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INDUSTRY 4.0 & SERVITIZATION:

ROLE AND IMPACT OF DIGITAL SERVITIZATION STRATEGIES IN INTERNATIONAL INDUSTRIAL MARKETS

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Abstract

This research project concerns the investigation of two main phenomena, digitalization and servitization, and the resulting Digital Servitization, in industrial markets. The major aim of the study is to contribute to building new knowledge on the investigated phenomena and provide managers and practitioners with insights on how to face them successfully. Digitalization and Digital Servitization are recent though emerging research streams, around which the attention of academics and practitioners is converging. Even if great dynamism characterizes such phenomena, industrial companies still face several challenges striving for their achievement. Indeed, managers perceive high barriers toward investing in digital strategies. Taking a problematization approach, it is possible to notice that further knowledge on digitalization and servitization is needed to untangle their benefits and challenges. Building on a series of identified under-investigated research streams in digitalization and servitization, this research empirically elaborates on them. To do so, this thesis is structured around five main chapters. Chapter I – *Theoretical foundations and methodological notes* – reviews the available literature on digitalization and Digital Servitization and provides a clarification of the adopted methodological notes. Its aim is to provide a preliminary theoretical analysis on digitalization and servitization. Chapter II – *The dissemination mechanisms of Industry 4.0 knowledge in traditional industrial districts: evidence from Italy* – empirically investigates digitalization at a contextual level of analysis. It looks at the context and mechanisms through which Industry 4.0 technologies are spreading. Chapter III – *Toward a multilevel perspective on Digital Servitization* – empirically tests a Digital Servitization journey at the inter-sectorial level by a cross-sectorial analysis of two servitizing manufacturers. Chapter IV – *Intra and interorganizational tensions of a Digital Servitization Strategy: Evidence from the mechatronic sector in Italy* – is an empirical, firm-level study of Digital Servitization tensions. Notably, it deploys an in-depth investigation of an industrial company by longitudinally exploring the stages of its Digital Servitization journey with the aim of disentangling Digital Servitization complexity. Chapter V – *Concluding remarks and future research avenues* – provides concluding remarks and traces future research lines. The main contributions of this thesis can be summarized as follows. It highlights the tight connection between the digitalization and servitization phenomena, and a 'dual' effect of digitalization. It describes Digital Servitization via its multilevel nature, which is displayed along three levels: microfoundational, organizational, and network. It underlines the impact of networking in digitalization and

servitization. New players become part of the value chain and they can influence the effects of the two phenomena. The complexity of digitalization and servitization is proven, and the difficulties encountered by managers along them are traced.

Keywords – Industry 4.0, Digitalization, Servitization, Industrial markets, Digital Servitization

Abstract (Italian)

Il presente progetto di ricerca riguarda l'indagine di due fenomeni principali, la digitalizzazione e la servitizzazione, e la risultante 'servitizzazione digitale', all'interno dei mercati industriali. L'obiettivo principale di questo studio è contribuire alla generazione di nuova conoscenza circa i fenomeni indagati e fornire a manager e professionisti validi suggerimenti su come affrontarli con successo. La digitalizzazione e la servitizzazione digitale sono ambiti di ricerca recenti ma in forte crescita, attorno ai quali sta convergendo l'attenzione di numerose figure accademiche e professionali. Nonostante il grande dinamismo che caratterizza tali fenomeni, le imprese industriali si trovano ad affrontare ancora oggi diverse sfide nel tentativo di implementarli. In effetti, le aziende manifatturiere dimostrano di percepire barriere elevate all'investimento in strategie digitali. Adottando un approccio alla problematizzazione, è possibile notare come sia necessario sviluppare ulteriori conoscenze circa i processi di digitalizzazione e servitizzazione al fine di comprendere al meglio i vantaggi e le sfide ad essi connessi. Partendo dall'identificazione di una serie di nuove aree di ricerca ancora poco studiate, questa tesi analizza empiricamente i fenomeni di digitalizzazione e servitizzazione. A tal fine, il presente lavoro di ricerca è strutturato in cinque capitoli principali. Il Capitolo I – *Fondamenti teorici e note metodologiche* – passa in rassegna la letteratura disponibile su digitalizzazione e servitizzazione digitale e fornisce chiarimenti sulle note metodologiche adottate in questa tesi. Lo scopo del capitolo è fornire un'analisi teorica preliminare sulla digitalizzazione e la servitizzazione. Il Capitolo II – *I meccanismi di diffusione della conoscenza di Industria 4.0 nei distretti industriali tradizionali: evidenze dall'Italia* – indaga empiricamente la digitalizzazione a livello di analisi contestuale. Il capitolo esamina il contesto e i meccanismi attraverso i quali si stanno diffondendo le tecnologie di Industria 4.0. Il Capitolo III – *Verso una prospettiva multilivello sulla servitizzazione digitale* – studia empiricamente i percorsi di servitizzazione digitale di due aziende manifatturiere a livello intersettoriale. Il Capitolo IV – *Tensioni intra e interorganizzative di una strategia di servitizzazione digitale: evidenze dal settore meccatronico in Italia* – è uno studio empirico circa le tensioni emergenti legate alla servitizzazione digitale. In particolare, il capitolo implementa un'indagine approfondita su un'azienda industriale esplorando longitudinalmente le fasi del suo percorso di servitizzazione digitale al fine di districarne la complessità. Il Capitolo V – *Osservazioni conclusive e percorsi di ricerca futuri* – traccia le conclusioni della ricerca e fornisce linee di ricerca future. I principali contributi di questo lavoro di ricerca possono essere riassunti come segue. Questa tesi evidenzia la stretta

connessione tra i fenomeni di digitalizzazione e servitizzazione e prova che la digitalizzazione può essere 'un'arma a doppio taglio'. I risultati empirici raccolti descrivono la servitizzazione digitale attraverso la sua natura multilivello, che si manifesta su tre livelli: micro (individuale), organizzativo e di network. Inoltre, sottolinea l'impatto del networking nei processi di digitalizzazione e servitizzazione; nuovi attori entrano a far parte della catena del valore e possono influenzare l'andamento dei due fenomeni. Infine, la complessità dei processi di digitalizzazione e servitizzazione è provata empiricamente e si propone evidenza delle difficoltà incontrate dalle aziende manifatturiere nel tentativo di realizzarli.

Parole chiave: Industry 4.0, servitizzazione, mercati industriali, servitizzazione digitale

Contents

Introduction

This research project is framed into the Business-to-Business context, and it relates to the investigation of two phenomena: digitalization and servitization. Through digitalization, industrial firms access new technologies which let them digitalize processes, production, and interactions, while discovering new ways of being innovative (Rachinger *et al.*, 2019). Not by chance, contemporary industrial markets are showing a trend of digitalization along the entire value chain in order to be more innovative, resilient, and to generate new business value and competitive advantage in a global scenario (Papadopoulos *et al.*, 2021). More recently, the unfortunate events of the Covid-19 pandemic significantly pushed firms toward digitalization and underlined the power of digital technologies to survive crisis times (Brem *et al.*, 2021). At the same time, servitization strategies, i.e., the adoption of service-centric business models by manufacturing firms, are quickly spreading. Servitization strategies can constitute a way out from volatile and unstable revenues coming from selling products, since they offer cyclical incomes by contractual formulas (Vendrell-Herrero *et al.*, 2021).

The link between the digitalization and servitization phenomena is strong and evident, when observing industrial markets. Even though servitization is not a new concept, since Vandermewe and Rada already coined the term in 1988, it is being re-evaluated in recent times, precisely because of the diffusion of digital technologies (Gebauer *et al.*, 2021). In particular, the spreading of Industry 4.0 technologies i.e., innovative digital technologies for the design and application of new materials and processes allows for the generation of digital services. Technologies as the Industrial Internet of Things, Cloud Computing systems or robotics allow industrial manufacturers to offer services linked to their products, such as preventive and predictive maintenance, video-remote assistance, usage-based leasing, research and development consulting, data-based smart services, and many others (Hsuan *et al.*, 2021). They flow into a new type of offering system defined as Product-Service Systems (Gaiardelli *et al.*, 2014). The combination of digitalization and servitization gives life to what recent literature defined as the 'digital servitization' phenomenon (Vendrell-Herrero *et al.*, 2017), a phenomenon which is quickly spreading at the international level.

Digital Servitization is thus a recent and emerging research stream, which is catching the attention of both researchers and managers internationally. A flourishing literature has been addressed during the last decade, observing it from different perspectives. On the one side, studies on the organizational impacts of the phenomenon emerged, which try to investigate the main challenges, barriers, and results faced by manufacturers in the transition toward

a service-centric business model (Bustinza *et al.*, 2018; Paiola & Gebauer, 2020). On the other side, an interorganizational analysis of the phenomenon is arising, which involves the investigation of the context surrounding Digital Servitization and of the actors and stakeholders involved along the value chain (Kohtamäki *et al.*, 2019; Kamalaldin *et al.*, 2020). Few, recent studies try to combine the intra and interorganizational perspectives on Digital Servitization with the aim to achieve an organic framework for its analysis and fully discern the origin of its complexity (Tronvoll *et al.*, 2020; Chen *et al.*, 2021).

Notwithstanding the great dynamism gravitating around digitalization and servitization literature, industrial firms still encounter difficulties in managing the two, interrelated phenomena. Managers perceive high barriers toward investing in digital strategies. A first challenge is represented by the lack of competences on how to integrate I4.0 technologies with the existing infrastructure and exploit them under the operative, technical, and managerial field (Schumacher, 2015). Knowledge diffusion is a key mechanism to facilitate I4.0 spread and overcome scepticism linked to its potentialities. Similarly, orienting the business model of manufacturers toward services is perceived as a complex and risky strategy for intra and interorganizational reasons. Internally, managers deal with the hurdles of a deep cultural change, a revision of the hierarchical structure, the innovation of the sales model approach, or the set-up of a service manpower (Paiola & Gebauer, 2020; Frank *et al.*, 2019). Toward the external environment, challenges imply redesigning the relationship with customers with a service-centric focus and infuse them the value of services, repositioning the industrial firm along the supply chain and adjusting power structures (Sjödin *et al.*, 2020). Furthermore, scepticism of industrial firms is justified by the economic and financial risk related to Digital Servitization investments. Case studies observed so far appear contradictory and diverging in term of performance results. Indeed, some authors registered cases of manufacturing firms with the successful implementation of Digital Servitization strategies, while others witnessed flattering results, which even led to deservitization, i.e., the process through which servitizing firms move back from Digital Servitization to refocus on their core business (Kowalkowski *et al.*, 2017; Martín-Peña *et al.*, 2020).

Taking a problematization approach, it appears evident as further knowledge on digitalization and servitization is needed to fully discern their benefits and challenges and support industrial companies while choosing whether to invest or not in Digital Servitization and how to approach it.

Some open points in the digital- and service-related literature can thus be identified. A first area to deepen concerns the required knowledge to implement a digitally-based evolution. Even though I4.0 adoption is highly influenced by the digital knowledge available within firms, the I4.0-related knowledge-building process has not been investigated in depth. Particularly, it is evident how firms at the global level are activating themselves to keep up in the escalation toward digitalization. Nevertheless, awareness is still missing about how digitalization happens in terms of the behaviours and processes activated by industrial firms within the business network in which they operate to build I4.0-related knowledge and invest in new technologies (Rubach *et al.*, 2017). Also, the business model transformations happening as a result of digitalization are partially still to discover. Digital servitization is just one of the main business model upheavals led by Industry 4.0 technologies spread (Ritter & Pedersen, 2020).

A second research area deserving further attention is linked to the understanding of the origins in Digital Servitization complexity. This 'business model' transformation revealed as a highly complex strategy to actualize for manufacturers. Difficulties have been noticed both at the intra and the interfirm level; this allows to consider the origin of complexity in Digital Servitization as a multilevel concept. Indeed, aiming at understanding the sources of complexity in Digital Servitization, authors are recently highlighting the necessity to provide both a holistic theoretical approach to overcome the actual fragmented view, and a multilevel and multi-actor perspective capable of explicating complexity from a comprehensive and multi-layered view (Eloranta *et al.*, 2021; Sklyar *et al.*, 2019).

A third neglected area of investigation relates to unveiling the phenomenon from the perspective of each actor involved in it. Describing Digital Servitization from various viewpoints including each type of actor can be useful to achieve a multifaced comprehension of the phenomenon. In this line, the perspectives of the servitizing firm, as well as the one of the servitizing firm's supplier have been widely taken into consideration. On the contrary, the viewpoint of the customer has not been analysed yet.

Finally, a fourth under-investigated research area is about the processual approach to Digital Servitization analysis. Empirical studies illustrating Digital Servitization journeys so far mainly adopted a firm-centric approach and focused on the shift from a product- to a service-centric business model. Existing studies on the topic disentangled the initial stages of a Digital Servitization journey, while less attention has been posed toward the successive stages of evolution. A processual, long-term vision on Digital Servitization is missing, which combines

a cross and multi-actor analysis with an investigation of the evolutionary stages of the strategy (Paschou *et al.*, 2020; Khanra *et al.*, 2021).

This study is aimed at an in-depth examination of digitalization and Digital Servitization processes because, even though they constitute the future of international industrial markets, they still present some under-investigated research areas. Under the light of the considered open points and given the historical times we are experiencing, building new knowledge on the two phenomena seems crucial. Economic environments worldwide are being characterized by new connectivity technologies with a significant financial and productive impact (Cave, 2018). Investigating such impacts helps in building new theories on business models and ecosystems and in understanding how business-to-business markets define opportunities on the basis of such innovative ecosystems. Not only, by investing in Digital Servitization research, new opportunities and challenges for the further development of the topic can be raised, enlarging practitioners' awareness and understanding of the strategy (Leminen *et al.*, 2022; Rabetino *et al.*, 2021).

The need to build further knowledge on Digital Servitization is witnessed by the increasing number of recent calls for papers on different journals. The *International Journal of Operations & Production Management* opened a call for papers titled "Servitization 2.0: Evaluating and progressing servitization-related research from novel conceptual and methodological perspectives" (Rabetino *et al.*, 2021). *Technovation* opened a call entitled "Digitalization and new types of connectivity-enabled business model innovations" (Leminen *et al.*, 2022), which is still open. The *Industrial Marketing Management* journal hosted the call "Intra and interorganizational paradoxes and actionable solutions in product-service networks" (Golgeci *et al.*, 2022). Finally, the call "Servitization, logistics and manufacturing in resilient and digital supply chains" (Murino *et al.*, 2022) is still opened in the *Sustainability* journal.

This thesis aims at contributing to the above-described current debate on digitalization and servitization, happening on a global scale, with the overall and primary objective to unveil new knowledge on the two phenomena. Notably, the purpose of this research is twofold.

On the one side, this work is performed to enrich the knowledge in the flourishing academic fields of digitalization and servitization. The intent is to expand the awareness on Digital Servitization in some identified, new research areas. Particularly, this thesis deals with a first innovative stream of research, which relates to the analysis of the mechanisms for the diffusion of I4.0-related knowledge and the resulting transformations in the business model. A second

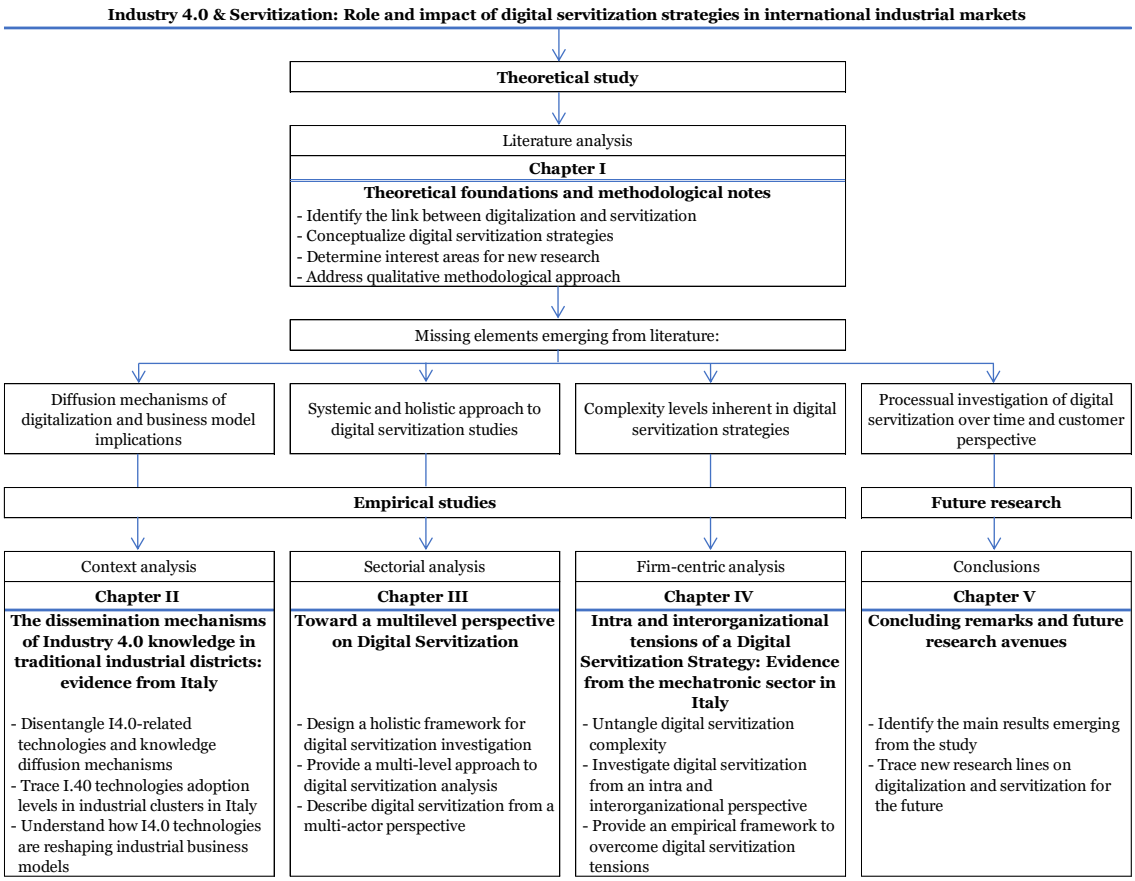
research area deepened in this thesis is connected to the identification of a holistic approach for investigating Digital Servitization strategies. Finally, an inquired research area is connected to interpreting the phenomenon from a multilevel and multi-actor perspective.

On the other side, the research project is significantly oriented toward building managerial contributions and supporting manufacturers who struggle with or interested in investing in digitalization and Digital Servitization. The research project is intended to offer insights and tools in order to support managers in reinforcing the strategic internationalization processes and competitiveness levels related to Digital Servitization. Therefore, the overall aim of this thesis is the following:

> *Investigate how business-to-business companies embrace I4.0-related digitalization and Digital Servitization and how such phenomena are transforming intra and interorganizational dynamics in international industrial markets.*

To this aim, the thesis is structured in five chapters. Each chapter contributes to some of the emerging research streams highlighted. Figure 1 graphically represents the structure of the thesis by chapters and shows the connections between each chapter.

