during digital transformation is thus motivated by the potential for value creation for the actors involved in the business network.

As mentioned above, it should be expected that digital transformation will put additional requirements on manufacturing firms' strategizing and related resource combination. However, it is still not clear how this strategizing process and resource interactions happen in business networks during the early phases of digital transformation. It is also not clear how value can be created in the business network. There is a need to investigate the "impact of digitalization on business relationships" (Ritter and Pedersen, 2020 p.188) and addressing this need is one goal of this study.

To understand the impact of the digital transformation on business relationships and value creation, a study of how digital transformation occurs, how a focal manufacturing company acts to achieve a new network position and how resources are combined and value created in the context of the early phases of digital transformation is proposed. As a result, the following research questions have been formulated:

RQ1: How are resources characterized in digital transformation in business networks?

RQ2: How are resources combined in digital transformation in business networks?

RQ3: How is value created from combining resources in digital transformation?

RQ4: How are strategic actions taken when combining resources in digital transformation?

3 METHODOLOGY

This chapter presents the methodological considerations and methods applied in the studies that form this thesis.

3.1 Research context

The research presented in this thesis was performed as part of the project Transitioning to IoT-enabled circular production systems and value chains (IoTCirProd), financed by VINNOVA. The project timeline is April 2021 to April 2024. The project consortium is formed by three global manufacturing companies, one small-medium enterprise (SME) acting in the area of information technology (IT), the research institute RISE and Chalmers University of Technology. The research team at Chalmers is formed of three senior researchers and one PhD student.

Chalmers University of Technology initiated the idea of this project. The author was involved with the project from the start of the fund application process and also participated in the formation of the consortium. All the manufacturing firms involved in the project have demonstrated an interest in developing knowledge about the topics of digitalization and/or circular economy. Two of the companies are currently advancing initiatives related to digitalization and/or circular economy (MANUFACTURING FIRMS 1 and 2), while the other is still in the investigation phase (MANUFACTURING FIRM 3). MANUFACTURING FIRM 1 was invited to join the project by the author, who conducted their master thesis work at the company some years ago and was aware of their current initiatives related to digital transformation. The author identified the interests of MANUFACTURING FIRM 2 in the area of digitalization from reading academic papers that used MANUFACTURING FIRM 2 as a case company. The Chalmers research team and the author approached MANUFACTURING FIRM 2 and invited them to join the project application. MANUFACTURING FIRM 3 was invited by MANUFACTURING FIRM 2 to take part in the IoTCirProd project. Representatives of RISE and the IT company (SME) were invited by other members of the Chalmers research team to be project members.

Having a background in project management, the author also acted as the substitute for the project manager and managed the project when the project manager was on holiday or parental leave. She also organized and led the first project workshop in February 2021.

An initial topic of inquiry for this thesis was developed based on the focus of one of the work packages of the project on IoT: business relationships and network. The thesis topic was further developed through the application of the systematic combining approach (Dubois and Gadde, 2002), and the focus became understanding the effects of digital transformation in resource combining and strategizing. More details of this development are provided in 3.4.1.

3.2 Research design

The research questions that have led the investigation were explorative. The aim was to contribute to Industrial Network Approach-related literature, and the design of the study was established by focusing on the intended theoretical contribution and research questions. Following the recommendations of Bluhm et al. (2011), careful consideration was given to the theoretical purpose of contributing to the Industrial Network Approach from the outset of the study. As the goal was to understand how resources are combined and strategic actions taken, it was recognized that an in-depth study of the phenomenon in its real-life context was necessary. Accordingly, a single case study method was applied; this involves "investigating one or a small number of social entities or situations about which data are collected using multiple sources of data and developing a holistic description through an iterative research process" (Easton, 2010 p.119).

Using a single case study method provided access to a rich source of data and empirical evidence in the context of digital transformation. As Dubois and Gibbert (2010) pointed out, there are three main dimensions of research with regard to case studies: theory, case method and empirical phenomena (see Figure 2). The results of the combination of these dimensions represents the contributions of the work.

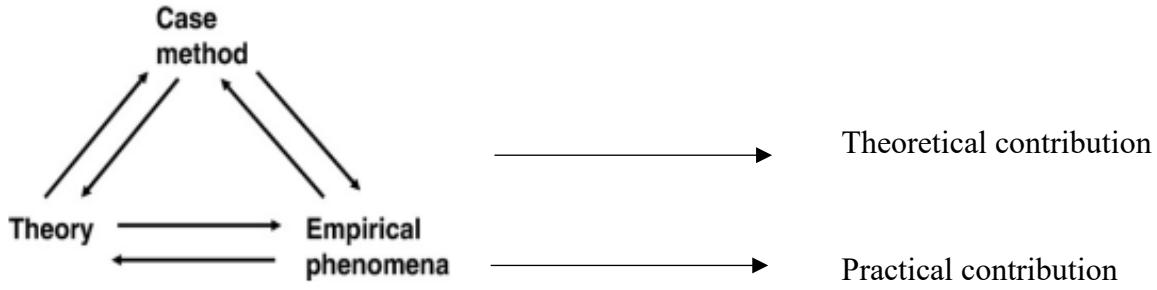

Figure 2: Three dimensions of research and contributions, adapted from Dubois and Gibbert (2010 p.129)

As per the 'theory dimension' (Figure 2), different models and lenses from the Industrial Network Approach toolbox were applied to the 'empirical phenomena dimension', which

provided a variety of illustrations from many angles about the development of the business network during the digital transformation of MANUFACTURING FIRM 1.

MANUFACTURING FIRM 1, and the respective business network related to its digital transformation, was chosen as the focal firm for the three studies performed. The focus on MANUFACTURING FIRM 1 was key to facilitating a detailed analysis of its context using different frameworks, literature streams and concepts within the Industrial Network Approach (e.g. supplier interfaces, resource combining and strategizing). The findings from the appended papers and the framework presented in this thesis (see Section 7.2) were developed based on analytical generalization of single case research (Andersen et al., 2018).

The research setting was thus defined as a business network within which a manufacturing firm was undergoing the process of digital transformation, in other words interacting with buyers and suppliers and using digital technologies to offer new digital services and enhance their product offerings. The focal firm perspective is shown to be effective for the purpose of studying business relationships. Taking the perspective of the focal firm, the main unit of analysis was the focal business network, formed by the relationships of MANUFACTURING FIRM 1 (see Figure 3). This way, the main effects on the business relationships that might have relevance to the focal firm and the study of digital transformation in question could be captured. As expected, the boundaries of the focal business network of MANUFACTURING FIRM 1 were determined by perception, in other words its network horizon (Håkansson and Snehota, 1995).

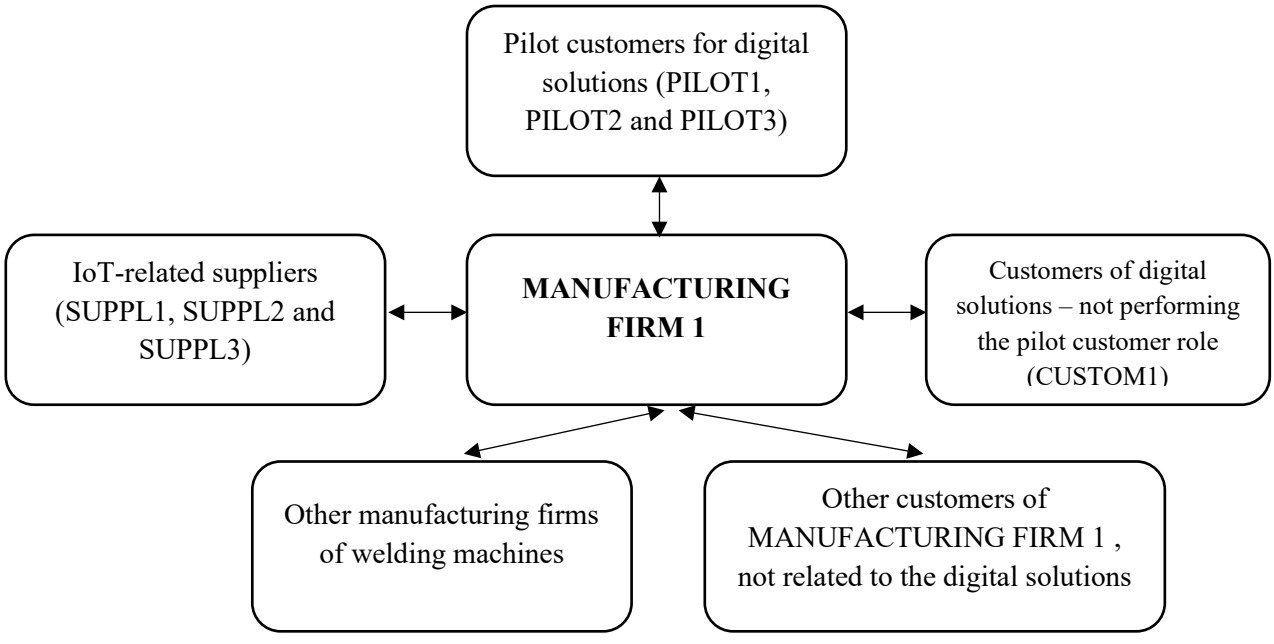

Figure 3: Business network of which MANUFACTURING FIRM 1 is a part

Other reasons MANUFACTURING FIRM 1 was selected as a focal case company included it being relatively advanced in the process of digital transformation and having started to commercialize digital solutions (unlike Manufacturing firm 3, for example). It was also internally focused on the question of digital transformation and maintained ongoing dialogue and interactions with both suppliers and (existing and potential) customers. Since the researchers were interested in investigating current business relationships, it was very important that a business network already existed and that digital services were not just plans for the future. Moreover, MANUFACTURING FIRM 1 also had sufficient availability to take part in the study for the required period. The collaboration between Chalmers and MANUFACTURING FIRM 1 began in April 2020, one year before the official start date of the IoTCirProd project. MANUFACTURING FIRM 1 is a global supplier of consumable products and equipment for use in welding and the cutting of steels, aluminium and other metals and metal alloys. More details of the business are provided in the case description chapters of the appended papers.

3.3 Research method and data collection

The research consisted of semi-structured interviews, literature reviews and other sources of data.

3.3.1 Semi-structured interviews

Semi-structured interviews were selected as the main method for data collection as they provide a flexible but structured method of obtaining a rich set of data for analysis (Kallio et al., 2016). During most of the interviews, two or three researchers participated. The data collection started in spring 2020 and ended in summer 2022. Information about the interview guides is included in the appended papers. The interviews that generated the data for each of the three papers are presented in the table below:

Table 2: Interview list

	Interviewee	Organization	Date of the interview	Papers that used the interview data
1	R&D manager Digital Solutions	manufacturing firm 1	2020/08/12	Paper I, Paper II, Paper III
2	Product Manager Digital Solutions	manufacturing firm 1	2020/08/26	Paper I, Paper II, Paper III
3	Supply Chain Leader	manufacturing firm 1	2020/08/26	Paper I, Paper II, Paper III
4	Aftermarket leader	manufacturing firm 1	2020/09/08	Paper I, Paper II, Paper III
5	Global Director of Supplier Development	manufacturing firm 1	2020/09/11	Paper I, Paper II, Paper III
6	R&D Manager Welding Equipment	manufacturing firm 1	2020/09/11	Paper I, Paper II, Paper III
7	VP Business Development	supplier 3	2020/09/12	Paper I, Paper II, Paper III
8	R&D Manager Digital Solutions	manufacturing firm 1	2020/09/22	Paper I, Paper II, Paper III
9	General Manager Digital Solutions	manufacturing firm 1	2020/09/23	Paper I, Paper II, Paper III
10	Product Manager Digital Solutions	manufacturing firm 1	2020/09/28	Paper I, Paper II, Paper III
11	Product Manager Automation	manufacturing firm 1	2020/09/28	Paper I, Paper II
12	Product Manager Solid Wires	manufacturing firm 1	2020/09/30	Paper I, Paper II
13	CEO	it-related SME	2021/05/05	Paper I
14	CEO	it-related SME	2021/05/12	Paper I
15	Digital Solutions Product Manager	manufacturing firm 1	2022/02/25	Paper II, Paper III
16	Global Welding Equipment Director	manufacturing firm 1	2022/02/25	Paper II, Paper III
17	R&D Manager Welding Equipment	manufacturing firm 1	2022/03/17	Paper II, Paper III
18	IoT Technical Specialist	supplier 2	2022/03/17	Paper II
19	Product Manager – WeldCloud Notes	manufacturing firm 1	2022/06/22	Paper II, Paper III
20	Process Manager, Metallurgic Engineer, Mechanical Engineer, Process Worker	pilot customer 1	2022/07/07	Paper II, Paper III

3.3.2 Literature studies

Literature reviews can help researchers gain a better understanding of a subject of study, especially in the early phase of a research project (Bell et al., 2022). In this research, literature reviews were conducted in all three studies presented in the appended papers. The topics covered in the literature review for Paper I were supplier interfaces and technology strategy, resource combining and resource interfaces, and characterizing IoT suppliers. In Paper II, the literature review synthesized knowledge about uncertainties in business relationships and networks and strategizing to cope with uncertainties of digital servitization. Paper III presents a literature review of the Industrial Network Approach, including resource interaction in business networks and value creation in business networks, as well as a literature review of key characteristics of digital resources.

3.3.3 Other source of data

Besides the interviews and literature studies, data were collected from other sources. These included confidential power point presentations, documents provided by the interviewees, industry reports and information from the firms' websites and served as a base for understanding the effects of digital transformation on business relationships. Additionally, the author participated in two workshops organized by the IoTCirProd project (February 2022 and August 2022) in which MANUFACTURING FIRMS 1, 2 and 3 took part to discuss challenges and opportunities related to digitalization and the development of new circular business models. The first workshop was an online event, while the second was held at a university campus in Sweden.

3.4 Research process

3.4.1 Description of the research process

From the beginning of the research process, it was known that the goal of the study was to investigate the interorganizational relationships involved in digital transformation. The application of the Industrial Network Approach, with its related assumptions and concepts, was a natural choice from the outset of the study. However, two big questions emerged at this point: 1) which concepts from the Industrial Network Approach toolbox should be used? And 2) should the Industrial Network Approach be combined with other approaches from the literature, such as operation management or information systems, and if so how?

Systematic combining (Dubois and Gadde, 2002) was chosen as the research process, and its application was helpful when answering the two questions that arose at the start of the study.

Systematic combining constitutes an abductive approach to a case study that entails a constant development of the empirical scope and theory (Dubois and Gadde, 2002). Systematic combining involves two main processes: a) matching between the theoretical and the empirical domains, and b) direction and redirection between the framework and case. In this way, matching between the theory and reality is dependent on the matching of the evolving case and framework. "The reason to that the framework is evolving during the study is because empirical observations inspire changes of the view of theory and vice versa" (Dubois and Gadde, 2002 p.558). As a result of these changes, the process of direction and redirection is required.

The theoretical concepts from the Industrial Network Approach were refined through interplay with the empirical study, and after a number of cycles of matching, direction and redirection, the main concepts and ideas to be included in the three studies were selected: supplier interfaces (Araujo et al., 1999) for Paper I, strategizing and uncertainties (Ford and Mouzas, 2010) for Paper II and resource combination and value creation for Paper III (Håkansson and Snehota, 1995, Lind et al., 2012). More details about the circular process of matching, direction and redirection during the development of this research are presented below.

Redirection in theory: Selecting and changing concepts and units of analysis

While the concepts of business networks and business models were initially both included in the framework of the study, it was decided that the concept of business models should be omitted, following a presentation of the research proposal and discussions within the research group, to keep the focus on business networks and digitalization. Paper I and Paper II were developed simultaneously. The concepts of supplier interfaces used in Paper I were chosen early in the process, and they fit the study well throughout. However, Paper II required additional cycles of matching between the case and theory. Initially, business relationships was selected as the main analytical concept for Paper II. However, after matching with the empirical case, it was decided that the concept of business relationship in broad terms should not be the focus of the paper. Ideas about combining the Industrial Network Approach with operation management theory emerged, and the concepts of uncertainties, bridging and buffering were selected and tested against the case as it evolved.

Redirection in the empirical case: Changing conditions in the IoTCirProd project

As previously mentioned, this research is part of the IoTCirProd project, in which three manufacturing firms are taking part. The initial idea was to run a multiple case study, with at least two manufacturing companies. This idea of running a multiple case study was even

included in the research proposal. It was also intended that some resources from the project would be applied within the current study, with a dual perspective of digitalization and circularity then being pursued. However, changes to the project resources in 2022 resulted in the focus on circularity being pared back. In the same year, one manufacturing firm requested to reduce their participation in the project due to the lack of resources. These events triggered discussions in the research group about how to continue the investigation into business networks. Following discussions, the supervising group and author decided that it would be more fruitful to focus on a single focal company in the study and explore the business network of this focal company instead of studying two business networks. This way, it was decided that this study would constitute a single case research and not a multiple case study. The focus on circularity was dropped in favour of a singular focus of digitalization. The author participated in several discussions and interviews with MANUFACTURING FIRMS 2 and 3, but the outcomes of these discussions have not been included in this licentiate thesis and instead currently form the basis for another conference paper.

Redirection in theory: Focus on the Industrial Network Approach as the main theoretical lens for the licentiate thesis

After testing the possibilities of combining the concept of uncertainties (bridging and buffering), from operation management literature with the Industrial Network Approach in Paper II, the research team decided not to combine the Industrial Network Approach with any other theory, at least for the purposes of this licentiate thesis. A PhD course in the Industrial Network Approach taken in parallel with this work provided the author with an opportunity to gain deeper knowledge about business relationships and business networks. The toolbox provided by the Industrial Network Approach was seen as sufficient for the purpose of the study. The analytical concepts ultimately selected for use in Paper II came from the strategizing literature within the Industrial Network Approach. Nevertheless, some inspiration from information systems literature was included in Paper III, but not with the aim of combining theories or literature. The main framework retained an exclusive basis in the Industrial Network Approach for the three appended papers. Information system literature was selected as a suitable source of inspiration for understanding and conceptualizing the ‘digital resource’. The decision to use this as a source of inspiration was reinforced following the conclusion of the author’s PhD course Frontiers in Digital Innovation Research Phenomena, Theories, and Approaches in 2022. The course was organized by members of the information system research community and was offered by the Swedish Center for Digital Innovation (SCDI). Readings

and learnings from this course served as a source of inspiration for the study presented in Paper III on resource combination involving digital resources.

Redirection in the empirical case: Adding a new focus in the case – customers of IoT-enabled digital offerings

In 2020, at the beginning of the research project, the focal company was in the early phases of its digital transformation and therefore focused on developing IoT technology and IoT-enabled digital offerings. At that time, the new software applications were mainly being tested by pilot customers, with few solutions being commercialized. In 2023, it has been observed that more and more customers are connecting their machinery to the Internet and using IoT-enabled digital offerings. Hence, the focus of the study should be changed from the development of relationships upstream (with suppliers of IoT technology; see Paper II) to the development of relationships with new customers starting to engage with the digital era.

Redirection in the theory: Greater focus on the Industrial Network Approach, especially in the resource dimension

Two main points were crucial in the decision to turn the focus of the research project toward the 'resource dimension'. Firstly, the development of Paper III and the conceptualization of 'digital resources' from the Industrial Network Approach, which was shown to be an interesting and promising avenue for future research. The paper was presented at the 2022 IMP Conference and was well received, reinforcing the conviction of the research team. Secondly, the inspiration came from the PhD course 'The Industrial Network Approach' that the author completed in February 2023. On this course, the author learned more about the roots of the theory and became aware of different types of research and theses that made use of the Industrial Network Approach toolbox exclusively. Knowing the opportunities and possibilities provided by the Industrial Network Approach to the study of interorganizational relationships, in the context of digitalization, was key to the preliminary decision of the research group and author to work within the Industrial Network Approach framework for future studies up to the doctoral defence.

At the same time as following these redirections, in terms of the theory and empirical case, the three appended papers were written for this licentiate thesis. The next step was to select the concepts that best explain the main findings of the thesis as a whole. The resource dimension was firstly chosen to be one of the main concepts for consideration in the thesis, which is aligned with the most recently mentioned redirection 'focus on the resource dimension and on

the Industrial Network Approach'. In the thesis, the resource dimension enables an analysis of the nuanced characteristics of digital resources, the identification of different types of resource combinations in digital transformation and a recognition of the value creation process that takes place in the business network.