***Figure 1**. Thesis structure*



Chapter I – *Theoretical foundations and methodological notes* – consists in a review of the available literature on digitalization and Digital Servitization useful to depict relevant streams of research and it provides a clarification of the methodological notes adopted within this thesis work. Notably, it encloses a preliminary theoretical analysis on digitalization and servitization which revealed significant in designing the overall thesis structure. Indeed, this chapter attempts at summarizing the main existing literature on the phenomena to describe the interrelation between them, conceptualize Digital Servitization strategies, and highlight emerging research areas that could be further expanded. Four emerging research areas are identified in Chapter I, which can be summarized as follows:

i. Diffusion mechanisms of digitalization and business model implications;
ii. Systemic and holistic approach to Digital Servitization studies;
iii. Complexity levels inherent in Digital Servitization strategies;
iv. Processual investigation of Digital Servitization over time and customer perspective.

In consideration of the emerging research streams, Chapters II, III, and IV try to explore them accordingly.

Chapter II – *The dissemination mechanisms of Industry 4.0 knowledge in traditional industrial districts: evidence from Italy* – is an empirical investigation that provides a contextual-level analysis on the digitalization phenomenon. It is connected to the first emerging research stream and investigates the context in which Digital Servitization strategies spread, with particular attention to the environment of industrial districts where new, Industry 4.0 technologies are diffusing. The general aim is to evaluate the level and processes of diffusion of such technologies and their impacts in terms of business model transformations. This chapter disentangles Industry 4.0-related technologies and knowledge diffusion mechanisms and explains how Industry 4.0 technologies are reshaping industrial business models.

Chapter III – *Toward a multilevel perspective on Digital Servitization* – deals with the second emerging research stream and empirically analyses a Digital Servitization journey at the inter-sectorial level. It calls for building a systemic and holistic approach to Digital Servitization studies by a cross-sectorial analysis of servitizing manufacturing firms. By observing the Digital Servitization transition of two firms operating in different sectors, the chapter catches the impacts and dynamics of Digital Servitization strategies from a multilevel perspective, which is simultaneously microfoundational, organizational, and of network. Through a problematized, empirically based approach, it contributes to defining a holistic framework for Digital Servitization investigation, providing a multilevel approach for its analysis, and describing Digital Servitization from a multi-actor perspective.

Chapter IV – *Intra and interorganizational tensions of a Digital Servitization Strategy: Evidence from the mechatronic sector in Italy* – relies on the third emerging research stream: it is an empirical, firm-level study of Digital Servitization tensions. Notably, it deploys an in-depth investigation of an industrial company by longitudinally exploring the stages of its Digital Servitization journey. The aim of embracing such perspective is to disentangle challenges and opportunities involved in a Digital Servitization strategy and define strategic tools to interpret them along its development. Furthermore, the chapter is key to untangle Digital Servitization complexity levels, to adopt a dual (multilevel) perspective on Digital Servitization by investigating its intra and interorganizational impacts, and to define an empirical framework to overcome Digital Servitization tensions.

The final Chapter V – *Concluding remarks and future research avenues* – provides concluding remarks and traces the future research lines. It includes a section of discussions, which critically observes the digitalization and Digital Servitization phenomena trying to provide an answer to the overall research question, and a description of the theoretical and managerial contributions arising from the research. This section highlights the tight connection between the digitalization and servitization phenomena, and a 'dual' effect of digitalization. On the one side, it could enable servitization and work as a supporting tool; on the other side, it constitutes a barrier hindering the servitization process because of the required knowledge and capabilities. The multilevel nature of the Digital Servitization phenomenon also emerges, which is displayed along three levels: microfoundational, organizational, network. Particularly, the network level demonstrates significantly impactful. New players become part of the value chain and they can influence the success of digitalization and servitization; 'collective cooperation' assumes high relevance, and the interorganizational dimension cannot be left behind. At the same time, the relevance of customer value co-creation practises is confirmed and underlined. The complexity of digitalization and servitization is proven, and the difficulties encountered by managers along them are traced. Particularly, Digital Servitization implies high interconnectedness between its various implications, calling for managerial responsiveness and the ability in coordinating choices with time. A processual view on digitalization and servitization is also suggested to allow the full comprehension of the two phenomena. Chapter V also encloses a concluding remarks section addressing future research lines, which will be interesting to deepen in the very next future.

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Chapter I - Theoretical foundations and methodological notes

1. Theoretical background

1.1 The role of digital technologies in servitization strategies

Industrial markets have experienced far-reaching changes over the past few decades. Among these, a fundamental role is played by the fourth industrial revolution. The advent of innovative digital technologies such as Internet of Things, Cloud Computing, or Artificial Intelligence offers companies multiple options for innovation. They allow for innovation at the technical and production level, as well as at the level of product and service offering and customer relationship management. The rush of industrial firms toward digitalization, with the aim of achieving competitiveness in constantly evolving markets, is a well-known, global process. Nevertheless, the process of adopting the so-called Industry 4.0 (from here forward I4.0) technologies is still being defined, as well as the various implications springing from it. What we can observe since the introduction of I4.0 technologies is a strong innovative push of industrial firms toward the revision and transformation of the business models adopted so far. The digitization process, combined with the application of I4.0 technologies, allows to redesign products and services in a 'smart' key, increasing the levels of flexibility and customization of the offering.

In such context, servitization strategies, i.e., the effort of manufacturers to obtain profitability through the sale of services, discover a second life. Numerous are the firms investing in such strategies, from the most famous Rolls-Royce to leaders in transversal sectors, such as John Deere or Kone. The recent, strong attention on servitization processes seems to be closely linked to the diffusion of I4.0 technologies. Indeed, digital, real-time access to product usage data and the immediacy of managing relationships along the value chain push managers to review the value offer in a creative way, giving them the opportunity to create solutions that could not be imagined in the past. It is for this reason that today we no longer refer to servitization but to Digital Servitization spread.

A thriving stream of literature deals with the phenomenon of Digital Servitization and its implications, although much is still to be discovered about it. The following paragraphs describe in more detail the evolution of industrial markets following the processes of digitization, I4.0 technologies adoption and the related implications, with particular attention to servitization processes.

1.1.1 Digital technologies are reshaping the industrial world

Contemporary business markets are more and more digital. Or better said, contemporary business markets are more and more 'digitized' and 'digitalized'. The difference between the two concepts resides in the impact and application of digital technologies. According to Ritter and Pedersen (2020:181), 'digitization' is the process of transforming analogue data into digital data, meaning the *technical process of converting streams of analogue information into digital bits of 1s and 0s with discrete and discontinuous values*. Instead, 'digitalization' means applying digital technologies to define new business models and reshape business markets; it is therefore the main implication of digitization. In such perspective, digitization increases the availability of digital data to be created, transferred, modified, and elaborated inside and between organizations. At the same time, digitalization calls for innovation in organizations' business model, without which investments in new technologies would not be justified (Ritter & Pedersen, 2020). It could be argued that both digitization and digitalization are contributing to restructure and reshape the industrial world in a new way (Brennen & Kreiss, 2016). This work will refer to digitalization through this lens, considering it as the transformational process deriving from digitization with implications in terms of markets and business models. For this reason, this interpretation of the term 'digitalization' coincides with the concept of 'digital transformation' (Verhoef *et al.*, 2021).

In recent years, a push toward digitization and, above all, digitalization is triggered by the so-called I4.0 revolution. Such revolution, introduced in Germany by Kagermann *et al.* (2011), consists in promoting *the idea of digitization together with some autonomy and self-behavior of the machines as an approach to strengthening the competitive power of the … manufacturing industry* (Oztemel & Gursev, 2020). The OECD (2016:3) provides a definition of the fourth industrial revolution which combines the involved technologies and their impacts; they define it as the *confluence of technologies ranging from a variety of digital technologies (e.g. 3D printing, IoT* [Industrial Internet of Things]*, advanced robotics) to new materials (e.g. bio or nano-based) to new processes (e.g. data driven production, Artificial Intelligence, synthetic biology)*. Quickly spread between industrial firms in Europe and worldwide, the I4.0 revolution basically consists in the adoption of innovative digital technologies, which can be unified under the hat of I4.0 technologies.

It is not easy to provide a list of the technologies enabling the I4.0 revolution which is clear and exhaustive. A definition of the I4.0 technologies appears

fragmented in literature. For example, Pereira and Romero (2017) provide an aggregation of a series of technologies (Internet of Things, Robotics, Big Data, Cloud Manufacturing, Augmented Reality) into three main categories that enables the I4.0 revolution, namely Cyber-Physical Systems, Internet of Things (IoT), and Internet of Services. Differently, the technologies taken into consideration by Oztemel and Gursev (2020) in describing the I4.0 framework are mobile devices, IoT platforms, location detection technologies, advanced human-machine interfaces, authentication and fraud detection, 3D printing, smart sensors, Big Data analytics and smart algorithms, multilevel customer interaction and customer profiling, augmented reality, and cloud computing. Such fragmentation in identifying I4.0 technologies contributes to weakening the awareness of companies about the digital revolution, increasing confusion, and limiting their potentiality of adoption (Çinar *et al.*, 2021).

Nevertheless, numerous are the industrial firms that adopted I4.0 technologies during the last decade (Brancati & Maresca, 2017; Digital 360 Research – IBM, 2017; Brozzi *et al.*, 2018). Many firms consider I4.0 digitalization as essential to gain operational agility, product/service offering flexibility, manufacturing and supply chain resilience, and time-to-market speed. This demonstrated particularly true during the Covid-19 pandemic, when 94% of firms already undergoing I4.0 utilization declared the technologies were crucial to keep their operations running during the faced crisis (Agrawal *et al.*, 2021). Preserving an already manifested trend, though, next years' rate of adoption will predictably be greater in large companies than in smaller firms (Brancati & Maresca, 2017). Reasons for smaller firms having greater difficulties in reaching digitalization can be related to the perceived barriers for I4.0 adoption. In 2019 and 2020, the barriers identified by small manufacturers were lack of people, skills and knowledge, data-security concerns, lack of funding, and limited understanding of technology and vendor landscape (Agrawal *et al.*, 2021). Many small firms also struggle in catching the potential value of I4.0 technologies (Osservatorio Industria 4.0, 2018). The major challenge for them is recognizing the varied directions in which I4.0 can lead them in terms of new business models and market innovation. Frequently, firms perceive the I4.0 change as necessary, also following the main market behaviours; however, they miss a complete overview on its long-term, strategic imports, with the risk of remaining stuck in the 'pilot trap' (Mancini *et al.*, 2021; Narula *et al.*, 2020).

Given the wide variety of technologies and applications of I4.0, it is hard to predict the innovative trajectories that will mark the future of industrial markets. In general terms, the innovative essence of I4.0 resides in the actualization of

systems that allow the alignment between physical and virtual world: *[…] for the first time ever it is now possible to network resources, information, objects and people to create the Internet of Things and Services* (Kagermann *et al.*, 2013:13).

Such change implies a disruptive rethinking of organizational settings and relational connections for firms pursuing it, leading to increasing uncertainty (Pirola *et al.*, 2020b; Hervas-Oliver *et al.*, 2019). On the one side, digitalization facilitates firms' business processes leading to an unprecedent interconnectedness. On the other side, though, it could add complexity by the requirements needed at the organizational and relational level. Failing in adjusting the company's features for digitalization at these two levels could translate into the 'digitalization paradox', i.e., missing revenue enhancement (Gebauer *et al.*, 2020). Organizational capabilities are needed to face an agile and responsive value chain management and technical capabilities to direct the infrastructural change and develop suitable digital strategies (Pirola *et al.*, 2020b; Schumacher, 2015). At the same time, a reorganization of operations, production lines, technical and digital tools is required (Frank *et al.*, 2019). On the relational side, as addressed by Koh *et al.* (2019:818), *Industry 4.0 requires a rethinking and shift in mindset of how products are manufactured and services are produced, distributed/supplied, sold and used in the supply chain; thus, it will drive significant structural theoretical evolution and revolution for operations and supply chain management*. One impact of I4.0 adoption is therefore the utilization of machines to link the manufacturing site within the overall supply chain (Roblek *et al.*, 2016). New actors integrate in the entire value chain 4.0, as KIBS, service and technology suppliers, and customers, and the role of organizations within their own network transforms (Hein *et al.*, 2019; Sklyar *et al.*, 2019b).

It is precisely in the processes of integrating I4.0 actors within industrial networks that the element of proximity plays a key role in facilitating (or not) the adoption and diffusion of I4.0 technologies. Entities as industrial districts and clusters could be of paramount importance in supporting I4.0 diffusion. Even if the local dimension of districts and clusters seem to limit the spread of digitalization, they also provide mechanisms to support the knowledge-building and knowledge-disseminating processes, which could be crucial to increase I4.0 technologies adoption, especially between small- and medium-sized firms (Götz & Jankowska, 2017). Moreover, proximity is not the only element characterizing industrial districts and clusters that stimulates the diffusion of I4.0 technologies (Alberti & Pizzurno, 2015). A series of other elements contribute to this as access to knowledge, deployment of institutional, cognitive, organizational, social

proximity and absorptive capacity (Giuliani, 2005; Camuffo & Grandinetti, 2011).

The innovative directions that I4.0 offers to industrial firms are various, and some of them are likely still to be discovered. As underlined by Vendrell-Herrero *et al.* (2017), digitalization is modifying customer preferences and consumptions; firms invest in digital technologies with the aim of improving competitiveness and redesigning customer relationships, organizational processes, and value propositions. Industry 4.0 makes all of this possible, which translates into various business model configurations (Ritter & Pedersen, 2020). Following the definition provided by Schallmo (2013), a business model includes five dimensions, which can be influenced by I4.0 technologies. Namely, business model changes can happen in the customer dimension (changes in customer segments, channels, and relationships), benefit dimension (changes in definition of products, services, and value offering), value-added dimension (changes in internal resources and processes), partner dimension (changes in partner channels and relationships), and financial dimension (changes in revenues and monetary performance). Between the trajectories industrial firms are embarking on recently, it is possible to observe a diffused effort to modify the product offering and integrate it with new, digital services (Schallmo *et al.*, 2017; Ennis *et al.*, 2018; Matthyssens, 2019). Innovating the product offering with digital tools and integrate it with digital services can be considered as a new business model configuration brought by digitalization and I4.0 adoption.

1.1.2 From Servitization to Digital Servitization strategies

Servitization is the term given to a transformation where manufacturers increasingly offer services that are tightly coupled to their products (Baines & Lightfoot, 2014:4). Indeed, within servitization, manufacturers base their competitive strategies no more just on products, but also on services (Bigdeli *et al.*, 2017). Literature defined various typologies of servitization strategies based on the link between products and services, which determine the business model orientation of firms. While Vandermewe and Rada (1988) and Lin *et al.* (2011) distinguish between *product-centric* and *service-centric* servitization, the former aimed at providing products and related services and the latter at providing services or servitized products, Tukker (2004) identifies three types of servitization based on the service offered (Kamal *et al.*, 2020). The first servitization type includes the offering of *product-oriented services* (the focus of

the business model are products), the second one offers *use-oriented services* (the business model is focussed on both products and services), and the third one concerns offering *result-oriented services* (the business model is entirely devoted to services, while products are not essential).

Independently of the type, servitization represents a key journey for manufacturing firms to generate new value and enlarge the offering by revising the business strategy (Gebauer *et al.*, 2021; Cortimiglia *et al.*, 2016; Kastalli & Van Looy, 2013). Various can be the reasons pushing industrial firms toward servitization strategies. Kamal *et al.* (2020) identify six categories of benefits emerging from servitizing activities: operational, strategic, technological, organizational, environmental, and financial. Between them, the most accomplished and recognized benefit triggering servitization journeys is the strategic one: manufacturers perceive servitization as a valid strategic approach to achieve sustainable competitive advantage through difficult-to-imitate services (Gebauer *et al.*, 2005; Guo *et al.*, 2015). Other drivers pushing firms to activate servitization strategies are increased chances of improvements in customer loyalty levels, in supplier-customer relationships value, and in revenue streams (Brax, 2005), chances of differentiation from competitors, and of allowing better customer relationships (Neuhüttler *et al.*, 2018; Gebauer & Friedli, 2005).

Notwithstanding the beneficial implications of servitization strategies, research highlights how achieving them can be complex or even impossible, leading to paradoxical situations (Kamal *et al.*, 2020). The analysis of Neely (2008:114) on a large sample of international manufacturing firms shows how companies can struggle in achieving improved economic performance by servitizing activities. In detail, the study let a paradoxical situation emerge between servitizing and non-servitizing manufacturers: *While servitized firms generate higher revenues they tend to generate lower net profits as a % of revenues than pure manufacturing firms*. The phenomenon, known as 'the paradox of servitization' (Neely, 2008) or 'the service paradox' (Gebauer *et al.*, 2005) has led some manufacturers to 'deservitization', meant as *the transformational process whereby a company shifts from a service-centric to a product-centric business model and logic* (Kowalkowski *et al.*, 2017b:8). Another emerging paradox intricating the servitization journey of manufacturers and, in some cases, leading to deservitization is the organizational ambivalence between product and service orientations (Lenka *et al.*, 2018; Ashforth *et al.*, 2014). Servitizing manufacturing firms can experience two co-existing and conflicting organizational orientations (toward product and service), which lead to servitization inefficacy and failure if not properly managed. Moreover,

Kohtamäki *et al.* (2020a) provide evidence of servitization paradoxes related to customization levels and engineering efficiency, service organizational structure, and innovation, jeopardizing the success of the investment toward services.

It is clear how servitization poses a series of challenges for manufacturers. Nevertheless, it is increasingly catching the attention of industrial companies, as well as the interest of researchers worldwide. Since its conceptualization, happened by mean of Vandermewe and Rada in 1988, servitization studies rapidly evolved and deepened several aspects of the phenomenon. During the last decade, an intriguing branch of servitization studies is the one of Digital Servitization (Vendrell-Herrero *et al.*, 2017). Recent years are witnessing the 'new life' of servitization thanks to the advent of the fourth industrial revolution (Paschou *et al.*, 2018). Digital servitization consists in *the deployment of digital technologies to support the transformation from a product-centric to a service-centric business model* (Tronvoll *et al.*, 2020:293). Basically, Digital Servitization is the actualization of servitization strategies allowed by the application of digital, I4.0 technologies. Even though digitalization implies facing organizational challenges, it offers great opportunities for firms to grow and expand in contemporary industrial markets. One opportunity is precisely represented by the adoption of Digital Servitization strategies. Introducing technologies as Cyber-Physical Systems, IoT and IIoT (Industrial Internet of Things), Robotics, Big Data, Cloud Manufacturing and Augmented Reality (Pereira & Romero, 2017), enables manufacturers to supply new, innovative services. Digital services are becoming a powerful tool for industrial firms to reinforce their competitive advantage in a digitalized world (Gebauer *et al.*, 2021).

I4.0 technologies let manufacturers rethink their organization and design new value for customers. The link between digitalization, I4.0 technologies adoption, and servitization is therefore evident. Digital servitization encompasses a new way to conceive industry, business, and markets due to the application of various technologies for service innovation systems. I4.0 technologies let companies be more connected, fluent, informed, and flexible in satisfying the customers' needs. Therefore, firms acquire major flexibility and knowledge, which naturally lead them to activate innovation processes connected to services. The new, 'smart products' can now be supported by customized, value-adding services (Porter & Heppelmann, 2015).

More and more companies are investing in Digital Servitization. As innovation leaders, larger companies are the driving forces in such business model transition. Nonetheless, there are interesting opportunities also for small and medium enterprises, and some of them are already investing in Digital

Servitization orientation (Kowalkowski *et al.*, 2017a). The introduction of services helps companies in delivering higher value to the customer and, therefore, the role of servitization in a digitalized field is to support business marketing in the value-creation process (Vargo & Lusch, 2017).

In the industrial context, one of the most spread technologies is IIoT, which let physical objects be connected to internet and generate data. Through such data, firms can understand their customers' workflow and productive needs and provide customized solutions (Paiola & Gebauer, 2020). Therefore, IIoT works as a powerful trigger for implementing Digital Servitization strategies. IIoT-based business models allow for effective data-acquisition, -warehouse, -monitoring, and -analytics, from which to guarantee customers product performance and efficiency, prevent breakdowns, and develop models of preventive maintenance (Hasselblatt *et al.*, 2018). Many firms are adopting IIoT technology to develop Digital Servitization. Well-known success cases of IIoT-based Digital Servitization are Rolls-Royce Aerospace with its Power-by-the-hour model, Alstom with its Train-life services, or Xerox with its document management solutions system (Baines, 2015). Through IIoT and Digital Servitization, such companies have been able to stabilize income, increase profit margins, and engage customers in high-value relationships (Rabetino *et al.*, 2015; Hasselblatt *et al.*, 2018).

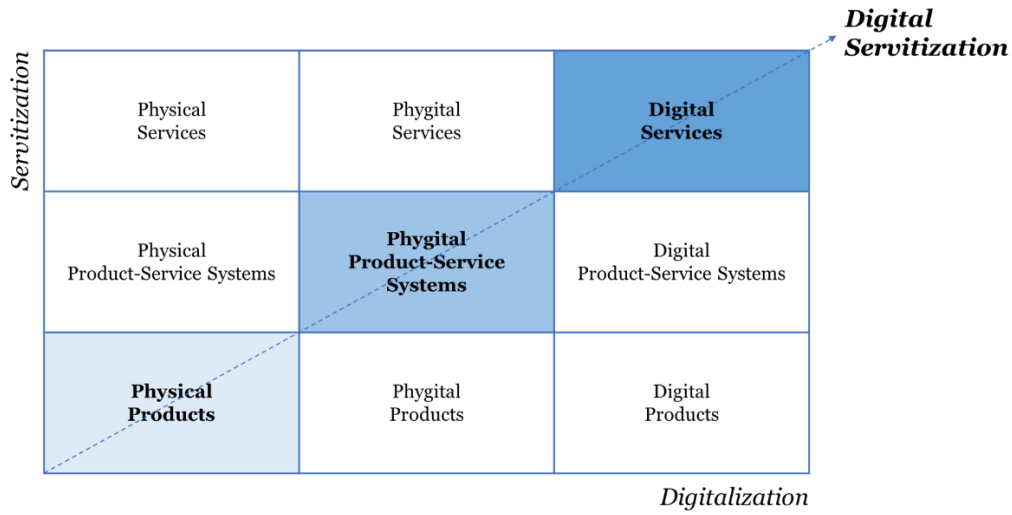
Digital servitization strategies let manufacturers introduce in markets innovative services of various types. In particular, IIoT-based services include a service offering which is strictly related to the realized products. In such cases, firms are realizing product-services (Baines & Lightfoot, 2014). Offerings combining products and product-services are known as Product-Service Systems (PSS – Mont, 2002). PSS is one of the options that Digital Servitization offers to manufacturers, but not the only one (Hsuan *et al.*, 2021). A recent, new trend is related to overcoming the PSS concept toward pure service offerings (Khanra *et al.*, 2021). The concept of service platforms is shaping new Digital Servitization trajectories. A service platform is conceived as a digital space where to offer a combination of PSS and pure services to reach a higher audience of actual and potential customers (Cenamor *et al.*, 2017).

When observing global industrial markets, it is evident how contemporary servitization strategies do not exist in isolation and without the implementation or exploitation of digital technologies. What is happening at the international level is a combined integration of both digitalization and servitization as strategic approaches to overcome uncertainty and dynamism in the industrial context. It seems that servitization per se is no more appealing; Digital Servitization is the

new imperative. The matrix below (Figure 1), elaborated starting from the *service opportunities* matrix defined by Gebauer *et al.* (2021), shows how companies could follow different paths to achieve a Digital Servitization strategy. Some firms could invest in digitalization and, with time, exploit the investment combining a business model orientation towards services. Vice versa, companies could limit to a first servitization effort or reinforce it through digital tools. However, what happens most frequently in contemporary markets is that firms diagonally cross the matrix and pursue from the beginning a Digital Servitization strategy. Via this path, they evolve the composition of their offering from physical products to 'phygital' (physical plus digital – Mikheev *et al.*, 2021) PSS or even to digital services, mainly depending on the intensity of the strategic change.

***Figure 1**. Digital Servitization Matrix*

(Source: elaboration from Gebauer *et al.*, 2021)



In this perspective, Digital Servitization takes the shape of a journey, a path which can lead to different results at different stages of its implementation. Digital Servitization studies have been so far mainly focused on the analysis of Digital Servitization adoption, i.e., implications of the transition from a product- to a product/service-oriented business model (Tronvoll *et al.*, 2020; Bustinza *et al.*, 2018; Paschou *et al.*, 2020), or the transition from offering physical products to offering phygital PSS. The evolution of the strategy, i.e., the transition from offering phygital PSS to offering pure digital services, is still an underexplored topic, especially in terms of organizational implications. Chen *et al.* (2021) posit the attention on the continuous evolutions of Digital Servitization offering as an incremental process, following the calls of Tronvoll *et al.* (2020), Kowalkowski *et*

al. (2012) and Gomes *et al.* (2021). However, the future developments of Digital Servitization need further exploration.

1.2 Adopted perspectives in Digital Servitization

The literature on Digital Servitization is growing rapidly (Zhang *et al.*, 2021; Paschou *et al.*, 2020). This research area has experienced an increasing growth in recent times, and today it is still under development. The attention of academics and managers is increasingly focusing on Digital Servitization processes, making Digital Servitization-related literature flourishing. Emerging research studies adopt various perspectives and focus their attention on different nuances of the Digital Servitization process. This may be due to Digital Servitization being a recent and new phenomenon, for studying which experimental approaches are adopted to better understand its main characteristics in an exploratory way.

It follows that the available literature on Digital Servitization appears as varied and fragmented. However, two main strands, or building blocks, of this research topic can be identified. The first building block has a firm-centric focus, and it describes the intraorganizational impacts of Digital Servitization strategies. The second building block assumes an interorganizational angle, and it observes the impacts of Digital Servitization on actors and stakeholders involved in the process.

The two building blocks have been analysed mainly in isolation, without an integration between the two. Very recently, a few studies are moving toward a more comprehensive perspective on the phenomenon. Combining the intra and interorganizational impacts of Digital Servitization appears effective in discovering the in-depth and long-term effects of contemporary servitizing journeys. The next paragraphs describe the theoretical perspectives adopted so far in the field of Digital Servitization, highlighting the split between the two building blocks and the current efforts to move toward a more defined and less fragmented theoretical approach.

1.2.1 An intraorganizational approach to Digital Servitization

Digital servitization is a phenomenon with varied implications, which are being explored by the emerging literature. Between the existing Digital Servitization studies, some common research areas and trends can be outlined. A

common ground is constituted by the applied methodology to analyse Digital Servitization. Indeed, most studies adopt a qualitative, empirical case-study methodology (Paschou *et al.*, 2020). The reason behind this choice is often related to the necessity of discovering a contemporary, unknown phenomenon with an exploratory approach (Yin, 2009). Similarly, the inquired sectors and technologies are recurring: the most investigated ones are industrial equipment, automotive, and IT, and IoT respectively. Moreover, the thematic focusses in Digital Servitization studies converge toward the role of digital technologies for implementing intermediate and advanced services (Paschou *et al.*, 2020), with particular attention to the first stages of the servitizing strategies that trace the boundary between the product- and the service-oriented mindset (Gomes *et al.*, 2021).

In terms of thematic analysis, managerial studies constitute one research area in Digital Servitization. It could be argued that a first building block of Digital Servitization literature is constituted by organizational studies. They are made of organizational sub-themes, all of them with a strong firm-centric perspective. One point of attention is constituted by the analysis of servitizing firms' performances in economic and financial terms. In this sense, literature on Digital Servitization is still contradictory about the potential value of the strategy in reducing or increasing the 'service paradox' risk. The work of Martin-Peña *et al.* (2020) untangles how the servitization paradox risk is real in servitization strategies; however, digitalization can constitute the discriminant factor to avoid it. Indeed, digitalization can enhance the performance of firms while converging with servitization to be part of the same transformation. Digital servitization is expected to outperform servitization. Cenamor *et al.* (2017) confirm the presence of the economic risk related to Digital Servitization strategies, but they relate it to the strategic configuration defined by the firm. They refer to PSS as a strategic configuration implying the risk of incremental costs with consequential lowering profits. Authors consider the platform approach to Digital Servitization as a valid configuration to improve the economic impact of the strategy.

Some organizational studies in Digital Servitization focus on the analysis of knowledge and capabilities as requirements for the strategy implementation. The premise is that implementing a Digital Servitization strategy requires changes on the managerial approach and internal organization (Bustinza *et al.*, 2018), calling for the acquisition of new competences. The research of Frank *et al.* (2019) shows how firms need to achieve convergence between the digital and the service innovation trajectories to succeed in Digital Servitization, as well as they need to reduce time to markets and revise the production management process.

Similarly, Hasselblatt *et al.* (2018:832) examine the internal criticalities stemming from IoT-based Digital Servitization and unravel *the importance of obtaining capabilities in: i) digital business model development, ii) building scalable solution platforms, iii) IoT value selling, iv) IoT value delivery, and v) business intelligence and measurement* to succeed in Digital Servitization strategies.

Another sub-theme in the organizational side of Digital Servitization concerns the adaptation or modification of the sales model. In this regard, challenges have been identified in terms of difficulties in aligning the value system position and the sales model to the Digital Servitization imperative (Paiola & Gebauer, 2020). Grandinetti *et al.* (2020) underline how the sales model adopted by industrial firms influences its capacity to generate value along the relationship with customers. In particular, if I4.0-related value-delivery processes are restricted to pre-sales services, the value is not fully exploited by customers and the chance of building a solid, long-term relationship is endangered. That is why authors observed that some firms of their empirical sample applied modifications to the adopted sales model from an indirect to a direct market approach while pursuing Digital Servitization. Mattila *et al.* (2021) confirm the relevance of sales model adaptations in digitalization processes. In a context of I4.0 evolution, markets interconnectedness, and self-service transactions, the role of salespersons still plays a key role to support customers in approaching highly complex products and services. The real challenge for salespersons consists in recognizing quickly and deeply how digital transformation is modifying customers' way of working and adapt the existing sales strategies accordingly.

The organizational building block of Digital Servitization studies is composed by great variety not only in terms of examined themes and contents, but also concerning the adopted theoretical perspectives. Indeed, research on this topic is still at its infancy and it is possible to observe high fragmentation across multiple disciplines and outlets; Digital Servitization studies still miss *a coherent set of explanatory theories and prescriptive models* (Paschou *et al.*, 2020:289). Examples of theories utilized to describe the phenomenon include (but are not limited to) business model innovation (Gebauer *et al.*, 2020; Paiola & Gebauer, 2020; Parida *et al.*, 2019; Frank *et al.*, 2019), organizational theory (Kohtamäki *et al.* 2019; Bustinza *et al.*, 2018), history-based management (Gomes *et al.*, 2021), dynamic capabilities (Coreynen *et al.*, 2017), or unlearning processes (Mattila *et al.*, 2021), witnessing the varied and disjointed structure of theoretical approaches.

1.2.2 An interorganizational approach to Digital Servitization

The managerial aspects of Digital Servitization are often linked to the network-building activity of firms and the ability to fruitfully use the connections inside of it to create major value for customers. Digital servitization is expected to show impacts at the network level, implying modifications in the relationship with customers, suppliers, and other stakeholders. Raddats *et al.* (2014) already introduced the need for a multi-actor and network perspective in servitization, which is arising also in Digital Servitization studies. Therefore, a second building block in Digital Servitization literature emerges in relation to the interorganizational impacts of the strategy (Vargo & Lusch, 2011; Vendrell-Herrero *et al.*, 2017).

The network level of analysis is considered to investigate the implications of Digital Servitization in the management of relations with external actors (Süße *et al.*, 2018; Raddats *et al.*, 2019). The paramount role of actors as customers, suppliers, or intermediaries in determining the success of a Digital Servitization strategy is being recognized (Vendrell-Herrero *et al.*, 2017). For example, the work of Reim *et al.* (2019) underlines the importance of developing servitization strategies taking into consideration the service network actors, which will play a key role in making the overall strategy work. Service network actors are considered as intermediaries, which encourage servitization relations between manufacturers and global customers. Therefore, their choices are strongly interrelated with those of manufacturers; coordination and alignment between all actors are essential. Actively participating in a Service Ecosystem (Vargo & Lusch, 2011) and proactively developing Digital Servitization strategies across firm boundaries is a required competence for innovating firms.

Consistent with the first building block (organizational), also in the second one (interorganizational) the variety and fragmentation of Digital Servitization literature emerges. In terms of thematic focuses, variety is given by the multitude of contents that this recent literature stream is providing. Similarly, the theoretical lenses adopted to do so are various and fragmented; they range from the highly diffused Service-Dominant Logic and Ecosystem perspectives (Sklyar *et al.*, 2019a,b; Reim *et al.*, 2019) to the Supply Chain Management approach (Vendrell-Herrero *et al.*, 2017), relational governance and relations quality (Sjödin *et al.*, 2020; Grandinetti *et al.*, 2020) or business relationships (Kamalaldin *et al.*, 2020) approaches.

One element of attention in interorganizational studies is the impact of digital technologies and infrastructures in reshaping relations with actors along the entire value chain. It has been proved that Digital Servitization strategies affect the entire firm's ecosystem, requiring intra and interorganizational adjustments, and the role of digitalization processes in determining the success of the strategy is underlined. However, difficulties are related to achieving digital alignment between actors and smoothening the digital transition along the servitization journey (Sklyar *et al.*, 2019a). The digitalization of companies is of critical importance to build an 'ecosystem-wide digital infrastructure', which let actors in the system communicate easily, resolve problems rapidly, have a more effective contact with the market and better coordination through the entire system (Sklyar *et al.*, 2019a).

Several actors populate the service context in which industrial firms operate. Between them, customers are of paramount importance. Literature underlines how reinforcing the relationship with customers is a powerful tool to increase the success rate of Digital Servitization. Of relevance is to build relationships with customers based on value diffusion, which can be achieved through investments in co-creation processes (Sjödin *et al.*, 2020). Digital services call for greater involvement of customers in the construction of the service offering (Sjödin *et al.*, 2016; Reim *et al.*, 2018); the more customers participate in building the digital service offering, the more they will be able to perceive (and invest in) its intrinsic value. To activate value co-creation processes, manufacturers should achieve a deep understanding of their customers' needs and competences and be able to distinguish customers interested in advanced services. Focussing mainly on proactive customers willing to experiment digital services let manufacturers calibrate financial and technological investments coherently (Grandinetti *et al.*, 2020). Moreover, beyond being interested in digital services, customer should be ready to adopt them. Vaittinen and Martinsuo (2019) investigate the customers' 'readiness' to adopt manufacturers' advanced services. Results show how the 'readiness' of customers influences their predisposition to buy digital services. It strongly depends on their networking activities since customers activate processes, involve different people, and exploit several criteria to evaluate new services.

A further element of attention in Digital Servitization studies with an interorganizational perspective is the analysis of dyadic, supplier-customer relationships and business-to-business interdependencies. The work of Vendrell-Herrero *et al.* (2017) describes how the distribution of power and the strategic position of actors along the supply chain can be influenced by the adoption of

Digital Servitization strategies. Particularly, the study confirms a transformation in the power structure and in the role of actors along the supply chain led by Digital Servitization. It then identifies actions and resources required by upstream and downstream firms to acquire new power or, at least, maintain the strategic positions obtained before the Digital Servitization start. Kamalaldin *et al.* (2020) deeply investigate the transformation process of the provider-customer relationship when a Digital Servitization journey begins. The study reveals four relational components (complementary digitalization capabilities, relation-specific digital assets, digitally enabled knowledge-sharing routines, partnership governance) to monitor and develop in Digital Servitization. It confirms a transformation of the relationship along Digital Servitization journey, where governance modifies from a contractual to a relational model to smoothen the increasing complexity inherent in the strategic path.

Since both building blocks on Digital Servitization revealed key aspects in untangling the complexity of the phenomenon, it is becoming more and more clear how the intra and the interorganizational perspectives cannot be analysed with a silo-thinking approach. The awareness of the need for multilevel perspectives in Digital Servitization is emerging. Following Coreynen *et al.* (2017), two organizational perspectives describe Digital Servitization: a back-end perspective, through which manufacturers improve operational efficiency, availability of resources and decision-making processes, and a front-end perspective, which facilitates the interaction with customers and enhances greater levels of integration. A Digital Servitization business model cannot be analysed only from the firm-side and in isolation from the ecosystem in which it is located, especially due to the nature of the product-service systems implied (Sklyar *et al.*, 2019b; Kowalkowski *et al.*, 2017a; Cenamor *et al.*, 2017). As Kohtamäki *et al.* (2019:381) claim, Digital Servitization is operated within a network: *the integration of smart solutions across firm boundaries is crucial*. Even though some studies are witnessing the effort of observing Digital Servitization from a wider, intra and interorganizational perspective (Tronvoll *et al.*, 2020; Kohtamäki *et al.*, 2020a; Chen *et al.*, 2021), a complete and holistic view on the phenomenon is still in development.

2. Open questions and research objectives

Digital Servitization is the phenomenon resulting from the combination of digitalization and servitization. As observed so far, digitalization is highly spread

between industrial markets thanks to the introduction of I4.0 technologies, which marked the advent of the fourth industrial revolution (Kagermann *et al.*, 2011; Koh *et al.*, 2019). The I4.0 technologies diffusion triggered the adoption of servitization strategies since they facilitate the process of creating and providing innovative digital services (Pirola *et al.*, 2020a; Lenka *et al.*, 2017; Coreynen *et al.*, 2017; Tronvoll *et al.*, 2020).

As highlighted above, Digital Servitization can be observed from two main perspectives. The first one is intraorganizational; it untangles features and implications of Digital Servitization with a firm-centric point of view. Organizational issues of various nature have been identified so far, depicting operational and managerial actions to overcome servitization-related paradoxes (Kohtamäki *et al.*, 2020b; Bustinza *et al.*, 2018; Hsuan *et al.*, 2021). The second one is interorganizational; it unravels the implications of Digital Servitization in terms of relationship management, distribution of power and roles between actors and stakeholders involved in the process (Sklyar *et al.*, 2019b; Vendrell-Herrero *et al.*, 2017; Raddats *et al.*, 2014). Few recent studies are showing an initial effort to combine the two perspectives to achieve a wider understanding of Digital Servitization complexity (Coreynen *et al.*, 2017; Tronvoll *et al.*, 2020; Kohtamäki *et al.*, 2019).