Secondly, strategizing was identified as an important analytical concept to be included in the thesis. Strategizing was seen as key mainly during data analysis for Paper II, which showed how a focal firm takes strategic actions in relation to selected actors aiming to create and consolidate elements of the business relationships.

Resource combination, value creation and strategizing were thus identified as building blocks for the analysis in the thesis. These analytical dimensions were used to explore changes in business relationships during the initial phase of the digital transformation process.

3.4.2 Reflections on the research process

Over the course of this journey, the author has encountered a broad range of literature, concepts and related theories, e.g. knowledge about business model concepts and theories, 'bridging' and 'buffering', digital innovation theories and circular economy theories. Several theories and concepts were ultimately discarded from the thesis through matchings and redirections. The author also had extensive access to empirical data and, through participation in the IoTCirProd project, had the chance to understand the digitalization strategies not only of the focal manufacturing firm and related business network but also of the digitalization and circularity strategies of manufacturing firms 2 and 3, which were also part of the IoTCirProd project. As before, data from manufacturing firms 2 and 3 were not included in this thesis.

It is the author's belief that this thesis, including the related concepts chosen and empirical case, represents a successful research work and that matching has been achieved. The author learned much from this process, and although not all the knowledge gained through access to data and theory was used in the final thesis it has indirectly contributed by opening up new perspectives; supporting workshops, discussions with managers and the development of papers beyond those appended in this work; and facilitating participation in conferences and seminars. The time invested studying different concepts, theories and 'matching' opportunities for the empirical case has been a source of growth and learning. This is what inspired the author to return to academia after years of working in industry.

The matching process was also crucial to ensure the quality of the study. Decisions made with regard to matching and redirections were always discussed within the research group, and the

consensus that the authors reached often yielded a richer result through the contribution of different perspectives, backgrounds and ideas. This has been a collaborative work, and decisions were always made through discussion and with consideration for the empirical world and focal theorical concepts.

Regarding the empirical context of digitalization, it is important to mention that it was a challenge to select the terms and perspectives used to explain the empirical phenomenon. Digitalization is an area that has been researched for many years and from different research streams. As a result, the nomenclature around the topic is abundant and somewhat confusing. It is not clear, either in the Industrial Network Approach or other research streams, how the phenomenon of digitalization in its various forms should be termed. Section 2.3 includes an explanation of how different terms were used in this work. If this work should be about digitalization, digital transformation, digital servitization or something else has been the subject of long discussions both within the research group and in seminars, lectures, conferences and talks with other senior researchers and those within the field of IMP. It is hoped that the result of these discussions and the final decision on the terms used, which are summarized in Section 2.3, can shed light on how the challenging process of referring to the context of digitalization in studies focused on interorganizational relationships was tackled.

3.5 Reflections on quality

Case studies are the most common method used in studies of industrial networks (Easton, 1995, Dubois and Araujo, 2004, Halinen and Törnroos, 2005). The study required a set of 'how' questions capturing details about different business relationships within the context of digital transformation. By doing a case study, the researchers were able to conduct a deeper analysis and gain a more detailed understanding of the dynamics that define the setting (Halinen and Törnroos, 2005). This was beneficial for the purpose of increasing understanding of how resources are combined, value created and strategic actions taken in the context of digital transformation.

At the same time, there are issues and dilemmas related to research quality and validation of single case research that qualitative researchers need to overcome (Andersen et al., 2018). In this research, different strategies were applied to ensure quality and reliability (Flick, 2018); these strategies are discussed below.

First, as suggested by Flick (2018), the work has been presented for external evaluation and critique on an ongoing basis to get feedback for improvements and quality assurance. The work

has been presented at several international conferences, in doctoral workshops at Chalmers (at both departmental and research group levels) and in workshops for MANUFACTURING FIRM 1. This work was also exposed to the scientific community for evaluation in other ways: PAPER I underwent the peer-reviewed journal process, and following a number of rounds of review was published. The peer-review journal process can be seen as a general indicator of scientific quality. An early version of PAPER II was presented at a conference, and a final version has been submitted to a journal and is currently undergoing the peer-review process. PAPER III was subject to the review process at the 2022 IMP Conference and was awarded as one of the best papers by the organizers.

Second, following the advice of Andersen et al. (2018), this work provides a comprehensive description of the research process. The development of the empirical data into a case was done based on 'systematic combining' (Dubois and Gadde, 2002) and this process has been described in 3.4.1. By providing the context of the research (see 3.1) and the steps taken when selecting the case and concepts, identifying key points of the empirical world and recording the findings, it was possible to guarantee transparency in the research process to improve validity.

Third, this work provides a detailed case description. The process of 'casing', in other words "*forming meaningful descriptions of the empirical reality"* (Andersen et al., 2018 p.543), was carefully performed. The case was a key asset of this research, as it was difficult to separate the phenomenon (business relationships) from its context (Halinen and Törnroos, 2005). Only through the case was it possible to bring together the phenomenon of interest (business relationships) and the context (digital transformation). The research team's deep understanding of the case also improved the validity of the study. In fact, the case itself became a showcase for the evidence-gathering process and how this was developed into the findings of the case study.

Fourth, the quality of the data collection process was ensured by having two or three researchers participating in most of the interviews. This way, extensive notes were taken by the researchers. This increased the validity of the analysis and helped to make the research team very familiar with the empirical case. Besides the interviews, data were also collected from other sources, such as literature studies, workshops, industrial reports and the company website. These data sources were used to triangulate respondents' answers (Miles et al., 2018). Moreover, this

investigation was based on rigorous case study protocol that documented the scheduling, interview guides and procedures (Eisenhardt, 1989).

Fifth, according to Easton (1995), the richness of the relationships between actors can only be investigated in a relatively limited number of cases, and the choice of the actors in a case study is very important. With this in mind, MANUFACTURING FIRM 1 and its respective business network in relation to digital transformation was selected as the focal firm for this single case study. By excluding MANUFACTURING FIRMS 2 and 3 and focusing on the case of MANUFACTURING FIRM 1, it was possible to explore this context in depth. The case of MANUFACTURING FIRM 1 was investigated by applying different frameworks, literature streams and concepts within the Industrial Network Approach (e.g. supplier interfaces, resource combining and strategizing), following the systematic combining approach (Dubois and Gadde, 2002). This provided different perspectives on the phenomenon, improving the validity of this single case study.

4 THE CASE

This thesis is based on a study of the focal firm MANUFACTURING FIRM 1 and its business network. MANUFACTURING FIRM 1 was founded in Sweden and is currently owned by an American group. MANUFACTURING FIRM 1 operates in the welding industry globally and has more than 8700 employees and manufacturing facilities on four continents. It has grown to supply a broad portfolio of equipment and wire (electrodes) to companies across different industries, such as the automotive trade, civil construction, manufacturing and shipbuilding. MANUFACTURING FIRM 1 has customers that range from niche welding shops to large enterprises. Following the digitalization trend, MANUFACTURING FIRM 1 decided to invest in an IoT cloud platform to connect the welding machines it sells and offer new digital services to customers. Today, MANUFACTURING FIRM 1 is gradually increasing its number of IoT-enabled offerings. However, most of the current offerings are still unable to connect to the cloud.

Two main phases of MANUFACTURING FIRM 1's digital transformation have been identified in this study: initiation and development. During the initiation phase, MANUFACTURING FIRM 1 started to establish its digital solutions, whereas the development phase was characterized by early adopters of the digital solutions and some changes in its supply base. Initially, MANUFACTURING FIRM 1 was developing its IoT digital platform in-house. This required on-site servers and extensive IT infrastructure, for which the company lacked expertise and resources. In this early phase, MANUFACTURING FIRM 1 did not have relationships with any IoT technology suppliers or customers for the emerging digital solutions. On the customer side, MANUFACTURING FIRM 1 has business relationships with end customers (that purchase heavy-industrial machines and consumables) and with distributors (that sell MANUFACTURING FIRM 1's light-industrial machines and consumables). Approximately 80% of its sales were made through distributors, behind each of which are many small customers.

4.1 Initiation phase of digital transformation

When MANUFACTURING FIRM 1's management team realized that the company was spending more time building infrastructure for the IoT technology than focusing on welding and business processes, the company decided to change its strategy and establish business relationships with technology and platform suppliers. Internally, MANUFACTURING FIRM

1 created the Digital Solutions Unit with the goal of channelling efforts towards the creation and commercialization of digital solutions. This also led to selecting suppliers for implementing the IoT technology in MANUFACTURING FIRM 1's portfolio.

Three main IoT suppliers were identified as key for the creation of the new IoT cloud platform and development of the digital solutions. Here, they are anonymized as SUPPL1, SUPPL2 and SUPPL3. SUPPL1 is a well-known cloud platform supplier and SUPPL2 is a software component supplier that provides a set of tools to support the development of new software applications (i.e. an application platform). MANUFACTURING FIRM 1's IoT offering depends on the cloud infrastructure provided by SUPPL1. MANUFACTURING FIRM 1 had to make significant adaptations to its resources to use SUPPL1's standards, in turn making it costly for SUPPL1 to change its cloud services supplier, which would require starting from scratch, re-routing all the data and changing the infrastructure.

In phase 1, MANUFACTURING FIRM 1 had a close relationship with SUPPL2, the software component developer. MANUFACTURING FIRM 1 needed developers skilled in the SUPPL2 framework to build the components for the digital solution. This was not something MANUFACTURING FIRM 1 initially had access to within its collection of resources.

The IoT gateway is a key component of the platform as it enables communication between the machines and the IoT cloud platform. MANUFACTURING FIRM 1 decided that a new gateway should be developed and installed inside the welding machine (product hardware). MANUFACTURING FIRM 1 outsourced the development of the IoT Gateway to an Indian supplier with experience in engineering design and IoT, here anonymized as SUPPL3. MANUFACTURING FIRM 1 had a team in India responsible for the relationship with this new external hardware supplier. There were three reasons why this supplier was selected: first, it had resources to both develop and produce the components; second, it had previous experience developing and producing IoT gateways for companies in other industries, including for one large globally known IT company; and third, it was already a supplier to MANUFACTURING FIRM 1, but of components unrelated to the IoT technology.

Three pilot customers were identified at this stage: PILOT1 (Brazilian pilot customer), PILOT2 (Finnish pilot customer) and PILOT3 (Italian pilot customer). In 2019, MANUFACTURING FIRM 1 Digital Solutions was piloted with two existing customers, one located in Italy (PILOT2) and one in Finland (PILOT3). The pilot customers were offered the use of MANUFACTURING FIRM 1 Digital Solutions without cost and asked to provide feedback

on the quality and value of the new services. According to the respondents, PILOT2 experienced the benefits of the cloud platform when it became familiar with it through insights from the IoT solutions. For example, PILOT2 identified that within one of its processes the equipment at one station was used less than 10 per cent of the available time and still represented a bottleneck. This awareness made PILOT2 rebalance its process.

After some time, MANUFACTURING FIRM 1 acquired a Portuguese company that had developed the module 'documentation' for the digital solution. This module was highly appreciated by customers. However, another supplier's platform was used in the development of the documentation module, rather than that of SUPPL1. Due to this new documentation module, MANUFACTURING FIRM 1 decided to introduce multiple cloud suppliers (SUPPL1 and SUPPL4). SUPPL4 was already part of MANUFACTURING FIRM 1's supplier base, but for other products. The feedback from PILOT1 was crucial for MANUFACTURING FIRM 1 to decide on which functionalities to develop and offer in the market in connection with the module 'documentation'.

4.2 Development phase of digital transformation

In the development phase the upper management decided that going forward, all heavy industrial machines would include connective functionality. The goal was to increase the number of connected machines in the market and increase the sale of digital solutions.

MANUFACTURING FIRM 1 acquired a number of companies with pre-developed software applications to incorporate in its digital solutions portfolio (examples: Notes and Digital application for Programming Robots). As the Director of product management explained: "We acquired an external company that had already developed that functionality or that application. And now we have, we're gradually integrating that into the cloud platform, more or less. So, so that was that, you know, it is already now an application sold on its own merit."

The digital solution offerings (services) began to be valued by customers in the market, and recently it was the main reason behind a large Australian company (CUSTOM1) deciding to buy a significant number of welding machines. CUSTOM1 concluded that the digital solution provided by MANUFACTURING FIRM 1 was the best in the bidding process. In line with this trend of valuing digitalization, PILOT1 decided to become a paying customer of MANUFACTURING FIRM 1, and it is now a large user of the module 'documentation' in its plant in Brazil. The interaction with PILOT1 contributed to the continuous improvement of the IoT platform.

In this phase, MANUFACTURING FIRM 1's employees started to have a greater presence at customer sites, demonstrating the new machines and functionalities connected to the IoT cloud platform. For MANUFACTURING FIRM 1, this interaction with potential new customers of its digital solutions has been fruitful, providing learning opportunities about both the solution itself and unexpected aspects of the use of IoT cloud solutions by customers.

On the supplier side, the relationships with SUPPL2 and SUPPL3 were ended in this phase. MANUFACTURING FIRM 1 realized that the solutions provided by SUPPL2 did not meet its requirements. It became clear that SUPPL1 could provide a better solution, and the end of the relationship with SUPPL2 led to an increase in the scope of the business exchange with SUPPL1. The lock-in costs identified in the development phase with SUPPL2 and the decision to maintain the relationship had meant that the long-term efficiency of including SUPPL1 in the supplier base had remained an open question.

MANUFACTURING FIRM 1 and SUPPL3 experienced some conflicts connected to delays of the IoT gateway design, which culminated in the end of the relationship. SUPPL3 finished the development of the IoT gateway in collaboration with MANUF. The initial plan was for SUPPL3 to continue its relationship with MANUFACTURING FIRM 1 by producing the component. However, this plan changed, and the business relationship ended after the development of the gateway. MANUFACTURING FIRM 1 currently holds the intellectual property rights of this development and is looking for another supplier to become the new producer of the IoT gateway.

5 SUMMARY OF THE PAPERS

Paper I – Supplier interfaces in digital transformation: An exploratory case study of a manufacturing firm and IoT suppliers

Paper II – Strategizing in business relationships to cope with uncertainties in digital servitization

Paper III – Value creation from combining digital and non-digital resources: The case of ‘smart products’

Table 3: Overview of the three papers

	Paper I	Paper II	Paper III
Title	Supplier interfaces in digital transformation: An exploratory case study of a manufacturing firm and IoT suppliers	Strategizing in business relationships to cope with uncertainties in digital servitization	Value creation from combining digital and non-digital resources: The case of 'smart products'
Status	Published in the Journal of Business & Industrial Marketing	Submitted to a scientific journal in February 2023. An early version of this paper was presented at the 2020 PLAN Research and Application Conference, Södertälje/Online	This paper was presented at the 2022 IMP conference in Florence, Italy.
Purpose	To characterize the interfaces between manufacturing companies and IoT suppliers involved in digital transformation	To understand how strategizing is used, by a manufacturing firm, to cope with uncertainties in the context of digital servitization	To explore value creation with regard to the combination of digital and non-digital resources in the context of smart products
Phase of digital transformation in focus	Initiation phase	Initiation and development phases	Development phase
Research design and approach	Qualitative case study	Qualitative case study	Qualitative case study
Main findings	Identification of three IoT supplier interfaces (connected supplier interface, digital supplier interface and digital-physical supplier interface) that show unique characteristics in terms of the resource interfaces, interaction patterns, technology strategy and organizing principle	The early phases of digital servitization are characterized by uncertainty. In the initiation phase, problem uncertainty and actor uncertainty are prominent. When reaching the development phase, problem, actor and efficiency uncertainties are identified. The paper also shows how the uncertainties are managed through different strategizing forms. Deepening with the same content, widening with same content and maintaining are strategizing forms that aim to consolidate existing elements of business relationships. Widening with altering content, screening, horizontal collaborations, networking with connections, identifying new customers for digital solutions, acquiring new business relationships, ending and deepening with altering content are forms of strategizing that aim to create new elements of business relationships.	By combining the Industrial Network Approach with concepts from the information systems literature, three forms of value creation are identified: 1) increasing flexibility with openness from digital resources, 2) increasing efficiency from reproducible digital resources and 3) providing novelty throughout the smart product lifecycle with reprogrammable digital resources. These are not the only values that can be created, but they illustrate how features of digital resources can contribute to value creation in combination with other resources.

5.1 Paper I

PI: Supplier interfaces in digital transformation: An exploratory case study of a manufacturing firm and IoT suppliers

The purpose of Paper I is to provide an understanding of the characteristics of interfaces between manufacturing firms and suppliers that collaborate in the context of digital servitization, defined in the paper as one type of initiative that is present in digital transformation. The paper also presents an account of how resources are combined by manufacturing firms and suppliers in the context of digital transformation.

Findings from this study point to the existence of three distinct types of supplier interfaces: connected, digital and digital-physical. They all contain technical resource interfaces with additional organizational and/or technical complexities that need to be managed.

Connected supplier interfaces are characterized by connectivity, which impacts technical and mixed interfaces. Actors are continuously connected and interaction patterns are predominantly thin. There is usually a high level of dependence from the manufacturing firm side. This happens because manufacturing firms need to adapt profoundly their technical resources according to the resources of the IoT supplier (usually proprietary components).

Digital supplier interfaces are distinguished by the combination of digital resources. Both technical and mixed interfaces can be present in digital supplier interfaces. While complex digital resource combination requires thick interaction patterns, when the business exchange involves standardized components the interaction pattern is thin. Again, manufacturing firms are dependent on the digital resources controlled by digital suppliers and have to make adaptations to form this interface (e.g. new capabilities, software engineers). This interface is characterized by joint development of digital components in combination with the use of standard digital components.

One important characteristic of the digital-physical supplier interface is the complex technical interface that is often present, since the resource combination involves both hardware and software. When resources are standardized, thin interactions are observed. However, tailored development entails thick interaction patterns, and adaptations from both actors are required. Due to the need for different capabilities, cross-functional teams usually take part in this business exchange.

The three IoT supplier interfaces identified in this study were observed during the initiation phase of digital transformation and are considered to be interdependent. This is because the infrastructure needs to function with digital components, physical equipment and software. Moreover, connectivity, the Agile approach to software development and strong technical dependence emerged as key factors that impact interactions between manufacturing firms and IoT suppliers.

The paper contributes to the conceptualization of supplier interfaces by recognizing important supplier interfaces when sourcing IoT technologies. The study develops a novel perspective by relating supplier interfaces to key exchanges involved in developing digital technologies.

The actors of the focal business network involved in the study presented in Paper I are coloured in grey in Figure 4.

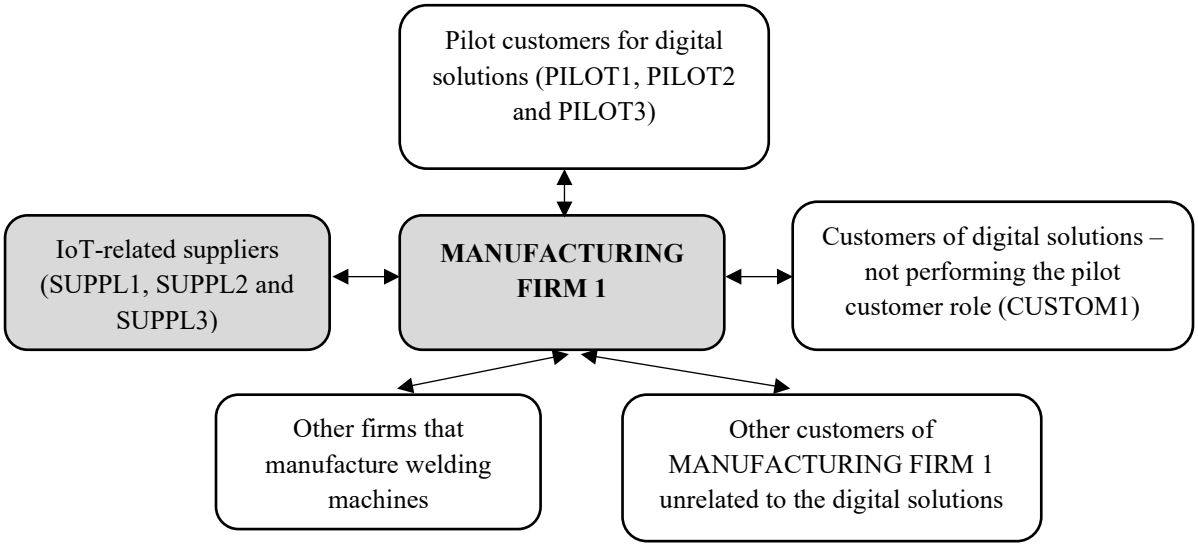

Figure 4: Actors of the study presented in Paper I coloured in grey

5.2 Paper II

PII: Strategizing in business relationships to cope with uncertainties in digital servitization

The goal of Paper II is to explore the uncertainties involved in early phases of digital transformation (in the paper, digital transformation is treated as digital servitization) and understand how manufacturing firms strategize to cope with uncertainties in their business network.