Within this context, interesting considerations emerge, which lead to unveiling new research lines. A first consideration is related to the diffusion processes of I4.0 technologies between industrial markets and its role in determining the advent of Digital Servitization strategies. It is clear that I4.0 technologies are influencing industrial business models. However, less clear is how firms access such technologies and access the related knowledge, and in which directions I4.0 technologies reshape their business models. Attention has been posed to the organizational factors enabling I4.0 adoption, while the interorganizational and contextual elements facilitating or hindering digitalization are underexplored (Pagani & Pardo, 2017; Götz & Jankowska, 2017; Hervas-Oliver *et al.*, 2019). Even though digitalization is at this point a necessity of contemporary markets, the modality of diffusion of digital tools and its business model implications have not been fully investigated.

A second consideration regards how to disentangle complexity levels involved in Digital Servitization strategies. Digital Servitization represents a complex and devious journey for manufacturers. Not by chance, some of them encountered challenges that let them rethink their business models and proceed with deservitization (Kowalkowski *et al.*, 2017b). Notwithstanding the research

built so far, manufacturers still approach Digital Servitization strategies with a high level of complexity and uncertainty about its possible outcomes.

This could be due to the fact that the challenges pinpointed so far concern delimitated events in specific spaces. Indeed, challenges provided by literature belong to the intra or the interorganizational level of analysis respectively, following a silo-thinking approach. A consistent conceptual approach, which considers Digital Servitization as a multilevel phenomenon and which combines its intra and interorganizational effects, is still missing (Pirola *et al.*, 2020a). This research gap emerges clearly from the literature review deployed by Paschou *et al.* (2020:288). The authors recognize that *several themes have been associated with the digital servitization concept […]; however, a fragmented view on them prevails* and therefore they call for future research which adopts *a systemic and holistic approach to the themes associated with digital servitization.*

The relevance of achieving a systemic and holistic approach to Digital Servitization studies is twofold. On the one side, it helps in bridging a research gap and in finding an organic, consistent theoretical approach to Digital Servitization. The literature encountered so far is fragmented and a systematic view is key to better assessing Digital Servitization complexity and implications (Paschou *et al.*, 2020). On the other side, considering Digital Servitization as an incremental and processual journey (Tronvoll *et al.*, 2020; Kowalkowski *et al.*, 2012) allows to disentangle its long-term effects and multidirectional implications. Such contribution would be precious for managers and entrepreneurs to increase their awareness of Digital Servitization potential benefits and pitfalls and to develop adequate strategic plans for its implementation. This means making the effort to both observe and describe Digital Servitization with a multi-level and multi-actor perspective and approach longitudinal studies, to trace its evolutions over time.

Recent literature is already witnessing attempts to achieve a holistic perspective, even though some elements could be further explored. For what concerns time-wide perspectives, many studies have focused on the implications of Digital Servitization at the adoption stage, i.e., when moving from a product- to a service-centred business model. Few studies look at its implications in the successive development stages, to observe if, how, and why the service offering evolves with time (Chen *et al.*, 2021; Gomes *et al.*, 2021).

Similarly, regarding space-wide perspectives, multi-actor studies exist. However, they are mainly focused on provider-customer relationships from the supplier point of view. The storytelling on Digital Servitization happens often from the perspective of the servitizing firm (Coreynen *et al.*, 2018; Mattila *et al.*,

2021; Bustinza *et al.*, 2018; Hydle *et al.*, 2021; Kohtamäki *et al.*, 2021). The customer perspective has not been investigated in-depth, even though authors addressed the issue (Vaittinen & Martinsuo, 2019; Vaittinen *et al.*, 2018; Gebauer *et al.*, 2021).

To sum up, the following research gaps emerge. First, the investigation of the diffusion mechanisms of digitalization and its business model implications; second, the search for a systemic and holistic approach to Digital Servitization; third, the understanding of the complexity levels inherent in Digital Servitization strategies; fourth, the adoption of a processual approach in analysing Digital Servitization over time and from the customer perspective.

This research aims at contributing to the digitalization and Digital Servitization body of knowledge. The final objective is twofold: increase the understanding of I4.0-related digitalization and Digital Servitization to contribute to the advance of knowledge in this under investigated area and provide managers and entrepreneurs with tools and knowledge to support them along I4.0-related digitalization and Digital Servitization actualization. Such objective derives directly from international industrial markets, where a consistent push toward digitalization and a dematerialization of products in favour of services are displaying. Since such processes have been reinforced and accelerated by the recent COVID-19 pandemic events, this research investigates them to potentially solve related issues. In particular, three issues are addressed within this thesis work. A first issue is to increase the awareness on the diffusion mechanisms of I4.0-related technologies to understand the factors enabling I4.0 adoption and observe the resulting business model implications. In line with this goal, Chapter II addresses the following Research Question:

> *How is Industry 4.0-related knowledge spread in IDs active in traditional industries and what are its main implications?*

A second issue is linked to providing an answer to the call for a holistic, multi-level and multi-actor perspective on Digital Servitization processes. Since the phenomenon misses a comprehensive theoretical approach for its observation, Chapter III looks for an organic framework to apply to Digital Servitization studies and posits the following Research Question:

> *Why do companies continuously struggle with DS despite extensive knowledge on hurdles and approaches to overcome them?*

A third issue addressed by this research work regards the effort to find an innovative theoretical framework to disentangle Digital Servitization complexity

from a systematic approach, which combines its intra and interorganizational perspectives. Coherently, Chapter IV aims at contributing to the understanding of Digital Servitization complexity by the empirical investigation of a Digital Servitization journey to discover additional elements jeopardizing such process. The Research Questions posited by this chapter are:

> *How does the emergence of intra and interorganizational tensions generate complexity along a DSS?*
> *Where and when can manufacturing companies intervene to dissolve such complexity?*

3. Methodological notes

The topic of this research is the recent and growing phenomenon of Digital Servitization, which is catching the attention of academia and practitioners in the business field. This work explores the reaction of business-to-business firms to I4.0-related digitalization and Digital Servitization and the way in which such phenomena are transforming intra and interorganizational dynamics in industrial markets.

Considering the exploratory nature of the research and the contemporary events under investigation, the methodology applied to this research is qualitative. A qualitative approach is justified by both the features of the investigated phenomenon (Digital Servitization) and the research objectives. Firstly, a qualitative approach helps in achieving a greater level of detail in results and deploy an in-depth analysis of under-investigated research themes, especially for theory-building purposes (Lindgreen *et al.*, 2021; Pearse, 2021). Being Digital Servitization a recent phenomenon, about which several aspects are still to be examined (Paschou *et al.*, 2020; Khanra *et al.*, 2021), and given the research objectives of this study, including theory-building to access a holistic theoretical framework for Digital Servitization, a qualitative approach seems particularly appropriate. Indeed, qualitative methodology is designed to collect rich and detailed information and build subjective findings, which are crucial in theory-building processes for mainstream, new research topics (Crick, 2021). It is well-suited for addressing relevant problems or gaps, from which to delineate strategic solutions for specific stakeholders (Epp & Otnes, 2021). Secondly, qualitative research is suitable for studies which are not limited to evaluating a phenomenon but that embark also on the analysis of the context and history around it (Yin, 2009; Meyer, 2001; Lindgreen *et al.*, 2021). Comprehending contextual and

temporal elements of Digital Servitization is of paramount importance for disentangling its complexity in a multilevel perspective. Interactions and interdependencies between actors determine and influence Digital Servitization processes; therefore, Digital Servitization is highly embedded in the context in which it happens (Hedvall *et al.*, 2019).

The qualitative approach unfolded in the three empirical chapters of this research consists in the case study methodology (Yin, 1994). The reason for adopting case studies is threefold. First, case study has been validated as a functional tool for researching in the field of Digital Servitization. Indeed, several authors have utilized case study methodologies to investigate digitalization and servitization, providing consistent results within an exploratory approach (see, between others, Tronvoll *et al.*, 2020; Ciasullo *et al.*, 2021; Naik *et al.*, 2020; Solem *et al.*, 2021). Second, adopting the case study method is relevant to get the complexity levels involved in the inquired relationships (Halinen & Törnroos, 2005). Since the aim of the research is to provide a deep and contextual analysis of Digital Servitization, case studies offer the chance of a methodical and extensive exploration. Third, case study methodology is beneficial for theory development in dynamic contexts (Pratt, 2009; Matthyssens & Vandenbempt, 2003); therefore, it applies to the aim of this research.

The type of case study methods deployed in this research are a combination of single and multiple case studies, in order to achieve completeness in the analysis. In particular, Chapter II presents a single case study involving an Italian industrial district; Chapter III introduces a multiple case study research, where the comparison between an Italian and a Belgian manufacturer is displayed; Chapter IV involves the single case study analysis of an Italian industrial firm. The single case study has been adopted to achieve benefits as high-quality theory, a deeper understanding of the main subject and a rich description of the examined phenomenon. In parallel, the multiple case study allows access to benefits as strong and reliable evidence, theory-building derived from the observation of similarities and differences between the cases, and a wide discovery of theoretical evolutions (Gustafsson, 2017).

The case studies examined along this research project followed a rigorous data collection method, with few distinctions between the three chapters. In general terms, the main data sources implied are semi-structured interviews and participant observation. In detail, in Chapter II interviews are combined with dissemination activities analysis as main data sources; in Chapter III the core focus of analysis are interviews; in Chapter IV participant observation is the main data source, together with interviews. Interviews have been selected as main data

source since they allow rich data collection and information triangulation, biases limitation, and findings validation when combined with other data sources (Jonsen & Jehn, 2009). Interviews happened in the form of one-to-one, in-depth, semi-structured, open-ended interviews (Cavana *et al.*, 2001). To ensure the validity of the questions addressed during the interviews, the writing of a formal protocol preceded the interviews' actualization. The aim of the protocol is to have a standardized and uniform interview approach, to collect focused and relevant data, and to keep a high degree of flexibility (Hunter, 2012). In line with the adopted theoretical approach, in each chapter of this research the interview protocol is based on literature insights and on the research questions of the study. Formulating the interview protocol is key to identify the proper respondents (Aguinis & Bradley, 2014). The selection process of interviewees has been guided by specific criteria. First, throughout this research, interviewees are crucial figures in the digitalization and servitization processes described within the case studies. They were sampled based on their involvement with the analysed initiatives and their ability to provide a unique perspective on the initiatives' evolution (Patton, 2005). Therefore, the selected respondents are the most representative figures in the described Digital Servitization journeys (Yin, 2009). Senior managers, project managers and key figures in the Digital Servitization process have been identified as informants for the interviews. Second, a snowballing technique was applied to understand the proper number and typology of interviewees to identify; interviews have been undertaken until saturation (Bott & Tourish, 2016). Total freedom has been left to respondents in answering the questions; no direct link to the investigated topic has been made explicit in the attempt to avoid *biased researcher's opinion* (Thirsk & Clark, 2017).

Concurrently, participant observations constituted a critical element in depicting the case study in detail and with increased reliability. Particularly, participant observation has been defined as a potentially powerful approach to understand market dynamics in the business-to-business service context (Keränen & Prior, 2020). Therefore, it appears suitable to investigate Digital Servitization journeys. Participant observation is of paramount importance for two main reasons. Firstly, it enhances the quality of the collected data and facilitates information triangulation between different data sources (Denzin, 1978). Therefore, participant observation can be considered both a data collection tool and a data analytics tool. Secondly, it contributes to encouraging creative thinking and addressing new research questions, starting from the grounded scenes' observation (DeWalt & DeWalt, 2011).

Finally, secondary sources contributed to enriching data collection and validity. Various types of secondary sources have been applied in the chapters of this research, including network pictures (Ramos & Ford, 2011), relevant websites, sectorial magazines and editorials, press briefings, media reports, newspaper interviews, official statistical data, or corporate reports.

A longitudinal analysis characterizes the methodological approach of the three empirical chapters in this research. Longitudinal case studies are relevant since they support the enhanced understanding of process dynamics and the analysis of the evolutions of the Digital Servitization phenomenon over time (Quintens & Matthyssens, 2010). Observing and describing events following the temporal order in which they happened guarantees clarity in the case study narration, helpful to empower the case study value (Sandelowski, 1999; Gustafsson, 2017). Since the goal of the research is to gain clarity on Digital Servitization as an evolving phenomenon, a longitudinal, case study approach seemed valuable.

The data analysis process adopted in this research is common to the three empirical chapters and based on the systematic combining technique, applicable through an abductive approach (Dubois & Gadde, 2002). This approach is in line with the exploratory research nature and the effort of matching constantly theory and empirical notes. It helps in investigating new research streams with full consideration of the existing theories developed on the inquired topic (La Rocca *et al.*, 2017). Along with the abductive approach adopted, data-driven and theory-driven coding of information followed. The empirical analysis of data has been guided by the analysed literature, from which the coding steps have been derived. Empirical findings of the research arise from the continuous interrelation between insights extracted from interviews, participant observation, and secondary sources (Denzin, 1978). Coding processes were developed without the adoption of software. Given the simplified structure of data typical of case studies, a manual information coding was possible (Lindgreen *et al.*, 2021). The coding activity revealed of paramount importance to detect key results emerging from the examined case studies and provide them with added value.

The techniques adopted to frame results and critically discuss them is different for each of the empirical chapters presented in this research. Each technique has been chosen depending on the case study features, to find the most suitable framework to describe it. In Chapter II, the adopted technique is the ARA (Actor-Resources-Activities) model provided by the IMP Group (Håkansson & Snehota, 1995). It is a valid framework to describe network processes, interactions, and relationships (Ingemansson Havenvid *et al.*, 2016; Rubach *et*

al., 2017). Therefore, is has been applied to the investigation of I.40-related technologies and knowledge diffusion processes in Italian industrial districts and clusters, based on network-like structures and long-lasting business relationships (Bocconcelli *et al.*, 2015). In Chapter III, the CIT (Critical Incidents Technique – Flanagan, 1954) has been adopted to describe the Digital Servitization hurdles of two industrial firms at the microfoundational, organizational, and network level. This technique has been defined as a valid approach to understand contextual elements, behaviours, and challenges of a main event (Bott & Tourish, 2016), and to untangle the *hidden* aspects of disruptive transitions (Durand, 2016:87). Therefore, it suited the study aim. In Chapter IV, the technique framing the discussion of results is the paradox theory lens (Smith & Lewis, 2011). The paradox theory allows the critical investigation of intricacies and challenges complicating business strategies (Waldman *et al.*, 2019). Recently, it is demonstrating a valid frame to describe and understand servitization strategies (Kohtamäki *et al.*, 2020a; Wagstaff *et al.*, 2021), and therefore it has been chosen to depict the intra and interorganizational issues of Digital Servitization.

Table I summarizes the methodological approaches exploited in the three empirical chapters of the research, to provide an overall view on the qualitative method applied.

***Table I**. Methodological approach of empirical chapters*

Empirical Chapter	Title	Research Question(s)	Case study type	Main data sources	Secondary data sources	Framing technique
Chapter II	The dissemination mechanisms of Industry 4.0 knowledge in traditional industrial districts: evidence from Italy	How is Industry 4.0-related knowledge spread in IDs active in traditional industries and what are its main implications?	Singe case study	Interviews	Websites, newspaper articles, annual reports, projects presentations, regional guidelines	ARA model / IMP Group
Chapter III	Toward a multilevel perspective on Digital Servitization	Why do companies continuously struggle with DS despite extensive knowledge on hurdles and approaches to overcome them?	Multiple case study	Interviews	-	CIT
Chapter IV	Intra and interorganizational tensions of a Digital Servitization Strategy: Evidence from the mechatronic sector in Italy	How does the emergence of intra and interorganizational tensions generate complexity along a DSS? Where and when can manufacturing companies intervene to dissolve such complexity?	Singe case study	Participant observation and Interviews	Websites, sectorial magazines and editorials, press briefings, corporate reports	Paradox theory

Basically, Chapter II empirically investigates the dissemination mechanisms of I4.0 knowledge in a traditional industrial district in Italy via interviews as main data source and websites, articles, reports, firm presentations, regional guidelines as secondary data source. The framing technique is the ARA model. Chapter III looks for a multi-level framework to describe Digital Servitization. It applies a multiple case study analysis based on interviews of a Belgian and an Italian manufacturer, described through the CIT. Chapter IV describes the intra and interorganizational tensions faced by an Italian industrial company with the paradox theory lens. Data collection relies on participant observation and interviews as primary source of data and websites, sectorial magazines, press briefings and corporate reports as secondary data source.

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Chapter II - The dissemination mechanisms of Industry 4.0 knowledge in traditional industrial districts: evidence from Italy*

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Abstract

This chapter aims to provide a contribution on the diffusion of Industry 4.0 (I4.0)-related knowledge in industrial districts (IDs). The main goal is to examine the dissemination of I4.0 knowledge, exploring the main mechanisms for its spreading and highlighting the main factors shaping such processes. The methodology applied is qualitative. Notably, this chapter presents a case study of the Pesaro ID specialized in furniture/woodworking machinery sector. A total of 18 in-depth one-to-one interviews have been conducted with relevant informants from a variety of organizations within the cluster: companies, institutions, and universities. The main contribution of this chapter relates with showing how the complexity of I4.0 requires a combination of traditional mechanisms with innovative ones within IDs characterized by the emergence of new players, activities, and resources. These changes led to some evolving patterns: the horizon of I4.0 upgrading shows blurred boundaries in terms of sectors and geographic location, the I4.0 diffusion appears fragmented in terms of initiatives and projects by both firms and institutions, the dissemination of I4.0 knowledge pushes ID firms and institutions to pursue deliberate initiatives leading to innovative forms of 'collective' cooperation, business model innovations are derived from I4.0 technologies. This chapter contributes to both theory and practice. From the theoretical point of view, it enriches the literature on innovation in IDs and clusters on two interrelated grounds. First, it provides further research on I4.0 and IDs and clusters. Second, it contributes to the stream of research on knowledge creation and diffusion in IDs and clusters, providing empirically based insights over emerging local learning processes in IDs. Moreover, relevant managerial and policy implications stem from the analysis.

Keywords – Innovation, Policy, Industry 4.0, Knowledge diffusion, Industrial districts

1. Introduction

Firms agglomeration is a relevant phenomenon for economic and industrial development. Economics and management scholars have examined in depth the features and the evolution of industrial districts (IDs) and clusters, leading to relevant conceptual developments (Porter, 1998; Lazzeretti *et al.*, 2014). Recently a stronger effort has been placed on a better understanding of the evolution of IDs and clusters (Camuffo & Grandinetti, 2011; Belussi & Sedita, 2012; Fornahl *et al.*, 2015), with a focus on the changes in their knowledge processes (Alberti & Pizzurno, 2015), and on the opening to outside sources and its effect on local knowledge circulation and exchange (Waxell & Malberg, 2007; Belussi & Sedita, 2012). Concepts such as *local buzz* and *global pipelines* have been developed and adopted to gain an understanding of these processes (Bathelt *et al.*, 2004). Such changes are strongly affecting IDs active in traditional sectors, which might be less prompt - in terms of business and technical culture - to absorb technological innovations developed elsewhere (Parrilli, 2009; De Marchi *et al.*, 2017).