The framework of the paper is built on strategizing based on network choices related to the 'consolidate' and 'create' elements of business relationships. The paper is based on a case study

methodology of a focal manufacturing firm and its business partners during the initiation and development phases of digital transformation.

From the analysis, the paper characterizes the early phases of the digital transformation in terms of uncertainties. In the initiation phase, problem uncertainty and actor uncertainty are prominent. Upon reaching the development phase, some uncertainties remain while others change. Problem and actor uncertainties are still observed. A new type of uncertainty not observed in the initiation phase, the efficiency uncertainty, causes the termination of some relationships and the expansion of others.

Findings from the paper show how these uncertainties are managed through different strategizing forms. By analysing the actions and interactions of the focal firm and related actors, three different forms of strategizing to cope with uncertainties are identified in the business relationships: deepening with the same content, widening with the same content and maintaining. The purpose of these is to consolidate existing elements of business relationships. A further eight forms of strategizing were identified that were intended to create new elements within business relationships: widening with altering content, screening, horizontal collaborations, networking with connections, identifying new customers for digital solutions, acquiring new business relationships, ending and deepening with altering content.

The paper also highlights a variety of strategizing forms to cope with uncertainties in digital transformation. Some of the strategizing forms (i.e. maintaining, horizontal collaboration, networking with connections, identifying new customers for digital solutions) are identified as being more affected by IoT technology, which is the focus of the study.

In conclusion, the paper contributes a new understanding of how strategizing can be used to cope with uncertainties in business networks. A variety of strategizing forms can be applied by a focal manufacturing firm engaged in a business network, mainly to create but also to consolidate elements of business relationships. Moreover, perceived uncertainties (actor, network and efficiency uncertainties) seem to evolve and vary during the early phases of digital transformation.

The actors of the focal business network involved in the study presented in Paper II are coloured in grey in Figure 5.

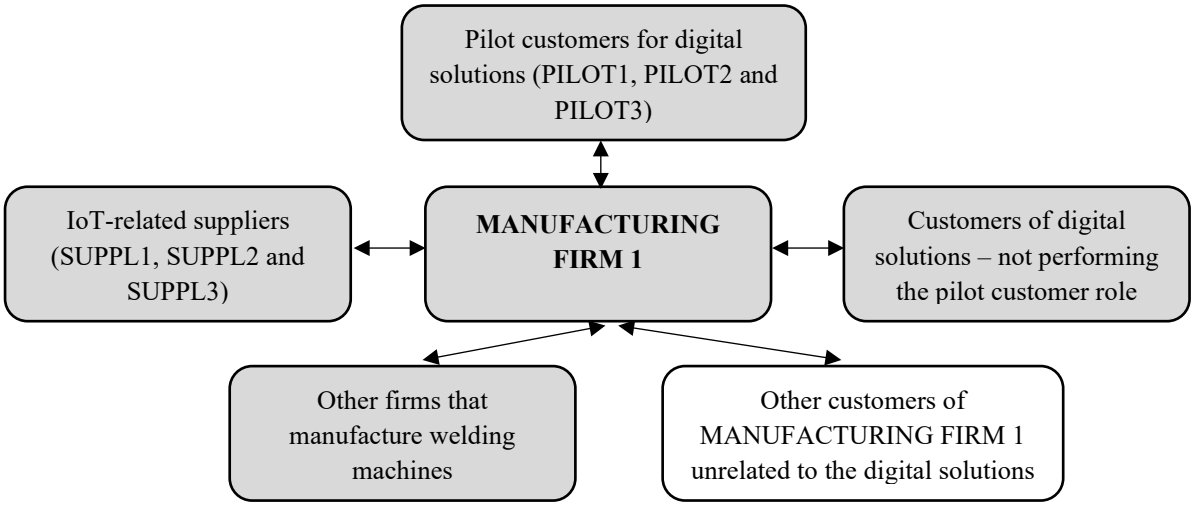

Figure 5: Actors of the study presented in Paper II coloured in grey

5.3 Paper III

PIII: Value creation from combining digital and non-digital resources: The case of 'smart products'

Paper III aims to investigate the features of digital resources and how they can be combined with other resources and create value. To fulfil this aim, the authors rely on the Industrial Network Approach to business markets (Håkansson and Snehota, 1995), which is well suited to analysing the inter-organizational phenomenon. In addition, concepts from the field of information systems (Yoo et al., 2010, Yoo et al., 2012), which incorporates the social, technical and organizational aspects of digital technologies, are used.

The paper is built on a case study of MANUFACTURING FIRM 1, which uses IoT technology to create new services and functions related to its traditional physical products by equipping them with sensors, IoT gateways and information technology to create 'smart products'.

The case suggests that smart products can create value in three different ways by combining digital resources with other resources (digital and non-digital). First, the openness of the digital resource promotes a flexible way to combine and use digital resources, which allows for new values and promising features. Second, the reproducibility of digital resources increase efficiency, which can be identified both when delivering digital products and in customer processes, when digital information is reproduced across devices instantly and with almost no cost. Third, reprogrammable digital resources ensure novelty throughout the life of a smart

product. This occurs in the form of new updates and features that are sent to the smart products during their lifespan.

In conclusion, Paper III set out to understand how value is created from combining digital resources with non-digital resources and/or other digital resources. By combining the Industrial Network Approach with concepts from the information system literature, three forms of value creation are identified: 1) increased flexibility through openness of digital resources, 2) increased efficiency from reproducible digital resources and 3) novelty throughout the smart product lifecycle with reprogrammable digital resources. The authors point out that this is not the only value that can be created, but they illustrate how features of digital resources can contribute to value creation in combination with other resources. Paper III intends to open the door for discussion and future research to understand the concept of digital resources and what digital resources and their potentially unique features can reveal about resource interactions in business networks.

The actors of the focal business network involved in the study presented in Paper III are coloured in grey in Figure 6.

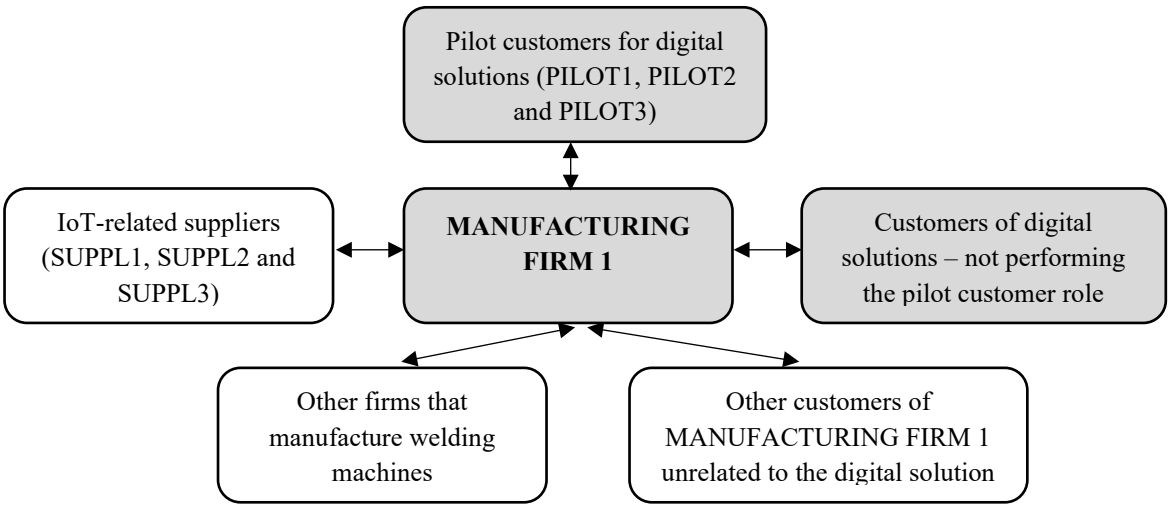

Figure 6: Actors of the study presented in Paper III coloured in grey

6 RESULTS

Figure 7 shows how the three appended papers relate to the research questions and overall purpose of the thesis

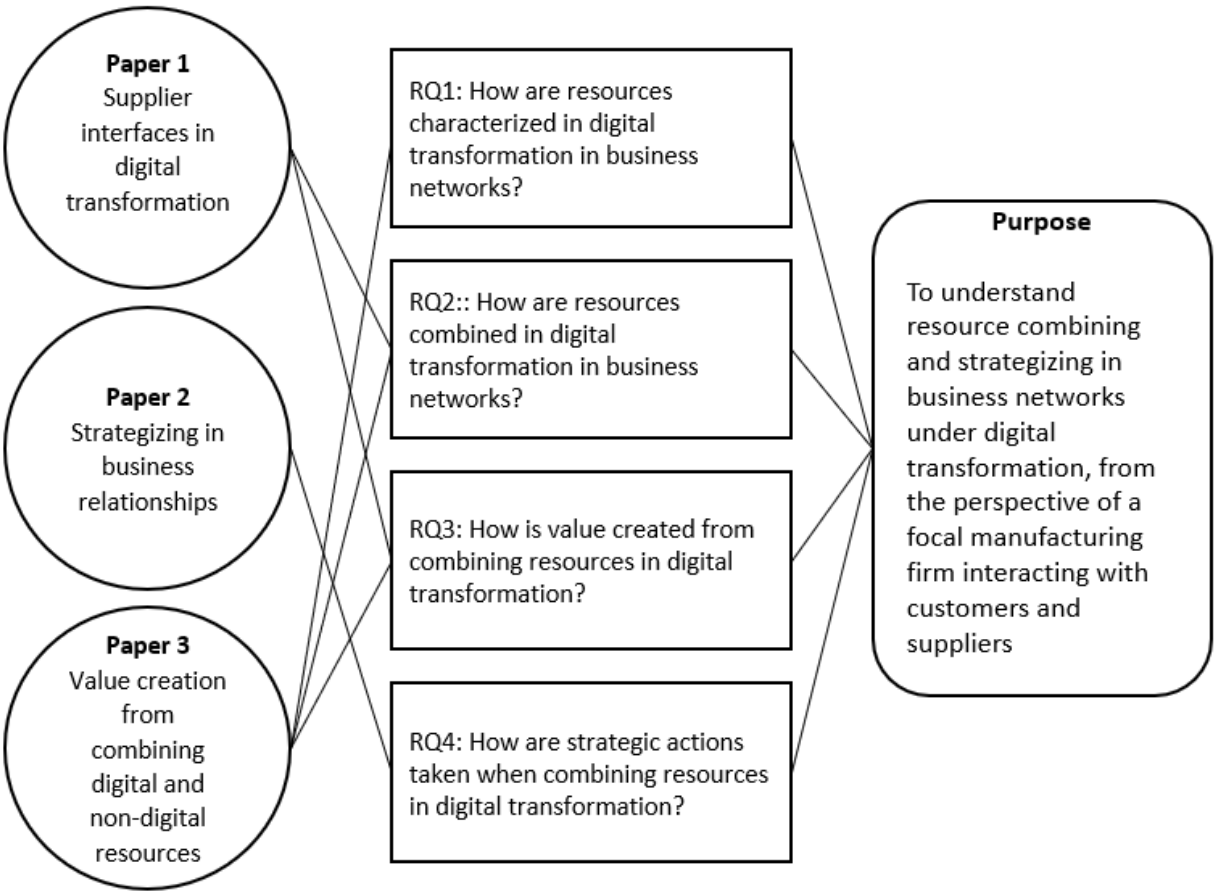

Figure 7 How the three appended papers contribute to answering the research questions to fulfil the purpose of the thesis

6.1 Research question 1

RQ1: How are resources characterized in digital transformation in business networks?

To identify the characteristics of resources in digital transformation in business networks, a study was performed into the resources that are part of exchanges between a focal firm and its customers. The analysis of these resource was done based on the Industrial Network Approach with inspiration from information system literature.

Findings from this investigation show that resources in digital transformation can be differentiated as digital and non-digital resources. A distinguishing feature of digital resources

is that they relate to binary encoding and bitstrings (Faulkner and Runde, 2019). Three intrinsic characteristics of digital resources were identified as key in this study: openness, reproducibility and reprogrammability.

6.1.1 Openness

Digital resources have more openness than non-digital resources, as they can easily be modified, are versatile and have high adaptability. Digital resources have different value paths that can be followed and combined in different ways. Although digital resources can sometimes become 'sticky' and unresponsive, such as when standards are adopted, digital resources are, in principle, more mutant and changeable that physical ones.

6.1.2 Reproducibility

Reproducibility refers to the ability to instantly reproduce a digital resource with almost no marginal cost (Henfridsson et al., 2014). Digital resources can be easily reproduced as they can be stored, transmitted and displayed on multiple devices and networks in countless ways (Sandberg et al., 2020). Reproduced digital resources (data) and functions can be distributed across contexts and devices using digital infrastructures (Sandberg et al., 2020, Kallinikos et al., 2013).

6.1.3 Reprogrammability

Reprogrammability is the ability to combine new digital resources (i.e. new sets of logic) to modify another resource's behaviour and functionality (Yoo, 2010). Reprogrammability enables continued, fluid expansion of a product's functionalities through the combination of new digital resources (i.e. new programs or modified programs). For instance, new features can be added to smart products when new digital resource combinations are developed after the initial product design via connectivity (e.g. by using gateways and/or Application Programming Interfaces, APIs).

6.2 Research question 2

RQ2: How are resources combined in digital transformation in business networks?

First, the findings from this study are presented in relation to the way in which the resources of a focal firm are combined with those of IoT suppliers. Second, they describe how digital resources are combined between a focal firm and customers of digital solutions.

For a focal firm undergoing digital transformation, new suppliers related to a new digital technology (i.e. IoT) and customers of new digital solutions play important roles as they control key resources and are involved in a variety of resource combinations that include digital resources.

6.2.1 Resource combination – focal firm and IoT suppliers

Three ways resources can be combined between a focal firm and related IoT suppliers are identified in this study: through connected supplier interfaces, through digital supplier interfaces and through digital-physical supplier interfaces. These resource combinations are seen in the analyses of interfaces associated with IoT suppliers, also identified in Paper I, including connected supplier interfaces, digital supplier interfaces and digital-physical supplier interfaces. For more details about the interfaces, see Ferreira and Lind (2023).

Resource combination involving connected supplier interfaces occurs when industry-specific knowledge (a focal firm's resource) is combined with infrastructure (the connected suppliers' resource) to create new resources in the form of digital solutions. When these resources are combined, dependence on a supplier is increased, making it harder and more costly for a focal firm to replace them.

Resource combination with a digital supplier involves the combination of a suppliers' digital resource with the resources of the focal firm, which usually include products and organizational resources (such as knowledge about the industry). As focal firms can regularly propose new types of resource combinations involving digital resources (such as when applying Agile software development to applications and identifying the need for further software updates for connected products), greater interaction between suppliers and focal firms is expected.

Resource combinations that include digital-physical supplier interfaces involve digital-physical components that usually have strong technical interdependencies with existing resources from the focal firm (e.g. existing product's components). This is because focal firms have often developed a physical product before they embark on digital transformation. Hence, this type of resource combination frequently involves new jointly developed resources (digital physical components) that need to be adapted to and compatible with those existing resources (physical products). Deploying the organizational resources (such as engineers and technicians) of suppliers and focal firms together requires the joint establishment of technical interfaces such that they do not interfere with existing resources (components/products). This requires thick

interaction patterns in the developing phase. Cross-functional teams within the focal firm that are normally required to handle this type of resource combination.

6.2.2 Resource combination – focal firm and customers of IoT-based solutions

The characteristics of digital resources presented in 6.1 (i.e. openness, reproducibility and reprogrammability) are used as a starting point for identifying possible resource combinations between the focal firm and customers of IoT-based solutions. Three types of resources combinations are observed in this study: resource combination involving open digital resources, resource combination involving reproducible digital resources and resource combination involving reprogrammable digital resources.

Resource combination involving open digital resources refers to the combination of digital resources that are characterized by their openness. As these digital resources are open, actors can choose to either create resource combinations that use the digital resources as initially intended or create a new type of resource combination. The authors' case involving smart products that are IoT connected exemplifies the openness of digital resources. Although a focal firm may design and exchange digital resources (e.g. software application) to be combined in a certain way, other actors (customers) can still change the way they use the digital resource. For instance, customers can use an Application Programming Interface (API) to combine a digital resource with other digital resources. As a result, a focal firm that designs a digital resource can never know all the possible uses of that resource when it is combined with those of other actors.

Resource combination involving reproducible digital resources is a type of resource combination that exploits the fact that digital resources are reproducible, and hence generating copies of digital resources implies almost no marginal cost. This is not true of non-digital resources, such as physical products. Resource combination involving reproducible digital resources occurs when digital resources controlled by the focal firm (e.g. the fleet management application) allow customers to reproduce their digital resources (e.g. machine settings) and transfer them to several other non-digital resources (e.g. connected machines) instantly and at almost no cost. This way, digital resources (settings) are quickly and easily combined with non-digital resources (welding machines). It is important to point out, as in the example of the authors' empirical case, that prior to this type of resource combination, customers had to set up their machines manually, which usually took much time and effort.

Resource combination involving reprogrammable digital resources is when digital resources are combined to add new functionalities to a non-digital resource over time (e.g. connected products). New digital resources (e.g. in the format of new functionality and software updates) are thus developed and distributed by a focal firm to be combined with non-digital resources (e.g. connected welding machines) throughout a product's lifecycle. Reprogrammable digital resources enable quick product redesigns and changes over time. Hence, with digital and non-digital resources being connected to the Internet, new resource combinations can lead to new functionality being incorporated at any time, even after the non-digital resources (e.g. machines) have been produced or started operating at a customer's site.

6.3 Research question 3

RQ3: How is value created from combining resources in digital transformation?

Findings from this study show that four forms of value can be created from combining resources in digital transformation: flexibility, efficiency, novelty and achieving functionality of the digital solution.

First, resources combinations involving open digital resources can lead to flexible ways of combining and using digital resources. This flexibility is seen as valuable because it enables the development of new promising features. While some features result from resource combinations that were expected and planned by actors in the industrial network, others result from resource combinations that are new to the focal firm and may not have been expected while the digital resources were initially being developed. The flexibility of digital resources enables new applications and possibilities for resource combination, and the expanded use of IoT technology has resulted in new resource combinations in new areas and types of applications.

Second, resource combinations that rely on reproducibility create value by increasing the efficiency of customer processes. Customers are able to reproduce digital resources and create new resource combinations with non-digital resources (e.g. machines) almost instantly at no cost. In a context where non-digital resources are distributed across large areas, resource combinations that rely on reproducibility and connectivity can save time and improve processes, for instance for applications involving smart products. The efficiency gain that results from combining digital resources incentivizes new resource combinations that make use of reproducibility and the ability to provide digital resources via the Internet.

Third, resource combinations involving reprogrammable digital resources generate value in the form of novelty. New resource combinations that include digital (updates and features) and non-digital resources (machines) can occur throughout a products' life. Reprogrammable digital resources enable combinations between new digital resources (software updates) and existing resources over time, leading to the steady emergence of novelties. The combination of reprogrammable digital resources is unique in facilitating the constant change and development of existing resources, to the extent that new updates and features are created.

Finally, the value of achieving functionality of a digital solution is the main building block for the creation of all three types of value mentioned above (flexibility, efficiency and novelty). To achieve functionality of a digital solution requires interactions between a focal firm and its IoT suppliers, as well as interactions between the suppliers themselves. One positive outcome of potential collaboration between IoT suppliers is that a focal firm can select partners that have proven functional resource interfaces between their solutions. On the other hand, it can lead to thick interactions in individual interfaces as well as lock-in effects across multiple suppliers. Hence, the functionality of a digital solution (value) is impacted by the interdependence of IoT suppliers, which might make it difficult and expensive to change suppliers later on.

6.4 Research question 4

RQ4: How are strategic actions taken when combining resources in digital transformation?