Another key phenomenon for economic and industrial development is the emergence of the Industry 4.0 (hereafter I4.0) paradigm. It can be viewed as the forefront of technological and organizational innovations related to the exploitation of current advancements of information technologies (Kagermann *et al.*, 2013; Fitzgerald *et al.*, 2014). The surge of the I4.0 paradigm is pushing academic scholars to explore its diffusion in terms of adoption processes in business firms (Horváth & Szabó, 2019) and its overall impact on companies (Barrett *et al.*, 2015; Arnold *et al.*, 2016; Müller *et al.*, 2018). In-depth empirical analyses of I4.0 diffusion in industrial clusters are still limited. A few insightful recent studies have started to assess whether and how I4.0 approach is diffused within IDs and clusters and whether its technological and organizational underpinnings could match the underlying interorganizational processes in contemporary industrial clusters (Götz & Jankowska, 2017; Hervas-Oliver *et al.*, 2019). This initial research effort is mainly focused on specific institutional projects - within the policy setting - related to the introduction of I4.0, while less emphasis is placed on exploring the variety of knowledge diffusion initiatives promoted - also in autonomy - by both business and non-business actors within the ID. Exploring the dynamics underlying such initiatives is likely to shed light on the digitalization levels achieved by IDs, the diffusion mechanisms characterizing them, and the related implications in terms of innovative business

model trajectories. These aspects of I4.0 are still under-investigated, especially within IDs (Babkin *et al.*, 2020; Chen *et al.*, 2021).

Therefore, the objective of this paper is to provide a contribution on the patterns of diffusion of I4.0 in IDs through the analysis of the main dissemination mechanisms, of the key factors shaping such processes, and the resulting business model innovations. The focus is on dissemination processes in IDs active in traditional industries, in order to analyse whether and how I4.0 approach is diffused in apparently culturally distant business agglomerations, which could represent the '*periphery*' of I4.0 application context (Eder, 2019). Notably, the research question (RQ) addressed in this paper is the following:

> *How is Industry 4.0-related knowledge spread in IDs active in traditional industries and what are its main implications?*

Thus, this paper represents a complementary contribution in the emerging research on I4.0 diffusion in IDs (Götz & Jankowska, 2017; Hervas-Oliver *et al.*, 2019), in the light of its focus on the main dissemination mechanisms and implications. This research orientation could, on the one side, provide useful insights to the growing stream of studies on knowledge creation and learning processes in IDs and clusters, placing emphasis on the degree of opening to outside sources of knowledge and the main diffusion mechanisms (Belussi & Sedita, 2012; Balland *et al.*, 2016; Maghssudipour *et al.*, 2020). On the other side, it could contribute to gain more understanding on the digitalization levels achieved by IDs and the resulting business model innovations in the business-to-business context (Paiola & Gebauer, 2020; Kohtamäki *et al.*, 2019).

In order to answer this explorative RQ, a qualitative research methodology based on a case-study approach is adopted. Notably, this paper is focused on the analysis of the furniture/woodworking machineries industrial district located in Pesaro in Centre Italy. The ID under investigation has been very active in a traditional sector - furniture/mechatronic - and has been greatly impacted by the economic crisis started in 2007-2008, showing a high degree of resilience. In recent years, the cluster has been characterized by various initiatives aiming at promoting both technological and organizational upgrading of district firms, with an increasing focus on I4.0 solutions.

The empirical analysis relies on the ARA (Activities-Resources-Actors) model (Håkansson & Snehota, 1995) developed in the Business Network approach of IMP (Industrial Marketing and Purchasing) group (Håkansson *et al.*, 2009). The ARA framework allows to catch the complexity of the I4.0 knowledge

diffusion in our empirical setting, represented by a traditional Italian ID. Notably, traditional Italian IDs have been already acknowledged as having a network-like structure based on a variety of key business relationships among different actors, playing a major role in the local diffusion of innovation (Bocconcelli *et al.*, 2015).

Results show the upgrading in the type of knowledge dissemination mechanisms adopted in the ID. The complexity of I4.0 seems to require a combination of traditional mechanisms, shaped by the existing interaction patterns of the Pesaro ID, with innovative ones, characterized by the emergence of new players, activities, and resources. These changes lead to three main evolving patterns: *i)* the horizon of I4.0 upgrading shows blurred boundaries in terms of sectors and geographic location; *ii)* the I4.0 diffusion appears fragmented in terms of initiatives and projects by both firms and institutions; *iii)* the dissemination of I4.0 knowledge pushes ID firms and institutions to pursue deliberate initiatives leading to innovative forms of 'collective' cooperation. Fragmentation is observed also in relation to the type of I4.0 technologies adopted within the district and the resulting business model innovations for both small and medium enterprises (SMEs) and large companies.

The paper is structured as follows. Section two is devoted to the analysis of the literature on knowledge and innovation diffusion in IDs and on the emergence of I4.0 and its impact on firms and IDs. In the third section the research objective and methodology are addressed. In section four - after a brief presentation of the historical evolution of the Pesaro ID - the main findings of the empirical research are presented along three main phases of the diffusion and dissemination of I4.0 knowledge: *i)* the pioneering phase; *ii)* the dissemination effort; *iii)* the pursue of institutional upgrading. Section five discusses the results of the analysis. The last section highlights the main contribution of the study, discusses the future lines of research, and outlines the main managerial and policy implications.

2. Literature background

2.1 Innovation processes and knowledge exchanges in industrial districts

IDs represent a relevant and complex phenomenon in industrial organization which has been extensively studied in the economics and management field, under various perspectives (Belussi & Pilotti, 2002; Pietrobelli & Rabellotti, 2004; Ingstrup, 2013; Lazzeretti *et al.*, 2014; Hervas-Oliver *et al.*, 2015). The increased interest on agglomeration of firms have spurred many

streams of research - in both conceptual and empirical terms - over the theme of IDs, clusters, and clustering processes (Speldekamp *et al.*, 2020). Lazzeretti *et al.* (2014: 22) *identify the ID as a particular kind of a more general category of clusters*. As the focus of this study is a traditional ID, the existing literature on knowledge creation and innovation in IDs is discussed and integrated with concepts deriving from the recent relevant contributions on clusters.

IDs have been defined by Becattini (1990: 39) as *a socio-territorial entity which is characterized by the active presence of both a community of people and a population of firms in a naturally and historically bounded area*. IDs are a complex form of industrial organization, whose main elements are the local production network composed by a population of firms, the community of people sharing a feeling of belonging and common identity, and the presence of the so-called '*industrial atmosphere*' (Marshall, 1920; Molina-Morales, 2002; Belussi & Pilotti, 2002; Boix & Galletto, 2009). IDs are characterized by a division of labour among local firms around a specialized sector, leading to increased efficient exchanges and external economies (Marshall, 1920; Becattini, 1991). Beside firms, IDs are influenced by the behaviour of other key actors - such as local institutions, training organizations, business associations, technological centres - providing resources in terms of financial, normative, and technical support (Coletti, 2010; Belussi & Sedita, 2012). This complex web of relationships - including both business and non-business actors - is embedded in strong social ties fostering trust and a sense of community in local networks (Dei Ottati, 1994; Belussi & Pilotti, 2002), leading to a shared identity (Staber & Sautter, 2011).

A stream of research on IDs has focused on their evolution processes, leading to mature stages and to their decline (Belussi & Sedita, 2009; Hervas-Oliver & Albors-Garrigos, 2014; Fornahl *et al.*, 2015). Understanding how and why IDs evolve has been a key concern for ID scholars, who have pointed out two main interrelated patterns: the opening of the ID and the incremental innovation path. Various contributions highlight the incremental opening of the ID system, due to the behaviour of ID firms creating business and technological linkages with actors outside the local ID (Becattini & Rullani, 1996; Camuffo & Grandinetti, 2011, Belussi & Sedita, 2012; De Marchi & Grandinetti, 2016). This has led to a reconfiguration of local relationships which are then combined with new emerging partnerships with other firms and organizations, often located in other IDs. This orientation has been pursued mainly by large firms, which have displayed increased autonomy in their strategic behaviour. One of the consequences has been the weakening of social ties and the reduced role of key actors, such as institutions and business associations (Camuffo & Grandinetti,

2011). A related pattern shaping the evolution of IDs concerns their technological trajectory, influenced by the type and degree of innovation and by the learning processes in place, generated by the interaction within and outside the ID (Camuffo & Grandinetti, 2011; Belussi & Sedita, 2012; Hervas-Oliver *et al.*, 2018).

One of the advantages possessed by IDs is their efficiency in stimulating the creation of new knowledge and in promoting local learning mechanisms (Belussi & Pilotti, 2002). Thus, IDs may be interpreted as cognitive labs or systems, as they are characterized by a high density of knowledge accumulation, elaboration, and circulation by means of various transfer mechanisms, such as interorganizational and interpersonal relations, observation or artifacts and actions, mobility of human resources, creation of new ventures (Becattini & Rullani, 1996; Maskell, 2001; Camuffo & Grandinetti, 2011; Grandinetti, 2011). Various studies claim that spatial proximity in existing localized overlapping networks facilitates knowledge sharing and thus innovation in clusters (Belussi & Pilotti, 2002; Carbonara, 2004; Boix & Galletto, 2009; Alberti & Pizzurno, 2015). Local networks function as key vehicles of knowledge transfer and diffusion: being in the right place is necessary but being in the right network is of utmost importance (Boschma & Ter Wal, 2007).

However geographical proximity is not enough *per se* to understand innovation in local industrial networks (Alberti & Pizzurno, 2015). In fact, even if belonging to the same cluster, firms might have a different degree of access to knowledge, depending on other factors than spatial proximity, such as institutional, cognitive, organizational, and social proximity and absorptive capacity (Cohen & Levinthal, 1990; Giuliani, 2005; Camuffo & Grandinetti, 2011). Innovation is the outcome of the *heterogenous recombination of a broader set of knowledge types* (Alberti & Pizzurno, 2015: 270), i.e., technological, managerial and market knowledge, and thus it should be considered as a synergy of a firm's internal - i.e., absorptive capacity - and external resources - i.e., relational resources - (Hervas-Oliver & Albors-Garrigos, 2009).

Interactive learning processes in IDs and clusters are organized in different ways, depending on the tacit or codified nature of knowledge. A distinction is made between the concept of 'local buzz' and of 'global pipelines: local buzz refers to *the learning processes taking place among actors embedded in a community by just being there*, whereas global pipelines concern *the knowledge attained by investing in building channels of communications to selected providers located in outside the local milieu* (Bathelt *et al.*, 2004: 31). Recent studies have shown

the increasing variety and complexity of learning mechanisms and processes, which rely on a mix of emergent (informal) and deliberate (formal) knowledge structures, implemented locally and/or in connection with actors outside the ID (Belussi & Sedita, 2012). *Emerging* or *informal* structures are those activated unintentionally through networking and personal contacts, while *deliberate* or *formal* structures are those planned, such as R&D interactions with distant partners (Belussi & Sedita, 2012; Lazzeretti & Capone, 2016).

The literature on knowledge exchange in IDs and clusters has focused on the role of specific actors - the '*gatekeepers*' - in the local dissemination of knowledge, in light of their *ability to access external knowledge and construct a conversion process which deciphers external knowledge and turns it into something locally understandable and useful* (Hervas-Oliver & Albors-Garrigo, 2014: 431). Their role as brokers is concerned with searching for, absorbing, and matching internal and external sources of knowledge, and then disseminating the resulting knowledge within the cluster (Giuliani & Bell, 2005; Boschma & Ter Wal, 2007; Morrison, 2008; Hervas-Oliver & Albors-Garrigos, 2014). The role of gatekeeper can be played by leading firms within the cluster (Morrison, 2008; Belussi & Caloffi, 2018) and by institutions, research centres, universities, business associations, and knowledge providers that operate as local/global cognitive interfaces (Grandinetti, 2011). Leader firms - more oriented to medium-long strategic views - tend to introduce more complex innovations within the cluster and to influence the decisions of the local institutional actors (Albino *et al.*, 1999; Corò & Grandinetti, 1999; Boschma & Ter Wal, 2007; Chiarvesio *et al.*, 2010). Knowledge providers and local institutions instead carry on activities to support the ID firms, as they offer support services and at the same time provide innovation opportunities and act as a repository of knowledge. Their role can be described as intermediary agents as they can act as broker for the development of relationships between district firms and potential external exchange partners (Molina-Morales *et al.*, 2002; Hervas-Oliver *et al.*, 2012; Belso-Martinez, 2018).

Innovation and learning processes in IDs are affected by the growing digitalization of business processes and interfirm interaction (Biggiero, 2006; Hervas-Oliver *et al.*, 2019). Digitalization questions the dichotomy of local buzz and global pipelines introduced by Bathelt *et al.* (2004), as buzz has started to appear in distant networks through internet-based applications, which can be described as a *buzz without being there* (Moodysson, 2008: 452). Even if there seems to be a contradiction between IDs and clusters promoting localized learning and new technologies enabling worldwide dispersion of activities, it has

been argued that these two patterns are not exclusive: IDs and clusters are of special importance as they could provide mechanisms facilitating knowledge development and dissemination, representing thus the possible answer to many challenges brought up by digitalization (Götz & Jankowska, 2017). Recent contributions highlight that the path towards digitalization in IDs and clusters could be affected by the impact of introduction of I4.0-related knowledge and technologies, considered as a '*disruptive innovation*' (Hervas-Oliver *et al.*, 2018). The next section will explore the nature of I4.0 technologies and the recent contributions in the literature on I4.0 in IDs and clusters.

2.2 The Emergence of Industry 4.0

In the contemporary business environment, I4.0 has become a buzzword. Managers and entrepreneurs are investing in I4.0 and factories are becoming 'smart factories', i.e., technological initiatives aimed at creating a common workshop for innovation in the manufacturing field (Shi *et al.*, 2020). The term 'Industry 4.0' was first used by the German government in 2011, when Kagermann and colleagues wrote an article about high-tech strategies to be applied in the country by 2020. In 2013, the 'Industry 4.0 manifesto' was diffused by the German National Academy of Science and Engineering (Kagermann *et al.*, 2013). The concept of I4.0 *is often referred to as the fourth industrial revolution and embraces a set of technological advances that are having a high impact in the current industrial landscape* (Pereira & Romero, 2017: 1208).

Some sectorial studies started to investigate the achieved level of adoption of I4.0 technologies by companies worldwide (Brancati & Maresca, 2017; Digital 360 Research, 2017; Brozzi *et al.*, 2018), showing a substantial level of diffusion, even if a higher pace of adoption is expected in the next years and, predictably, the rate of adoption in large companies will be greater than the one in smaller firms (Brancati & Maresca, 2017).

A significant adoption level of I4.0 technologies is justified by the benefits manufacturers can encounter. Indeed, the improvements that a company can achieve with the introduction of I4.0 technologies are diverse. Roblek *et al.* (2016:2) identify three main advantages: *digitization of production-information systems for management and production planning, automation-systems for data acquisition from the production lines and using machines [and] linking manufacturing sites in a comprehensive supply chain*. Digital technologies, as the combination of physical and cyber technologies, allow companies to improve

the performance, quality, monitoring, and transparency of each manufacturing process (Shi *et al.*, 2020). Not only, introducing I4.0 technologies by manufacturers means achieving greater flexibility in the design and production processes that lead to higher customization, optimized resources allocation, and reduced complexity (Mohamed, 2018). However, despite the potential benefits of I4.0 technologies, in industrial markets it is possible to observe a general lack of awareness about them, particularly by small firms (Osservatorio Industria 4.0, 2018; AmCham, 2018). What is still missed by firms is a complete perception of the possible directions towards which the I4.0 innovation can lead them. Companies understand the relevance of the I4.0 change, but they are still not able to foresee its possible future developments.

Beyond facilitating internal processes and contributing to improved firm performances, digitalization has a proven impact in terms of business models innovation (Rachinger *et al.*, 2019). With business model we intend the tool which contributes to realizing the strategic intent of the firm by means of interlinked activities and corporate processes, i.e., the conceptual scheme moving firm's strategic goals into its ordinary functioning (Ancillai *et al.*, 2019). Innovation of the business model is realized into one (or more) of the five dimensions of value constituting it: *value proposition* (the product/service offering set), *value creation* (the tangible/intangible resources set), *value delivery* (the distributing activities and channels), *value networking* (the external relationships set), *value appropriation* (the costs/revenues structures) (Cortimiglia *et al.*, 2016). Rachinger *et al.* (2019) underline how digitalization is crucial in contributing to business model innovation in terms of innovative value proposition and value creation processes. For example, a consistent impact of I4.0 technologies is related to accessing an increasing and valuable amount of data, which constitute a '*precious raw material*' (Mohamed, 2018:261). The availability of digital data about the productive process of the firm and of its customers supports the accessibility to servitized business models, where manufacturers expand their product offerings to services (Schroeder *et al.*, 2019; Paiola & Gebauer, 2020), therefore actualizing innovation in the value proposition. Often, it results into a Product-Service System (PSS) offering, where products are matched with product-related, paid services (Mont, 2002; Baines & Lightfoot, 2014). Examples of innovating in the value creation are business models characterized by open innovation approaches, mass customization or mass individualization (Weking *et al.*, 2020). The possible impacts of digital technologies for business models innovation can ben numerous and various, and it is likely that some of them will also display in the next future. In particular, the

digitalization 'evolution' toward I4.0 could mark new innovative paths for companies in this sense. So far, while looking at the current situation in industrial markets, it seems that many of these changes have not been experienced yet, nor fully understood by firms, especially SMEs. Precisely SMEs could easily approach changes as customer-driven, pay-per-use, individually tailored-value business models (Müller *et al.*, 2018). The scepticism around new, I4.0-related business models could be due to both lack of awareness of the I4.0 impacts and potential, and lack of I4.0-related knowledge to face such changes.

In the context of IDs, it is challenging to assess the future implication of I4.0, partially because adopting disruptive innovations in IDs is highly complex, due to the nature of IDs, which tend to innovate incrementally. The literature on this topic is still limited. Hervas-Oliver *et al.* (2019) analyse the successful implementation of a place-based project of I4.0 in the Castellon ceramic tile district. This study underlines a bottom-up approach of policies, based on the involvement of relevant stakeholders and collective actors in decisional processes, to generate spillovers and I4.0 innovation at the regional level. On the same wavelength is the work of Götz and Jankowska (2017) on formal clusters and I4.0 industrial transformation, where it is argued that the knowledge diffusion mechanisms in clusters could facilitate the upgrading in firms and institutions. Both studies look at empirical settings where institutional actors play a leading role in diffusing I4.0 knowledge in IDs and local clusters. It could be argued that this initial stimulating research effort could be enriched by further empirical evidence over the variety of knowledge dissemination mechanisms - related to I4.0 technologies - involving both business and non-business actors in IDs, and its consequences in terms of business model innovations.

3. Research objectives and methodology

This research aims to investigate the process of diffusion of I4.0-related knowledge within a traditional Italian ID, while evaluating its impacts in producing business model innovations. The explorative nature of the outlined research question required the collection of rich empirical data around an industrial district and, therefore, the use of a qualitative methodology.

Notably, this paper applies a single case study methodology (Yin, 2003) of an industrial cluster located in centre Italy: the Pesaro industrial district, specialized in the furniture and woodworking machinery sector. Thus, consistent with extant work on clusters and IDs, the unit of analysis is contextualized as the

ID (Mitchell *et al.*, 2014). The main advantage of such methodology is local groundedness which helps to overcome limitations of quantitative analysis, uncovering latent and basic social and institutional dynamics that underpin patterns of interaction (Samarra & Belussi, 2006; Wolfe & Gertler, 2004). Moreover, case study method has been already proven effective in the analysis of the specific issue under investigation in this research (Belussi & Sedita, 2012; Hervas-Oliver *et al.*, 2019; Müller *et al.*, 2018).

The cluster has been chosen according to two distinct criteria: *i)* its specialization in a traditional industrial sector - furniture/mechatronics; *ii)* available evidence of undergoing projects related to I4.0 implemented by both local institutions and businesses.

The empirical study was designed to have an overview as complete as possible on the I4.0 related-knowledge diffusion within the cluster and different sources of data has been employed consistently. The first data source was one-to-one, in-depth, semi-structured open-ended interviews (Cavana *et al.*, 2001). In order to select interviewees, we compiled a list of companies, institutions - universities, industry associations - professional consultants, based on local and public industry documents and on two interviews with a key informant and with a representative of the local Industrial Association. Within these categories, we choose potential participants based on the preliminary information collected and asked them to participate to the interview process. We completed 18 in-depth interviews during a four-months period over September 2019 and January 2020. In some cases, for the more relevant companies/organizations we interviewed different people in different positions in order to triangulate data and to have different perspectives (see Table I). The interviews lasted for approximately 1 hour each and were, in some cases, supplemented by written notes of the interviewer. All the interviews were recorded and transcribed verbatim.

A second important data source was represented by the mapping of what we called the knowledge dissemination 'initiatives'. These include all the activities prompted by different institutions (i.e., Region, universities, business associations, technology centres) and businesses to widen and circulate information on I4.0-related knowledge. Six typologies of dissemination initiatives have emerged: workshops and conferences; training courses; R&D projects; non-research business partnerships; industrial PhD scholarships; public tenders. This classification is based on categories used in the ID/cluster literature (Alberti & Pizzurno, 2015; Calignano *et al.*, 2018). Each initiative has been coded in terms of promoters, duration, membership, content, and project horizon.

Table I *– Interviewees' profile*

Company/Organization/ Institution	**Interviewees**
ACCENTURE *Consultancy*	Senior Manager
BERLONI BAGNO *Furniture*	Administrative Responsible
BIESSE *Mechatronics/woodworking machineries*	Innovation Manager Service Marketing Assistant Sophia Ambassador
CLUSTER MARCHE *Regional Insitution*	Cluster & Project Manager
CONFINDUSTRIA *Industrial Association*	Fiscal and Financial Representative
COSMOB *Furniture Consortium*	General Manager Post-Doc Industrial Researcher (from University of Urbino)
IMAB *Furniture*	HR & Organization Manager Technical Area Manager
LC MOBILI *Furniture*	Purchasing and Production Director
UNIVERSITY OF URBINO *University*	Professor of Quality Management - Tutor for a post-doc industrial position in I4.0 Professor of Business Management - Supervisor Industrial PhD student (Biesse) Professor of Computer Science - Representative for Uniurb in the Stakeholders' table for INNOPROVEMENT project Professor of Computer Science - Expert in Machine learning and IoT KTO Representative
SINERGIA CONSULENZE *Consultancy*	Founder and Senior Partner

Dissemination initiatives were identified through official websites of the European Union, of the Italian Government, of Regional Institutions - such as Marche Region and Cluster Marche - of local actors - firms, technology centres, universities. Also, a search through newspapers articles, annual reports from local knowledge providers, projects presentations and reports, regional guidelines released from the Regional Government has been used to map the initiatives.

Throughout interviews and secondary sources, we have been able to collect and map a total of 83 dissemination initiatives (see Table II). Each dissemination activity has been classified according to different parameters (i.e., organizers and promoters, year, participants, content, level of the initiative, speakers, and follow-up). This mapping activity allowed to have a broad picture of the process of diffusion initiatives of I4.0 knowledge in the ID.

Table II *– Mapping of the dissemination activities*

	Workshops and conferences	Training courses	R&D projects	Non-research business partnerships	Industrial PhD scholarships	Public tenders
2014	1	0	0	1	0	0
2015	0	0	0	2	1	0
2016	2	1	3	3	0	0
2017	13	1	0	7	0	1
2018	13	5	4	4	1	1
2019	15	0	0	3	1	0
	44	**7**	**7**	**20**	**3**	**2**

In-depth interviews with cluster actors, the mapping of the knowledge diffusion initiatives, along with desk-top reviews of secondary data (previous studies, media reports, official documents and internal reports, official statistical data, web-sites, newspapers' interviews) allowed us to monitor the process of I4.0 knowledge diffusion over time in the 2015-2019 period and to introduce in the study the process perspective that is crucial to address the 'how' nature of the RQ (Halinen & Törnroos, 2005). All these sources enhance data reliability, due to both the composition of data sources and to relevant experience of the interviewees over the issue under investigation. We based interview content on theoretical considerations and asked all interviewees about their role in the cluster, and their perception of knowledge flows and exchange between actors within the cluster. All data sources have been used in generating questions to be submitted to our interviewees and in order to triangulate information and responses.

In addition, for some interviewed people we also asked to draw Network Pictures. Network pictures are graphical representation of the network of actors and relationships around a specific theme (Ramos & Ford, 2011). This research tool has been proven particularly useful when dealing with a novel theme such as I4.0 and when different people within an organization are interviewed (Öberg, 2012).

Data analysis followed a systematic combining, i.e., we adopted an abductive approach (Dubois & Gadde, 2002) in line with the explorative nature of the case research, based on logic of investigation aimed at matching recursively theory and empirical observations. Systematic combining is suitable for studying a new or under-researched phenomenon while also paying attention to existing theories around the topic (La Rocca *et al.*, 2017). Finally, we coded the analysis into common themes in relation to the diffusion of I4.0 knowledge in order to link again empirical observations to theoretical knowledge. Through this process, we consistently considered the question of what exists in extant literature and what is novel, with a view to integrating appropriate literature. In doing this we relied

on the ARA (Activities – Resources – Actors) model developed in the IMP approach (Håkansson & Snehota, 1995) as the main analytical framework that helped us to frame the discussion around these three layers. In our perspective ARA model is a powerful analytical tool in the data analysis and interpretation since it allows to unveil *'hidden network processes'* (Ingemansson Havenvid *et al.*, 2016: 100) and the interactions and relationships between relevant actors, activities and resources that are considered in the IMP perspective the actual fuel of innovation networks (Rubach *et al.*, 2017). Italian IDs have been recognized as network-like structures based on long-lasting business relationships, notably in the context of learning and knowledge diffusion (Bocconcelli *et al.*, 2015). The case has been presented in three different temporal phases (Quintens & Matthyssens, 2010).

4. Empirical findings

In this section the main empirical findings are discussed. In the following section we will provide a brief description of the evolution of the Pesaro industrial cluster. Afterwards the trajectory of diffusion and dissemination of I4.0-related knowledge is developed along the three main phases.

4.1 Evolution of the Pesaro industrial districts

This study is centred on the Pesaro ID, located in Centre Italy in the Marche Region and belonging to Pesaro-Urbino province. The growth path of Pesaro district reflects the traditional concept of ID given by literature, as it derives from the proximity of firms in the same and contiguous sector that start to build a network of relationships. Historically, the ID arose in the second post-war period by the appearance of the first furniture firms. Between the '50s and the '60s a great growth followed. The first firms to populate the district were mainly small furniture-maker artisans. Only in the late '60s, the local production of woodworking machinery originated in the same location and, from that point on, the two sectors grew together as a whole ID (Musso, 2000). The following years witnessed a constant development of the ID, with the entrance of new firms and the enlargement of the existing ones also thanks to a series of mergers and acquisitions by the leading furniture and mechanical companies. In the 2000s, the Pesaro-Urbino district was already one of the main Italian production sites

for the wood-furniture sector and the 35% of the local economy was implemented around the furniture sector (Bocconcelli, 2004). Along with the growth of the economic actors in the ID, new institutional actors have been set up to support the flourishing local wood-furniture sector. In 1983 the specialized technology centre COSMOB was established as a joint initiative of local public bodies, business associations and firms, with the aim of helping local firms to gain competitiveness through the offering of technological services, innovation, and research solutions. The district has notably evolved in time, showing a great dynamism and adaptation capability. The economic crisis of 2007/2008 hard hit the economy of the ID until nearly 2010/2011 and led to a significant decrease in the production and turnover. Some well-known companies have experienced crises – as Berloni Bagno and Febal -, while other companies have grown substantially, such as IMAB. Many district SMEs suffered heavily in this period. However, the overall reaction of the local companies has been positive and since 2014 they have been improving their performance, especially thanks to the implementation of product diversification (De Michele & Foresti, 2019). The exporting rate has experienced a great growth from 2009 on, achieving 453 million euro in 2017 (Intesa Sanpaolo, 2018). In 2018, the Foundation Cluster Marche was established with the support of the Regional Government and the involvement of local leading manufacturing and service firms, in order to upgrade the local technological and managerial competences. In the Pesaro ID, we can identify some leading firms, which represent a focal point for all the district in terms of innovation and growth. Among them, we can consider Biesse for the mechatronic sector (De Michele & Foresti, 2019), and IMAB and Scavolini for the furniture one. Already in the 2014-2015 period the ID experienced a first wave of digitalization projects, in line with the global trends (Fitzgerald *et al.*, 2014). Nevertheless, the digital change has been pulled primarily by the local leading firms, which invested on digital infrastructures in those years, while SMEs have started gradually to follow the same path only in the recent years, implementing their first digital projects (Intesa Sanpaolo, 2018).

Notwithstanding the overall resilience of the ID while facing the economic crisis and the market changes, the degree of cooperation and sense of belonging has decreased in the recent period. Both mechanical and furniture firms have been pursuing more autonomous technological and marketing strategies outside the ID horizon, while both local large and small firms have gradually reduced their involvement and commitment in local business associations and in collective projects.

4.2 The Trajectory of diffusion and dissemination of I4.0 Knowledge

4.2.1 The Pioneering Phase

Knowledge over I4.0 in the ID has been first introduced in the years 2015-2016 through the effort of a few local pioneers - mainly large firms, knowledge providers and universities.

Biesse has started to discuss about I4.0 with one of its key consulting partners - Accenture - already involved in other innovative projects. Indeed, Accenture accumulated knowledge about I4.0 technologies and in particular IoT (Internet of Things) applications before cooperating with Biesse, even if in different business sectors. The Biesse CEO Assistant for Innovation underlines the leading role of Biesse in approaching I4.0, at least in the mechanical sector: *We have been absolutely the first one, the others [competitors] followed us after one or even two years.* Biesse launched the project SOPHIA - an IoT project started in 2016 - which, thanks to the installation of sensors in the machineries, allows to receive data about their performance and functioning from customers worldwide. For the design of SOPHIA project, some key competences were already available internally: *There is no discontinuity, meaning that Biesse invested in internal digitalization for years. In the context of I4.0, Biesse found something already existing that could exactly be part of the stream, the trend of I4.0 […]. Digitization and automation are continuous processes in the company, the real discontinuity of I4.0 is the IoT technology* (Innovation Manager - Biesse).

Other local firms - not belonging to the furniture/woodworking cluster - have started early on with I4.0 projects. Benelli Armi - active in the gun sector - approached I4.0 in 2016, when the Plant Manager took part into a study tour in Stuttgart to learn more about the I4.0 industrial model (Fabbrica Futuro, 2018). Benelli Armi started investing in I4.0, especially through the expansion of the industrial plant with a space entirely dedicated to I4.0 technologies for the completely automated material handling: it hosts AGV, beacon and cobots (StartUp Grind, 2018). Another key local firm - not belonging to the furniture ID - is Schnell, which implemented I4.0 technologies already in 2016. The company invested in the adoption of a robot called APPS with a supporting role in the production line. In the same year Schnell contacted the Department of Computer Science of the University of Urbino *[…] just to know more about the opportunities that could stem from I4.0 technologies. […] They decided to contact us after they had known about Biesse and SOPHIA project. They were curious about the possible applications in their sector. This first contact did not*

develop further. But I know that some of our students have been hired in Schnell (Professor of Computer Science - Expert in Machine learning and IoT - UniUrb).

The dynamism of these companies over I4.0 trajectory has become visible in the local ID - through the press and the local business association - and other companies have started to monitor and follow their evolution. In particular, Benelli Armi has been very open for organizing business meetings and visits - involving local institutions and companies - to its plant. In addition to these high-tech companies, the two local universities based in Ancona and Urbino, have started R&D projects and courses on I4.0-related themes. The Marche Polytechnic University (Ancona) undertook various research activities and analysis concerning I4.0 in this early phase. This is the case of research and teaching activities in the Engineering Department of the University. The University of Urbino instead - more focused on social sciences and humanities – began in this phase to establish only some contacts with local firms concerning digitalization with the contribution of researchers belonging to the Computer Science Department. The University of Urbino in this phase lacked an *ad hoc* strategy with regard to I4.0 collaboration with local firms. The only formal initiative launched in this phase was the launch of an Industrial PhD on the themes of I4.0 by the Department of Economics with COSMOB, a local technological centre supporting furniture companies.

The recognition of the potential positive impact of I4.0-related technologies pushed some key local knowledge providers and technological centres to undertake activities to increase their ability to assess and exploit these new technological opportunities. This is the case of COSMOB, a technology centre operating at international level, dedicated to the furniture sector. COSMOB has been aware of the importance of research on these themes already since 2015-2016 and undertook different initiatives. It participated to a regional call on Made in Italy and Innovation, not explicitly addressing I4.0, but that paved the way to these themes, involving more than 40 cluster firms. Concurrently COSMOB financed the previously mentioned PhD position on Additive Manufacturing in collaboration with the Department of Economics of the University of Urbino. Sinergia - a local consulting company active both on management and on IT consulting - became interested in I4.0 in the same years through a business trip to Germany with Benelli Armi. This initiative made them aware about the need of promoting aggregation and collaboration with other types of institutions - i.e., universities and firms - to address these disrupting themes: *We saw synergies with local universities and started to work with them in some specific areas,*

such as Artificial Intelligence, Robotics, Vision-Based Systems (Founder and Senior Partner - Sinergia).

Therefore, in this phase the pioneer companies and organizations have become increasingly aware of the future impact and relevance of I4.0, even though they still did not have a clear plan over the selection and adoption of I4.0-related knowledge and technologies in their business processes, already implementing digital solutions. Digitalization - in combination with automation processes - has been undertaken also by some other key local furniture producers, such as Scavolini and FAB. The local Universities, instead, developed knowledge about I4.0 technologies building on their previous research projects and their extensive network of international collaborations.

4.2.2 The Dissemination Effort

The approval of the "National plan on Industry 4.0 2017-2020" by the Italian Ministry of Economic Development, placed I4.0 at the centre of the national debate on industrial policies. The plan allowed for high tax benefits for firms undertaking investments on I4.0 technologies. This opportunity raises nation-wide interest for I4.0 by industrial companies. Pesaro ID companies started considering the adoption of these technologies, mainly to enjoy the tax incentives.

Local institutions instead took action to apply for financial resources for the implementation of projects and initiatives - such as the establishment of Digital Innovation Hubs and Competence Centres - whose goal is the promotion and assistance over I4.0 projects towards local companies. Local institutions and business associations undertook various initiatives to promote visibility to the government plan and to diffuse knowledge about I4.0 technologies. On the one hand, various workshops and seminars have been held, involving local and national experts on I4.0. At the regional level, the formal cluster – Cluster Marche – played a key role as promoter and organizer of labs and projects. In various events local Universities have been involved and this has allowed for establishing initial contacts among local ID firms and the Universities' Departments more active on I4.0. Also, the Industrial Business Association promoted formal and informal initiatives to involve firms in I4.0 and stimulate awareness on these topics.

In addition, *ad hoc* training courses have been organized to support companies in becoming aware of the challenges related to the adoption of I4.0.

The local Industrial Business Association organized a course in collaboration with the School of Management from the Polytechnic of Milan, previously involved in a national roadshow by the National Federation of Industrial Companies. The course aimed at improving the understanding the potential of I4.0 and at providing concrete tools for firms to increase the efficiency of production processes and systems. The course involved firms from the mechanical sector belonging to the district, as well as local knowledge providers, and aimed to provide an overall picture of both technological and managerial challenges related to I4.0. Also, the Marche Polytechnic University organized a course on Industry 4.0 based on an interdisciplinary approach for both students and practitioners. The University of Urbino organized a conference and a roundtable to discuss with local academics, businesses, and business associations how to fully exploit the opportunities of I4.0. In addition, the University organized a Summer School in Project Management, having an impact on local companies active in digitalization processes: the HR & Organization Manager of IMAB reports that *taking part to the Summer School in Project Management had a concrete impact on the company as it made us aware over the upgrading of the digital management of processes.*

The local pioneering firms further developed their path oriented towards I4.0 approach. Biesse continued the implementation of the key project - SOPHIA. During the second phase of the project, Biesse started spreading knowledge about SOPHIA through international trade fairs. The further implementation of SOPHIA made Biesse more aware of the implications of some I4.0 technologies - such as IoT, Sensors and Big Data – and, as a result, it launched an Industrial PhD project in collaboration with the Department of Economics of the University of Urbino. The project started in 2018 and concerned applied research on I4.0 and servitization. For the development of SOPHIA platform other research institutions have been involved, as the Marche Polytechnic University and the Polytechnic University of Milan. These collaborations played a major role in *acquiring competences in the phase of technical implementation of the project and in developing concrete ideas* (Innovation Manager - Biesse).

COSMOB started specific projects, such as the FabLab, a digital manufacturing laboratory, with the aim of creating a connection between I4.0 enabling technologies and the local technical know-how. The FabLab is defined as *the innovative part of the technological centre* and has been used *as a tool to involve local businesses through the provision of services such as 3D printing and laser cutting* (Post-Doc Industrial Researcher - University of Urbino/COSMOB).

Sinergia Consulting has strengthened its collaboration with the Marche Polytechnic University aiming to develop applied knowledge complementary to the core scientific and technological capabilities held by the University. Sinergia grasped the need to *integrate existing competences and to encourage skill transfer from the university* (Founder and Senior Partner). In this sense they started an Industrial PhD scholarship in collaboration with the Marche Polytechnic University to address I4.0 and Artificial Intelligence.

In addition to the ID pioneers, in this phase other local furniture companies have started specific projects concerning I4.0-related technologies (see Table III).