A focal firm may combine resources in an uncertain business context, specifically when undertaking the process of digital transformation. In this context, the case study highlights that a focal firm can take strategic actions aiming mainly to 'create', and to a lesser extent 'consolidate' elements of, business relationships. When aiming to consolidate elements of business relationships, a focal firm can use three different strategizing forms: deepening with the same content, widening with the same content and maintaining.

Deepening with the same content occurs when, for instance, a pilot customer becomes a paying customer. Widening with the same content occurs when a relationship with an existing supplier is increased in scope, and in the authors' case this happened at the same time as other supplier relationships were ended. Maintaining can be observed when, for instance, a focal firm maintains a relationship with its distributors despite the possibility of introducing a direct sales model for its digital solutions as well as when relationships with suppliers are maintained despite undesirable lock-in situations.

Eight strategizing forms used to create new elements of a business relationship were observed in this study: screening, horizontal collaboration, networking with connections, identifying new customers for digital solutions, acquiring new business relationships, widening with altering content, ending and deepening with altering content.

Screening is when a focal firm assesses its network to find new customers and suppliers. Horizontal collaborations are also pursued by focal firms when looking to develop new partnerships with other actors that produce the same resources. This way, their resources can also be connected to the focal firm's IoT platform. Networking with connections relates to new supplier relationships that are formed based on suppliers' connections with existing suppliers and/or other customers. Identifying new customers for digital solutions includes both the introduction of direct sales for customers of digital solutions and the creation of new customer relationships based on digital solutions. Acquiring new business relationships refers to, for instance, new pilot customer relationships developed through an acquisition strategy. Widening with altering content refers to maintaining existing supplier relationships but widening their scope within a radically different context (such as an IoT platform or IoT gateway). Ending is when relationships with suppliers are terminated due to, for instance, inefficiency. Finally, deepening with altering content refers to existing customers becoming pilot customers of digital solutions.

7 DISCUSSION

In this section, the results of the thesis are discussed in light of other studies in the areas of interorganizational relationships and digitalization. Thereafter, a framework for resource combining and strategizing in a business network is presented.

7.1 Discussion of the results

The three appended papers present qualitative studies conducted over a period of approximately three years. The papers focus on interorganizational relationships of a focal firm interacting in a business network while undertaking digital transformation. The findings of the study fulfil the aim of increasing understanding of how a focal firm interacting in its business network combines resources and strategizes during digital transformation. The licentiate thesis provides evidence that digital transformation is a relational topic and that taking an interorganizational approach, such as the Industrial Network Approach, is necessary to understand this phenomenon (Fremont et al., 2019, Ritter and Pedersen, 2020, Fremont, 2021, Pardo et al., 2020, Pagani and Pardo, 2017).

The findings from Paper I include the identification of IoT supplier interfaces (connected supplier interfaces, digital supplier interfaces and digital-physical supplier interfaces) that exhibit unique characteristics and lead to different types of resource combining between a focal firm and IoT suppliers. Paper I also reaffirms previous findings that there is no best interface in absolute terms and that different interfaces applied to a group of suppliers will have pros and cons that need to be evaluated on a case-by-case basis (Araujo et al., 1999). The choice of interface is context and content dependent and situational (Andersen and Gadde, 2019). Similar contexts, relationships and interactions between buyers and suppliers of different sizes with varied potential power dynamics (in the authors' case the supplier involved in the connected supplier interface), have also been studied by other researchers (Bocconcelli et al., 2018). Suppliers that are strong actors in the network do not seem to invest in thick interactions (Waluszewski and Johanson, 2008). However, if and when a supplier relationship becomes interactive, it may indicate that a focal firm has also increased in importance to the IoT supplier. This would suggest that the counterparts may become mutually interdependent, though this is not the situation currently observed. Paper I also emphasizes that in the context of digital transformation, new roles, interdependencies, and technology strategies are not well defined and are not expected to be in the near future. Hence, firms will need to develop and re-configure their relationships, interfaces with IoT suppliers and resource combinations over time.

Paper II was based on theories and models related to strategizing (Öberg et al., 2016, Håkansson et al., 2009, Gadde et al., 2003) and shows how the dynamic context of digital transformation, characterized by rapid change, large IT players and the development of new digital resources, can impact the way focal firms strategize in business networks. The eleven strategizing forms identified in Paper II illustrate how focal firms apply a variety of strategic actions when undertaking digital transformation. It reveals that several interconnected actors are usually needed to develop digital resources in digital transformation, for example in the case of an IoT platform. Hence, the interconnections between the different interaction processes in which a focal firm is engaged are very important, since it is interactions with counterparts that provide access to external resources (Aaboen et al., 2013). The eleven strategizing forms identified in the study are further categorized according to whether they create or consolidate interactions (Håkansson et al., 2009, Ford and Mouzas, 2010). Only three strategizing forms were identified for consolidating existing relationships. They were deepening with the same content, widening with the same content and maintaining. On the other hand, eight strategizing forms related to the creation process were identified: screening, horizontal collaboration, networking with connections, identifying new customers for digital solutions, acquiring new business relationships, widening with altering content, ending and deepening with altering content. Hence, Paper II expands on previous studies of strategizing and network choices (Ford and Mouzas, 2010, Öberg et al., 2016) by providing a nuanced view of strategizing forms to consolidate and create business relationships.

The findings from Paper III support fundamental assumptions and concepts related to resources and resource combinations provided by the Industrial Network Approach (Prenkert et al., 2022, Baraldi et al., 2012). Additionally, Paper III provides insights about the concept of digital resources, including their unique features, and what happens when they are combined with other resources in a business network. Paper III shows how the characteristics of digital resources are related to resource combinations (Prenkert et al., 2022) in the context of smart products (Pardo et al., 2022). The interpretation of digital resources in light of the concepts of resource interaction and value creation in business networks provides a detailed view of the process of combining digital resources in a business network. Value is created as a result of resource interactions and combinations (Håkansson and Waluszewski, 2002b, Lind et al., 2012). From the value creation perspective, Paper III shows that value creation through combining digital resources can be seen in the forms of flexibility, efficiency and novelty. Intrinsically, value can have different forms and is perceived differently by different actors

(Cantu et al., 2012). Value can be created for individual actors and/or span firm boundaries (Håkansson and Waluszewski, 2002a, Lind et al., 2012). Value is always context dependent, therefore the actor for which value is created in the business network depends on context and the focal actor in the analysis (Cantu et al., 2012, Lind et al., 2012).

Aligned with Fremont (2021), this thesis shows how digital resources are combined within and across organizational boundaries with other technological and organizational resources to be purposeful and create value. This study contributes to the work of Fremont (2021) by introducing to the discussion the intrinsic characteristics of digital resources (openness, reproducibility and reprogrammability) and the strategizing forms for creating and consolidating elements of business relationships during digital transformation. By considering the characteristics of a digital resource, a more nuanced view of the process of combining resources is achieved, which sheds light on the 'how' question of involvement of digital resources in the value creation process. By considering the variety of different strategic actions that a focal firm may take to access digital (and non-digital) resources in a business network, this study demonstrates how complex and dynamic the process of collaborating with other actors can be during digital transformation.

Looking at the three stages of the change cycle provided by Fremont (2021), this study can be positioned within the 'transitionary stage': when changes occur in resource structures, leading to conflicts and/or the replacement of established resource structures. Hence, this study looks at the transitionary stage in greater detail (Fremont, 2021) to understand how the process of resource combining involving digital resources (with their intrinsic characteristics) actually happens and how value can be created during a period (stage) when deep and structural changes take place within the focal firm and related business network.

Another study involving digitalization and the Industrial Network Approach is that performed by Pagani and Pardo (2017). The authors relate digital transformation to certain value creation logics by identifying one type of value creation for each type of digitalization, which are in turn related to each dimension of the ARA model (Håkansson, 1987), i.e. activities, resources and actors. This study expands on the study by Pagani and Pardo (2017) regarding the understanding of value creation in business networks by scrutinizing the resource dimension, more specifically the characteristics of digital resources, and identifying the different forms of value that can be created from combining digital resources.

7.2 Towards a framework

The overall purpose of this study was to understand resource combining and strategizing in business networks during digital transformation from the perspective of a focal firm interacting with customers and suppliers. From the findings presented above, it can be noted that a focal firm going through the process of digital transformation is embedded in a complex business network. The focal firm needs to take a variety of strategic actions in order to relate with other actors in the business network and to access key digital and non-digital resources.

All three papers appended to this thesis applied concepts from the Industrial Network Approach as their main analytical tools. Using the Industrial Network Approach as the main analytical framework allows the three studies to be connected and combined to draw theoretical conclusions between them. Hence, as a result of this study, a framework for describing resource combining and value creation in business networks during digital transformation is presented in Figure 8.