Table III *– Main I4.0 projects promoted by ID firms*

Project Name	Promoter	Duration	Partnership members	Content	Project horizon
SOPHIA Platform	BIESSE SpA	2017 - 2021	BIESSE Accenture	A service platform connected to the info coming from IoT in the mechanical machinery	International
Smart Factory	IMAB	2016 - 2020	IMAB INTAC	Software with I4.0 Cloud for lean production	Regional
E-commerce platform and digital commerce transformation	Scavolini	2017 – N/A	Scavolini Websolute	E-commerce platform with interactivity between producer and dealer	Local
Production Transformation	LC Spa	2019 - 2020	LC Spa TeamSystem Ancona	New IoT machinery for planning and implementing lean production	Regional
Integraded ERP Aliante	Paiardini	N/A	Paiardini Team System	ERP System together with I4.0 machinery for internal optimization	Local
REVYTA Project	Not specified	2014 - 2020	Toscana Region Effebi Spa DIFE Spa SNIAP Srl Flashpoint Srl Consorzio Polo Tecnologico Magona University of Pisa - Department of Architecture	I4.0 technologies as robotics to implement a new way of fiberglass waste disposal	National
Microsoft Dynamics AX	FAB	2019 – N/A	FAB Microsoft	ERP System for integrated information and communication in all business processes with a single workflow	International
Hi Pedini	Pedini Cucine	2018-2020	Pedini Kitchens Microsoft IoMote	I4.0 kitchen with technologies as IoT and sensoring at disposition of the final customer	International

A common feature of these projects is the emphasis on digitalization of production and, in some cases, there have been attempts to integrate products with I4.0 technologies. The main sources of stimuli have been the suppliers of process technologies and the IT partners, based both locally and outside the district. In most cases the partnership for the development of an I4.0 project came from previous partnerships with the software house or consultant on other topics. All the firms involved in I4.0 projects in the ID are some of the major representative firms in the district, such as IMAB, FAB or Scavolini. However, for these ID firms, even the larger ones, the adoption of I4.0 technologies

represented a difficult and complex challenge. Other relevant ID firms have not invested thus far in I4.0 projects, such as Berloni Bagno, because of the scarcity of resources and the negative perception of the potential advantages offered by such technologies.

The emergence of awareness about I4.0 and the initial attempts to launch I4.0 projects have pushed local institutions and business associations to plan and implement the first monitoring activities. At the regional level, Cluster Marche has recently taken part to Osservatorio 4.0, a regional committee composed of business associations, trade unions and universities, with the aim of supporting regional intervention and to acquire data to identify the main obstacles for the development and diffusion of I4.0, together with appropriate solutions to better allocate resources through regional industrial policies.

4.2.3 The Pursue of Institutional Upgrading

The more recent period is characterized by a stronger effort by regional institutions in providing a framework for further promoting and supporting the development of I4.0 projects in local companies, notably in SMEs. The Regional Government is aware that the complexity of I4.0 requires stronger coordination. This effort is based on various specific policy measures: *i)* the establishment of Digital Innovation Hubs (DIHs) and Competence Centres; *ii)* the financing of advanced projects proposed by local companies; *iii)* the active promotion of cooperation between firms and universities, mainly through Industrial PhD projects and multilateral R&D projects.

The stronger effort by the Regional Government has received mixed feedback by local institutions and companies. On the one hand the financial support has been welcomed in the light of the required investment scale for implementing I4.0 projects. On the other hand, the unresolved fragmentation of coordination activities over I4.0 themes is perceived as a negative factor for the effectiveness of the limited resources for knowledge dissemination and for promoting the awareness of the local late-comer firms, which might have difficulties in choosing the most appropriate institutional and business partners.

The upgrading also took place through the establishment of the Regional DIHs, that have been planned during the previous phase when the regional Industrial Association and the regional Cluster Marche prompted a feasibility study for the creation of a digital innovation centre in the Marche Region and won a European Call within Horizon 2020. DIHs should represent the main ‘gateway’

to I4.0 for local companies. Their aim is creating a network of 'territorial innovation actors' to strengthen the level of knowledge and awareness of the opportunities offered by digitalization and I4.0 and offer consultancy, mentoring, training and assistance services for I4.0.

In addition to the upgrading of the regional and local institutional framework, local firms show an increasing propensity to create more stable and formal networks in order to undertake I4.0 projects. On the one hand, some of the local cluster firms are involved in formal collaborative projects promoted by the Regional Government. This is the case of the regional platform aimed to create a laboratory of excellence to encourage collaboration between businesses and Universities on I4.0. Another project started in 2018 is INNOPROVEMENT, where a working group – which includes the cluster firm IMAB and the universities of the Marche Region – on I4.0 has been created. The representative of the Urbino University stated: *My feeling is that there is a lot of work to do in order to address the right policies for SMEs. The main difficulties are linked to put together the objectives of the larger firms and those of the SMEs. I believe that Universities will have a major role in this* (Professor of Computer Science – Representative for UniUrb in the Stakeholders' table for INNOPROVEMENT project).

On the other hand, local active firms pursue aggregations to combine complementary resources and capabilities. This is the case of Sinergia being an active member of Overlux, a formal network including local firms – also academic spin-off firms from local Universities – and companies based outside the ID. This network of companies aims at leading businesses towards I4.0 through the implementation of innovative solutions in IoT.

An emerging dissemination pattern is the 'Open Factory' approach, after the recognition by some of the key actors – the Industrial Business Association and the Cluster Marche – of the effectiveness of initiatives organized in and by innovative companies active in I4.0 projects. Cluster Marche started promoting this mode of knowledge exchange after experiences with other partner formal clusters in Northern Italy. Promoting direct contact on site, with front-runner firms is perceived as a tool for pursuing knowledge contamination and attract furniture producers and small firms, having limited IT and technological capabilities. Firms such as Benelli Armi – even though not active in the furniture sector – have been keen on opening their offices and plants, also for a shared sense of belonging to the local territory. These initiatives – proposed after a careful planning by these collective actors – in various cases have prompted

informal cooperation among participants, which have been monitored in their evolution.

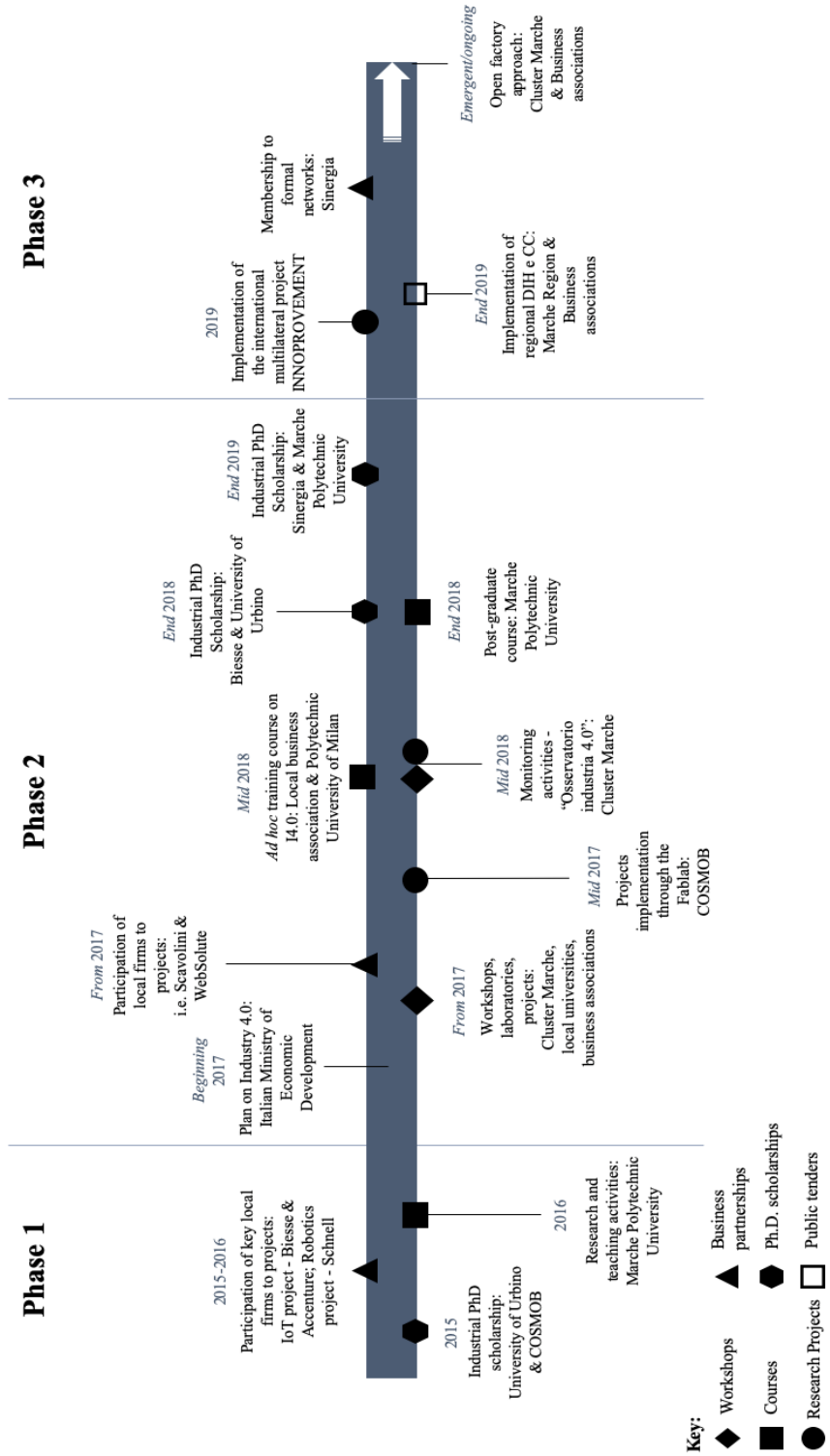
5. Discussion of results

This section attempts to provide an answer to the RQ stated in the introduction. Firstly, it summarizes and discusses the evolution of I4.0 knowledge dissemination along the various phases, shown in the timeline in Figure 1. Then it examines more in depth the dissemination process using the ARA framework and focusing on actors, activities, and resources. Lastly, it provides a synthesis of the distinctive dissemination patterns emerging from the empirical analysis.

In the 'pioneering phase' knowledge about I4.0 has been introduced through the explorative attitude of some key local players, which have autonomously established external pipelines (Bathelt *et al.*, 2004) and gained incremental awareness about the complexity and the possible benefits of I4.0 technologies in the medium-long term. Formal and informal interactions have been carried out with other actors – in Italy and abroad – more skilled about the development of I4.0 technologies, which represent a body of knowledge to a large extent 'exogenous' (Albino *et al.*, 1999) to the Pesaro ID. As soon as the tax incentives have been publicly announced, a variety of ID actors – firms, institutions, IT suppliers, knowledge brokers – have become interested in understanding the implications of I4.0 upgrading. Since then, various types of initiatives for knowledge diffusion have been set up by institutions, business associations and knowledge providers, with the involvement of local and nationally-based Universities and technical experts. The main goal was stimulating the awareness of local firms about I4.0 and accelerate the involvement of local businesses in projects related to I4.0 technologies. After this phase showing a remarkable dissemination effort, a more deliberate approach emerges among both institutions and key players (Belussi & Sedita, 2012; Lazzeretti & Capone, 2016). The Regional Government supports the implementation of DIHs linked to the main local business associations in order to provide 'interfacing' resources to support local firms in undertaking I4.0 projects. The most active knowledge providers establish formal networks – involving local and nationally-based firms and Universities – to integrate and consolidate complementary knowledge and capabilities and to undertake complex R&D projects related to I4.0. In the meanwhile, the local collective actors – business associations and formal clusters

– promote an 'Open Factory' approach to disseminate knowledge about I4.0 and thus stimulate contamination and emulation by local firms.

***Figure 1** – Timeline of I4.0 knowledge dissemination along the three phases*



The diffusion of I4.0 knowledge in the ID of Pesaro could be better understood discussing in more depth the behaviour of key actors, the nature of activities carried out and the relevant resources at stake in the process, following the ARA model framework (Håkansson & Snehota, 1995). It could be argued that the diffusion of I4.0 knowledge in the Pesaro ID has been characterized by a combination of 'traditional' and innovative dissemination patterns, which have been shaped by the existing structure and interaction processes characterizing the district in the recent years. Table IV outlines a distinction of traditional/new actors, activities, and resources in place along the dissemination process.

Table IV *– Diffusion of I4.0 in the Pesaro ID – continuity and innovation in actors, activities and resources*

Actors	Activities	Resources
Traditional		
Large furniture firms Technology suppliers COSMOB (Technological Centre) IT suppliers Consulting firms Business Associations Regional government	Local business interaction Local buzz External pipelines Workshops/Seminars Training courses	Financial resources (corporate) Furniture-making knowledge Mechanical knowledge IT/digital knowledge Social ties
New		
Large firms in different sectors Network alliances Universities Digital Innovation Hubs Cluster initiatives (Regional Government)	Open Factory initiatives Industrial Ph.D.s Multilateral research projects	I4.0 technologies knowledge I4.0 managerial knowledge Financial resources (national and regional government programs on I4.0)

Traditional ID actors have started approaching I4.0, even though with mixed attempts to disseminate related knowledge. On the one hand large ID firms, such as Biesse and IMAB, pursued I4.0 projects following an 'autonomous' approach – with respect to the local technological trajectories and initiatives – already in place before the spreading of I4.0 interest (Belussi & Pilotti, 2002; Morrison, 2008; Belussi & Caloffi, 2018). They have set up relationships with IT partners and Universities developing a mix of local and national relationships (Grandinetti, 2011), without an explicit and deliberate 'district' horizon in terms of knowledge diffusion. On the other hand, other key traditional actors – knowledge providers, business association, the Regional Government – have been very active in their dissemination effort. Knowledge providers such as Sinergia and COSMOB have attempted to fulfil their 'mission' of knowledge

providers and gatekeepers (Morrison, 2008; Grandinetti, 2011) since the beginning of I4.0 diffusion in the Pesaro ID. They have actively set up relationships with other local key actors and with partners outside the district (Molina-Morales *et al.*, 2002; Belso-Martinez, 2018). In this respect they have been able to maintain and consolidate a central role in the local innovation setting both as providers and brokers of knowledge (Molina-Morales *et al.*, 2002; Grandinetti, 2011; Belso-Martinez, 2018). Sinergia has been able to integrate business-related and technological knowledge while implementing consulting services in I4.0, while COSMOB has attempted to translate I4.0 opportunities in furniture industry-specific projects, as its FabLab project shows. I4.0 has represented a challenge also for local business associations. Evidence shows a very active behaviour by the local business associations in involving local firms – mainly SMEs – through innovative approaches in knowledge dissemination. These attempts have been even more difficult in the light of the long-time decreasing participation of local firms in local business associations, thus I4.0 has represented an opportunity for local business associations to renew their role in the ID of Pesaro. I4.0 knowledge diffusion has been a strategic goal pursued by the Regional Government, engaged in the promotion of direct regional funding related to I4.0 projects and in the setting up of the DIHs. The institutional setting is still in-progress while being embedded in the already existing mix of policy measures and procedures supporting local innovation processes within to the Smart Specialization Strategy.

In parallel new actors have emerged as key players in the ID in relation to I4.0 knowledge diffusion processes: large firms operating in different sectors, network alliances promoted by local ID firms, local formal clusters, newly established DIHs and Universities. Large firms not belonging to the furniture industry – such as Benelli Armi and Schnell – have been perceived by both local Institutions and firms as key successful examples of I4.0 implementation. This orientation is further promoted by the active behaviour of the regional formal clusters lead by Cluster Marche, as these collective actors in the digital context tend to be *more cross-sectoral, horizontal and less geographically concentrated* (Götz & Jankowska, 2017: 17). Universities have played an increasing role over time in the light of their specialized knowledge about I4.0 technologies (Camuffo & Grandinetti, 2011; Muscio *et al.*, 2012; Capó-Vicedo *et al.*, 2013). The I4.0 challenge has represented a key driver for a higher involvement and integration of local Universities into the Pesaro district, if compared to the marginal role played in the past. Universities have been perceived by both institutions and firms as sources of '*global pipelines*' (Benneworth & Hospers, 2007; Camuffo &

Grandinetti, 2011; Muscio *et al.*, 2012; Capó-Vicedo *et al.*, 2013) connected with advanced I4.0 knowledge sources based in Italy and abroad. It seems that cooperation among traditional and new actors in the Pesaro ID is contributing to develop an emerging shared '*sub-identity*' with regard to I4.0 approach and technologies (Hervas-Oliver *et al.*, 2019), as it is promoted actively by local gatekeepers engaged in I4.0 translation as Sinergia and COSMOB.

The increased complexity of the networks of actors has implied a shift and upgrading in the nature of dissemination activities concerning I4.0 knowledge: traditional initiatives – such as workshops, courses and formal/informal business interactions have been integrated by '*collective*' projects (Fornahl *et al.*, 2015; Hervas-Oliver *et al.*, 2019) – such as the Open Factory initiatives, the Industrial PhD positions financed by the Regional Government and the multilateral research projects involving firms, collective actors and institutions of the ID and of the Marche Region. An innovative form of knowledge diffusion is the 'Open Factory' approach, implemented by the local Industrial Business Association and by Cluster Marche. It represents a form of 'organized buzz', being a deliberate and planned attempt to foster informal interaction among firms, universities, and institutions (Belussi & Sedita, 2012). Collective actors engage in organizing the initiative, while the provision of the knowledge content and the interaction is mainly left to voluntary participants, willing to experience knowledge contamination and search for potential knowledge providers, such as consulting firms, technology centres and Universities. An important role is played by the social underpinnings of the project, promoting on the one hand social recognition for innovative firms, entrepreneurs, and managers, on the other hand igniting emulation by participants (Staber, 2009; Camuffo & Grandinetti, 2011).

The upgrading of dissemination activities has been driven by the combination of high complexity of I4.0 knowledge – requiring complementary capabilities, notably technological and managerial capabilities and aggregation of a variety of actors (Coletti, 2010; Belussi & Sedita, 2012) – and the financial support and tax incentives provided by the national and regional governments – pushing large firms to undertake large scale R&D projects and SMEs to approach in the majority of cases the first steps of the digitalization process (Hervas-Oliver *et al.*, 2019). Funding by the National and Regional Government has been crucial for raising interest by local institutions and firms and for implementing the first R&D projects in the I4.0 context. Therefore, the monetary dimension is a key factor for explaining ID-based processes concerning I4.0 (Perna *et al.*, 2015). Another relevant factor is the degree of absorptive capacity of local ID firms and institutions (Cohen & Levinthal, 1990; Giuliani, 2005; Camuffo & Grandinetti,

2011). On the one hand, Universities in the first place and pioneering firms – large companies and knowledge providers – have been increasingly aware of the I4.0 opportunities and implications and had already previous knowledge of the benefits and challenges of digitalization processes. On the other hand, institutions, business associations and local firms – mainly SMEs – have suffered initially their limited knowledge about I4.0 and have attempted to fulfil this gap through participation to training initiatives and hiring qualified personnel. It could be argued that, overall, the knowledge brokering effort has been initially impaired by the limited awareness and knowledge about I4.0 technological and managerial opportunities and challenges (Mittal *et al.*, 2018).

In synthesis, this research sheds light on the main I4.0-related initiatives in the Pesaro IDs and allows the observation of the consequent innovations derived from them, while describing in-depth the mechanisms that guided the I4.0-related knowledge diffusion process.

For what concerns the I4.0-related business model innovations, findings provided so far are limited and would certainly benefit from further investigation to achieve completeness. Nevertheless, some preliminary considerations can be drawn starting from them.

Firstly, within the analysed district it was possible to observe how Industry 4.0 adoption stimulates firms to consider (or even adopt) innovative business models (Klos *et al.*, 2021). I4.0 seems to have an 'enabler function' toward business model innovation, even if the pace of innovation looks low. Indeed, the majority of firms within the district combined I.40 adoption and business model innovation. Most companies who invested in I4.0 adoption also redesigned their business model to generate new value: this is the case, for example, of Biesse Spa, Scavolini, or LC Spa. A few firms, as Paiardini or FAB, embraced I4.0 technologies but their business model remained mostly unvaried. However, it is likely that the internal optimization process they are experiencing with new technologies will lead them to innovative business models in the next future.