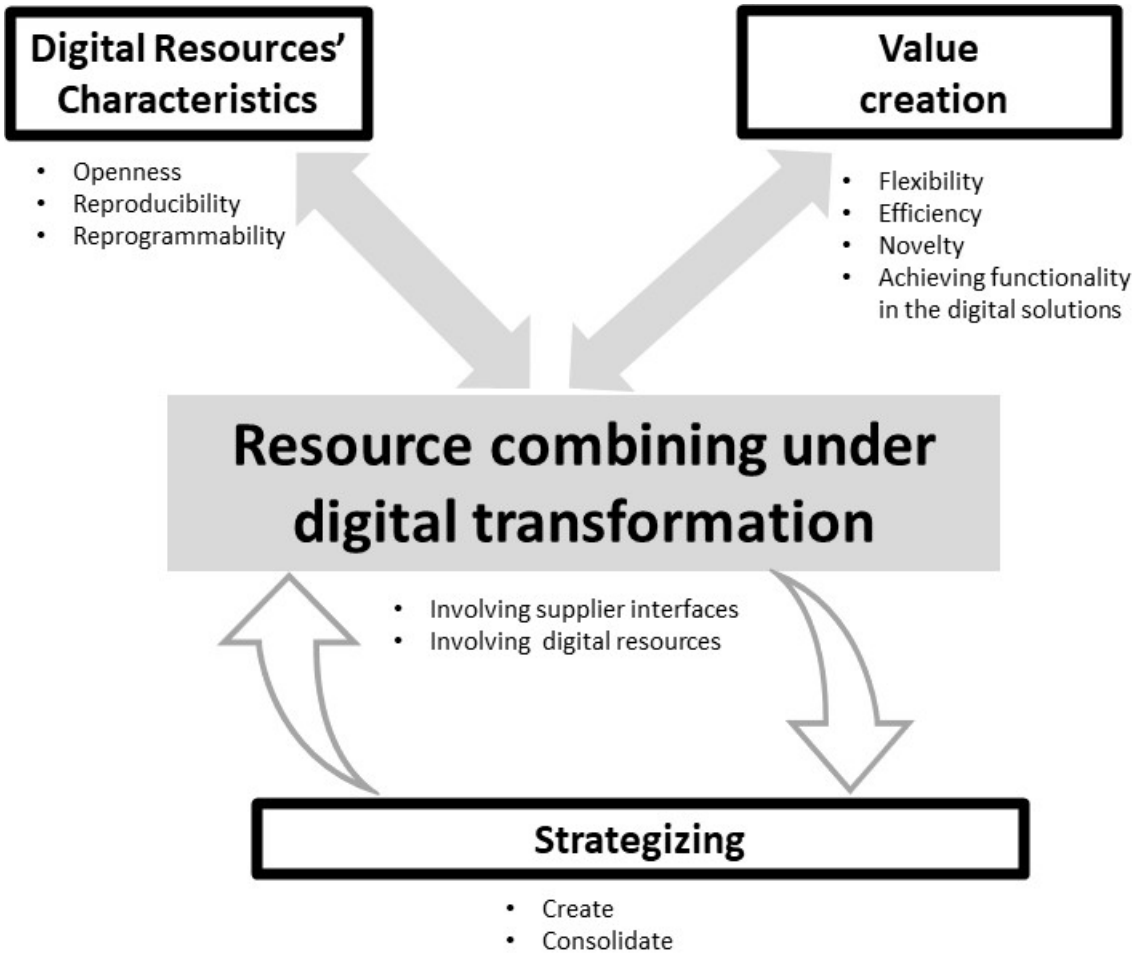

Figure 8: Framework for describing resource combining and value creation in business networks during digital transformation

The framework is formed by four main blocks: *digital resources' characteristics*, *resource combining under digital transformation*, *value creation* and *strategizing*. The framework pinpoints how the characteristics of digital resources affect resource combining and how value is created as a result of resource combining. It also indicates that to enable digital and non-digital resources combinations, a focal firm undertaking the process of digital transformation needs to take various strategic actions in its business network (strategizing) to both create and consolidate elements of its business relationships.

The characteristics of digital resources are key elements that distinguish them from non-digital resources. Only in combination can these characteristics actually create value within the business network. The interactive aspects of the *digital resources' characteristics*, *resource combining under digital transformation* and *value creation* are highlighted by the two-directional arrows that indicate their connections.

Resource combination involving digital resources is continuously occurring in industrial networks in which a focal firm is undergoing the process of digital transformation. This key process of *resource combining* is indicated in the framework by its position in the middle of the figure. Sometimes resource combination occurs as expected by the focal firm, while at other times it occurs in an unexpected way. This is especially due to the openness of digital resources. This is an example of the influence of the *digital resources' characteristics* on *resource combining*.

The process of resource combining needs to occur both upstream, involving IoT suppliers' interfaces, and downstream of the focal firm, engaging customers of digital solutions. Resource combining that occurs upstream can involve connected supplier interfaces, digital supplier interfaces and digital-physical supplier interfaces. Resource combining between a focal firm and downstream actors can involve open digital resources, reproducible digital resources and reprogrammable digital resources.

It is also indicated in the framework that as a result of the resource combining process that occurs during digital transformation, *value creation* can take the form of flexibility, efficiency, novelty and achieving functionality from digital solutions. These forms of value creation are impacted by the digital resources' characteristics (types of value: flexibility, efficiency, novelty) as well as the IoT supplier interfaces that are formed between a focal firm and IoT suppliers (type of value: achieving functionality in the digital solutions). Similarly to Forsström (2005), a distinction is made between value (i.e. perceived value) and value creation, and the focus of the framework is on value creation, the process in which actors in a business network (buyers and sellers) make use of each other's resources with the aim of creating value. It is important to highlight that while value creation is a result of resource combining, it can also impact resource combining and can, for instance, trigger new resource combining.

"No business is an island" (Håkansson and Snehota, 2006), so for a focal firm to access and combine digital and non-digital resources, it needs to develop business relationships with a range of actors within the business network. As a result, the *strategizing* block has been included in the framework, which indicates that a focal firm going through the process of digital transformation needs to take a variety of strategic actions to connect with other actors. These strategic actions are essential in choosing other actors to collaborate with and for being chosen as a collaboration partner by other actors in the business network.

Working collaboratively with other actors is crucial to enable resource combining involving digital resources across company boundaries. A focal firm takes strategic actions mainly to create new elements in a business relationship and, to a lesser extent, consolidate elements of existing business relationships. In the same way that strategizing forms impact resource combining by enabling or even ending business relationships, resource combining can influence strategizing forms by revealing the details of an exchange between two actors. Resource combining can highlight, for instance, if combinations are efficient, and this knowledge can trigger new strategizing forms. In the case of efficient combinations, strategic actions can be taken for the purpose of 'widening with the same content'. If a lack of efficiency is identified, however, ending a relationship can be an appropriate strategic action to take.

To sum up, the framework presented in Figure 8 illustrates the different ways in which digital and non-digital resources are combined and how value is created in various forms when a focal firm is strategizing during the process of digital transformation. This framework provides a number of insights into how firms may address resource combining during digital transformation by underlining how the characteristics of digital resources can impact resource combining and value creation, as well as the need for firms to take a variety of strategic actions to access digital and non-digital resources in the business network.

8 CONCLUSIONS AND IMPLICATIONS

8.1 Conclusions

This licentiate thesis advances the understanding of how manufacturing firms, their customers and suppliers interact to access resources and overcome the challenges that arise during the early phases of digital transformation (Björkdahl, 2020, Albukhitan, 2020). Relying on the Industrial Network Approach, this study analyses the phenomenon of digital transformation, aiming to reveal the nuances and effects of the characteristics of digital resources in resource combining and value creation.

The features of digital resources and how these differ from those observed in non-digital resources (e.g. physical artefacts) leads to new reflections about how resources can be combined. The study also leads to reflections about the strategic actions needed to enable these combinations and how value can be created in the business network.

Based on the intrinsic characteristics of digital resources, the resource combinations identified in this study provide a new way to see opportunities and challenges that digital resources can bring to an ever-evolving, digitalized and uncertain business landscape.

8.2 Theoretical contributions

This thesis makes a number of contributions to the literature on resource combining, value creation and strategizing. First, it proposes a new way of characterizing resources by distinguishing between digital and non-digital. This categorization proved to be valuable for the present thesis and it is assumed that it will help in future studies of digitalization that apply the Industrial Network Approach. Second, it shows different ways in which digital resources are combined in business relationships with IoT suppliers and customers of digital solutions. Third, it identifies how value is created from resource combining in business networks. The identified types of value are flexibility, efficiency, novelty and achieving functionality of the digital solutions.

Fourth, this thesis conceptualizes supplier interfaces in digital transformation (i.e. connected supplier interfaces, digital supplier interfaces and digital-physical supplier interfaces) and shows that these interfaces have unique characteristics in terms of interaction patterns, technology strategy and organizing principle.

Fifth, the thesis also contributes to the strategizing literature stream, providing an in-depth and nuanced characterization of eleven strategizing forms that expand the view of how to operationalize the two types of network choices 'consolidate' and 'create', provided by Ford et al. (2003).

Finally, this thesis contributes to the development of the literature that relates to the Industrial Network Approach and digital transformation (Pagani and Pardo, 2017, Fremont, 2021) by providing a conceptual framework (see Figure 8) for analysing resource combining and strategizing in business networks during digital transformation. Drawing inspiration from information system literature, the framework represents an initial link between the Industrial Network Approach and information systems and affords novel conceptualizations of resource combining involving digital resources, value creation and strategizing forms with regard to digital transformation. The framework is grounded in empirical data from the case company's business network (MANUFACTURING FIRM 1), and its building blocks are identified in the studies presented in the appended Papers 1, 2 and 3.

8.3 Managerial contributions

The thesis offers the following managerial implications regarding the importance of interactive relationships during digital transformation for accessing key resources from customers and suppliers. First, managers involved in digital transformation need to manage the dynamics of collaborations required by digital technologies and maintain interactions with IoT suppliers and customers of digital solutions at different levels. Second, managers need to be aware that introducing digital solutions and smart products into a portfolio is a complex task that requires adaptation. It puts significant demands on personnel, as employees will be required to develop new skills and create new resources interfaces within and across firm boundaries to work with both new digital and non-digital resources in different combinations. Third, digital transformation opens up countless possibilities, which can cause confusion since too many possibilities is not always positive. Fourth, digital resources and the Internet make information systems more vulnerable, and this can lead to undesired resource combinations with negative consequences, such as cyberattacks or problems with software incompatibilities. Fifth, managers need to be aware that taking strategic actions in the business network is key to enable access to the resources of other actors. These actions might have to change over time to cope with new uncertainties that emerge.

8.4 Limitations and future research

Findings from this thesis are based on a case study. Hence, only one manufacturing firm and its business network, each with unique characteristics, were studied. This represents a limitation of this thesis. However, the research goal was not to generalize specific characteristics but rather to provide initial empirical evidence to drive theory development.

Since digital transformation of traditional manufacturing firms is an emerging field, there is a need to continue discovering ways to explain this phenomenon and conceptualize aspects of the related business network. Hence, further research into the phenomenon of digital transformation applying the Industrial Network Approach is necessary and could benefit from the findings of this thesis.

Opportunities for future research to increase the understanding of business networks and digital resources are identified in two areas. First, while this thesis conceptualizes the supplier interfaces involved in digital transformation, little is known about customer interfaces. Future research could try to conceptualize customer interfaces, which could be helpful for explaining business relationships built on the downstream side of value chains during digital transformation. One idea is to try and conceptualize customer interfaces by applying concepts related to resource interactions and resource development. Second, future research is needed to further develop the concepts of digital and non-digital resources in business networks. Investigations about how digital resources can impact activities and network settings can be of value to further understanding of the phenomenon of digitalization in business networks.

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