Secondly, results underline how business model innovation, when driven by I4.0, can assume a variety of different forms (Mohamed, 2018) and, more relevantly, it can allow to leverage innovative value proposition, delivery, and networking. Firms of the observed district as Biesse, Pedini, and LC Spa oriented their business model toward digital servitization, therefore exploiting new value propositions, which become more service-centric via the application of IoT technologies (Paiola & Gebauer, 2020). Scavolini, instead, operated along the value delivery dimension, which allowed for the generation of an innovative business model, i.e., a business-to-business e-commerce platform dominated by

the interactive approach between producer and dealer. At the same time, Pedini or firms participating in the REVYTA project operated along the value networking dimension to refresh their business model, which translated into a circular economy-based productive process for the latter and a digital servitization one for the former. The value networking dimension is exploited by the introduction along the supply chain of new actors, as the technology providers Microsoft and IoMote in the case of Pedini or the University and firm partner members in the REVYTA project, which drastically contribute to the definition and application of a new business model.

Thirdly, not only the ID consistently invested in the adoption of I4.0 technologies, also it exploited such technologies to define innovative business models and acquire further competitiveness and size upcoming opportunities (Weking *et al.*, 2020). This trend has been manifested primarily by large firms, which traditionally guide the ID in its innovative flow, but also by small and medium companies, as in the case of Pedini Cucine. In this sense, the study goes along with what highlighted by Müller *et al.* (2018) on the potential of SMEs to develop new business models related to I4.0. To do so, critical has been the collaboration with other companies inside and outside the district, which balanced the shortcomings of SMEs by bringing knowledge and resources for the actualization of complex I4.0 projects (Schroeder *et al.*, 2019).

About the I4.0 knowledge dissemination mechanisms, this study shows that in the furniture ID of Pesaro the dissemination of I4.0 knowledge has been characterized by three main interrelated patterns. Firstly, the horizon of I4.0 upgrading – in terms of focal actors, main activities, and key resources – shows blurred boundaries in terms of sectors and geographic location (Götz & Jankowska, 2017). Most of the dissemination activities involve firms active in different sectors and have a regional dimension, as ID firms and institutions have attempted to search for I4.0 expertise in closer geographical areas. Secondly, the I4.0 diffusion shows a fragmentation of initiatives of both firms and institutions; some firms – mainly large sized – have often pursued autonomous paths involving selected partners (Belussi & Pilotti, 2002; Morrison, 2008; Belussi & Caloffi, 2018), while institutions, public bodies and business associations, show both cooperative and competitive behaviour, due to the conflicting objectives of diffusing a complex type of knowledge – leading to institutional collaboration – and searching for financial resources – leading to increased competition. This fragmentation is shaped on the one hand by the reduced intensity of social ties experienced in the ID community in the recent years, on the other hand by the 'explorative' orientation of the various ID actors engaged in knowledge search.

Moreover, the analysis of Pesaro ID shows the lack of a specific policy/program targeting the ID as such, as instead other studies on I4.0 diffusion in traditional IDs have shown (Hervas-Oliver *et al.*, 2019). Thirdly, the diffusion of I4.0 knowledge – characterized by high complexity and by the integration of technological and managerial knowledge (Alberti & Pizzurno, 2015) – pushed ID firms and institutions to pursue deliberate structured initiatives – allowing for informal and formal interaction (Belussi & Sedita, 2012; Lazzeretti & Capone, 2016) – which in various instances implied the experimentation of new interaction processes, leading to innovative forms of '*collective*' cooperation (Leckel *et al.*, 2020).

6. Conclusions

This paper presents and discusses an in-depth, empirical research over the diffusion of I4.0-related knowledge in the Pesaro ID in Italy active in a traditional industry such as the furniture sector. This research contributes to the literature on innovation in IDs and clusters on three interrelated grounds.

Firstly, it provides further research on I4.0 and IDs and clusters (Götz & Jankowska, 2017; Hervas-Oliver *et al.*, 2019), developing an in-depth analysis of the variety of knowledge dissemination processes – where both institutions and firms are involved – mapped through the ARA framework able to highlight key actors, activities, and resources (Håkansson & Snehota, 1995). Notably, our study on the traditional Pesaro ID points out three main patterns: *i)* the horizon of I4.0 upgrading shows blurred boundaries in terms of sectors – firms active in different sectors are involved – and geographic location, reaching the regional dimension; *ii)* the fragmentation of I4.0 diffusion in terms of initiatives and projects by both firms and institutions; *iii)* the pursuit of deliberate and structured initiatives allowing for experimentation of new interaction processes, combining formal and informal exchanges (Belussi & Sedita, 2012; Lazzeretti & Capone, 2016; Leckel *et al.*, 2020).

Secondly, this paper contributes to the stream of research on knowledge creation and diffusion in IDs and clusters, providing empirically-based insights over emerging local learning processes in IDs (Belussi & Pilotti, 2002; Camuffo & Grandinetti, 2011; Belussi & Sedita, 2012; Bocconcelli *et al.*, 2015). Notably, the forms of 'collective cooperation' in I4.0 projects represent innovative mechanisms linking traditional ID actors to technologically advanced firms and organizations, fostering open localized learning and exploiting localized social

ties. These 'collective' mechanisms could represent one key driver to renew the cooperative interaction in IDs and clusters (Hervas-Oliver *et al.*, 2019) and promote local initiatives inspired to '*open innovation*' logics (Leckel *et al.*, 2020), pushed by the self-interest of those local firms available to commit time and resources (Munksgaard & Medlin, 2014) to improve their absorptive capacity in order to join and exploit '*selected*' business networks within and outside the ID (Belussi & Sedita, 2012). Each initiative could be considered as a *temporary resource constellation and activity pattern in which the actors form a distinct logic and develop new solutions in relation to each other* (Ingemansson Havenvid *et al.*, 2016: 86). The analysis of innovative knowledge diffusion projects – linking ID/cluster studies and the IMP business network perspective – could therefore contribute to the emerging conceptual debate on '*temporary spatial clusters*' (Palmer *et al.*, 2017).

Thirdly, this research contributes to expanding knowledge on the implications of I4.0-related technologies application in shaping innovative business models. It underlines how I4.0 can spur business model innovations, as highlighted also by Klos *et al.* (2021), by leveraging not only the value proposition and deliver, but also the value networking. At the same time, it shows how transitions in business models could require long times to be accomplished, suggesting that the pace of innovation of I4.0-leveraged business models is low. It provides examples of the multiple and varied business model innovations that could be embraced thanks to I4.0 adoption (Mohamed, 2018), as digital servitization, circular economy, or business-to-business e-commerce business models. Furthermore, it highlights how both SMEs and larger firms can catch the potential of I4.0 technologies to apply innovative business models (Müller *et al.*, 2018). Between the possible outcomes deriving from I4.0 technologies, the supremacy of servitized business models via the application of IoT is underlined (Paiola & Gebauer, 2020), at least within the boundaries of the investigated ID. In line with Schroeder *et al.* (2019), this study supports the need to investigate I4.0-related technologies diffusion through a business network perspective, since major changes in the ID are possible only thanks to existing interrelationships with actors inside and outside the district.

This research has obviously limitations. Firstly, the empirical analysis concerns the initial phase of the spreading of I4.0 related knowledge in the Pesaro ID, which is still undergoing. Therefore, this paper provides insights over in-progress processes and does not provide a complete ex-post analysis. Secondly, the main goal is the mapping of the variety of dissemination processes, therefore the in-depth analysis of specific initiatives is out of the scope of this paper.

Thirdly, the impact of I4.0 technologies on business model innovation should be evaluated for a longer period of time, which was not possible to apply to this research.

The phenomenon of I4.0 adoption in IDs and clusters deserves further empirical research and conceptual development. Future research could focus on specific and interconnected aspects that have been pointed out in this paper: the trajectory of specific I4.0 technologies, the nature and features of key dissemination activities, the role played by new actors. Future studies could examine more in depth the dissemination of knowledge of specific I4.0 technologies, such as IoT, AI, collaborative robotics, whose diffusion and implementation in industrial clusters might follow different trajectories (Cucculelli & Lena, 2017; Ingaldi & Ulewicz, 2019; Ivanov *et al.*, 2020) and concern different type of actors and dissemination mechanisms. Furthermore, additional research is needed on the implementation of key I4.0 projects and initiatives – courses, PhD programs, bilateral and multilateral R&D projects, regional programs – in IDs and their underlying interaction processes – whose features might generate different kind of knowledge diffusion processes – in line with recent research (Götz & Jankowska, 2017; Hervas-Oliver *et al.*, 2019). Future contributions on this phenomenon could also explore the role of the main actors, with a focus on those emerging firms and organizations – including collective actors (Hervas-Oliver *et al.*, 2019) – playing an innovative role in the I4.0 diffusion, such as formal clusters, Universities (Benneworth & Hospers, 2007), *ad hoc* organizations such as DIHs. Lastly, future research could benefit from an in-depth, longitudinal analysis of the I4.0 impacts on business model innovation via a multiple case study approach or through quantitative studies. This could be particularly valuable to understand how to support firms along their digital transition and benefit from the innovative possibilities that are opened up by I4.0. A multistakeholder perspective would perfectly fit this aim (Chen *et al.*, 2021). The empirical research undertaken in this paper has various managerial implications. Firstly, IDs and cluster firms should pay attention to the selection process of I4.0 knowledge providers. Local knowledge brokers could provide assistance in fostering contacts with potential partners based both inside and outside the cluster (Molina-Morales *et al.*, 2002; Belso-Martinez, 2018). Dissemination activities in the ID could represent useful opportunities for networking with potential partners and for assessing the adequate type of investment in technology and organizational innovations. Secondly, the evaluation and adoption of I4.0 technologies is a complex process which requires establishing relationships also with universities, in order to develop R&D projects

and to hire qualified personnel and to address effectively both the technological and managerial challenges of I4.0. Local Universities might represent adequate partners for ID firms – especially SMEs – if appropriate interaction mechanisms are in place, thus reducing the '*cognitive*' distance between them (de Zubielqui *et al.*, 2015). Thirdly, firms in traditional IDs are required to invest in human resources in order to evaluate and exploit I4.0 technologies. While firms active in high-tech clusters might have a stronger cognitive proximity with I4.0 related technologies (Götz & Jankowska, 2017), traditional cluster firms require strengthening their absorptive capacity in order to interact with key actors, both inside and outside the cluster (Becattini & Rullani, 1996; Camuffo & Grandinetti, 2011, Belussi & Sedita, 2012). Pursuing I4.0 trajectories in IDs requires '*talent*' in addition to technologies (Salter *et al.*, 2000). Investment in human resources could concern upgrading technical/IT functions, introducing hybrid positions such as Innovation Managers, setting up Industrial PhD positions in cooperation with Universities.

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Chapter III - Toward a Multilevel Perspective on Digital Servitization*

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Abstract

The purpose of this chapter is to provide a theoretical lens on Digital Servitization (DS) for future research purposes. By developing a multilevel framework that helps structure and untangle its complexity, it aims to increase understanding into the persistent challenge of DS. On the methodological side, building on a problematization approach, critical incident technique (CIT) was applied to a comparative, longitudinal, multiple-case study in which DS journeys from one Italian and one Belgian manufacturing firm were analysed. Analysis revealed that different levels and elements of the multilevel framework were simultaneously involved in the identified critical incidents. This huge interconnectedness severely challenged the DS journeys. Managerial (un)responsiveness played a central role in the organizational outcome for both firms. The main contribution of this chapter is answering the call for a more holistic approach toward DS. A multilevel framework is provided to be employed by future researchers and practitioners alike. A mid-range theory for DS and propositions for future research are developed.

Keywords – Manufacturing, Industry 4.0, Digital transformation, Digital servitization, Multilevel theory

1. Introduction

Since the late 80s, companies have been described as increasingly offering fuller market packages or 'bundles' of customer-focused combinations of goods, services, support, self-service, and knowledge (Vandermerwe & Rada, 1988, p. 314). Even today, services' promise of enabling growth and sustainable competitive advantage continues to motivate manufacturers to bank on such strategies (Vendrell-Herrero *et al.*, 2017; Kowalkowski *et al.*, 2017). Servitization, or the addition of services to manufacturers' core product offerings to create additional customer value (Raddats *et al.*, 2019a, p. 207), has inspired ample research leading to the establishment of a brand new, well-studied field of knowledge in which the identification of obstacles to servitization has become a popular topic (Gebauer *et al.*, 2005; Matthyssens & Vandenbempt, 2008; Alghisi & Saccani, 2015).

Despite extensive research, however, companies continue to struggle in their attempt to realize service strategies (Kohtamäki *et al.*, 2020; Zhang & Banerji, 2017). Digitization nowadays adds to this challenge as companies, encouraged by promises of data-driven optimization and innovation, explore how they can provide customers with technology-enabled knowledge-based services (Coreynen *et al.*, 2017). Barriers to the implementation of this strategy known as Digital Servitization (DS), have been pinpointed (Gebauer *et al.*, 2020b). For example, horizontal and end-to-end integration of systems requires companies to find ways to differentiate themselves from network partners whilst fostering co-creating relationships with them at the same time (Kamalaldin *et al.*, 2020; Vendrell-Herrero *et al.*, 2017). At a lower level, tensions rise as organizational members try to make sense of the transition from the traditional ways of working toward becoming digital service providers (Tronvoll *et al.*, 2020). Marked as most significant are the organizational hurdles (Bustinza *et al.*, 2018). Particularly unintended consequences of the strategic implementation process often hinder the realization of the expected financial returns (Kohtamäki *et al.*, 2020; Gebauer *et al.*, 2020b). Unfortunately, like with servitization, identifying barriers to DS and solutions to overcoming them seems insufficient to guarantee a smooth evolution. Gaining understanding in this perpetual challenge of effectively transitioning toward digital service strategies is relevant, especially given the COVID-19 crisis (Rapaccini *et al.*, 2020).

In this paper, we therefore aim to unravel the mystery behind the persistence of the DS challenge. Rather than investigating additional barriers, we take a problematization approach and challenge existing theory using critical

incident technique (CIT) (Alvesson & Sandberg, 2013; Bott and Tourish, 2016). We question the often-implicit assumption of servitization barriers being independent, clearly discernible and definable issues to which explicit, definite answers exist and ask ourselves:

> *Why do companies continuously struggle with DS despite extensive knowledge on hurdles and approaches to overcome them?*

A comparative case study on DS in which managers' responses to DS barriers are explored, is used as motivation for the development of a multilevel framework in which key ingredients to DS are congregated.

Several theoretical contributions are made. First, calls for multilevel research on servitization (Rabetino *et al.*, 2017; Lenka, 2018) and the development of mid-range theories which provide insight into potential barriers of organizational change in servitization journeys (Rabetino *et al.*, 2018) are answered. Second, the developed framework meets the demand for frameworks that support decision-making and a more systemic and holistic approach to DS (Paschou *et al.*, 2020). Third, by including microfoundations of DS, we add to the emerging consciousness of the importance of emotions for strategic change and management theories (Ashkanasy *et al.*, 2017). Additionally, practitioners can employ the multilevel framework to support them in taking a holistic and proactive approach toward their DS.

The paper is structured as follows. In the first section, DS's context and content are reviewed based on literature. We present multilevel theory as a novel lens through which to explore DS and introduce our preliminary multilevel framework. Next, we elaborate on CIT, our chosen method for theory building, and introduce our comparative case study. Findings are deducted after which propositions for future research are developed in the discussion section. We conclude with a summary of our results highlighting limitations and future research avenues.

2. Theoretical background

2.1 Digital servitization

DS, the market strategy which merges servitization with digitization, is a relatively new topic for academics and practitioners (Coreynen *et al.*, 2017; Vendrell-Herrero *et al.*, 2017). Research on servitization (Vandermerwe & Rada,

1988), its first essential building block, has been firmly consolidated. Yet, this transformational process of shifting from a product-centric business model and logic to a service-centric approach remains challenging (Kowalkowski *et al.*, 2017, p.7; Kohtamäki *et al.*, 2020; Zhang & Banerji, 2017). The adoption and exploitation of new digital technologies, DS's second building block, now further complicates this process as digital technologies highly impact the implementation and offering of advanced services and can directly affect customers' core business processes (Coreynen *et al.*, 2017; Vendrell-Herrero *et al.*, 2017).

Paschou *et al.* (2020, p. 284) comprehensively defined DS as the development of new services and/or the improvement of existing ones through the use of digital technologies [...] to enable new (digital) business models, to find novel ways of (co)creating value, as well as to generate knowledge from data, improve the firm's operational and environmental performance, and gain a competitive advantage. Table I summarizes recent literature on DS.

Two sections can be distinguished within the different literature streams. The first largely focuses on internal, company-specific challenges. The second mainly investigates external challenges relating to changing stakeholder relationships and network configurations. The employment of divergent theoretical lenses has led to DS authors pinpointing numerous barriers relating to different levels of analysis. Together they reveal an increasing complexity, defined by the number of different items or elements that must be dealt with simultaneously by the organization (Scott, 1992, p. 230), in both the content and context of DS. Several authors have highlighted the need for a more systemic and holistic approach to DS (Paschou *et al.*, 2020) to boost understanding of its challenges. We believe a multilevel perspective can be valuable to structure and unravel DS complexity, which might underlie the perpetual DS challenge. In the next section, we further motivate our choice for and elaborate on a multilevel perspective for DS.

Table I *– DS literature review table – Thematic focuses and theoretical lenses*

Thematic Focus	Main Contributions	Theoretical Lenses	References
Firm Performance and Strategic Development	Identification of challenges and impact of DS on firm performance. DS can have a positive correlation with firm performance though this is not guaranteed. The following elements can have a positive impact on firm performance: data analytics supporting the business model evolution, a proper relational governance strategy, a focused sales model and a sufficient digitization level which contributes to the success of the strategy but also increases its complexity.	Business Model Innovation Organizational Theory Strategic Management Value Chains	Gebauer *et al*., 2020a Kohtamäki *et al*., 2019 Kohtamäki *et al*., 2020 Paiola & Gebauer, 2020 Parida *et al*., 2019
Organizational Development	Investigation of organizational resources reconfiguration in support of DS complexity and the implementation of novel business models. A competitive DS strategy relies on crucial capabilities: strong firm commitment, strategic agility, deployment of digitization and its fusion with service implementation, digital management capabilities, and skills facilitating integration into customers' processes and the development of high-value services.	Dynamic Capabilities RBV Value Co-creation	Bustinza *et al*., 2018 Coreynen *et al*., 2017 Frank *et al*., 2019 Hasselblatt *et al*., 2018 Saunila *et al*., 2019
Supplier-Customer Relationships	Exploration of resources, strategies, or relational approaches which can support and optimize changing supplier-customer relationships. Supplier-customer relationships are fundamental to DSTs and require among others a suppliers' ability to deploy unique resources to maintain its strategic position in the supply chain, a firm's ability to develop supplier-customer relational intimacy and informational openness, and co-create with customers from the early stages of DST in an agile, iterative approach, and customers readiness for advanced services, something manufacturers should promote.	SCM Industrial Marketing Business Relationships	Grandinetti *et al*., 2020 Kamalaldin *et al*., 2020 Sjödin *et al*., 2020 Vaittinen & Martinsuo, 2019 Vendrell-Herrero *et al*., 2017
Networking Development	Exploration of DST's impact on networks and existing relationships and an identification of shifts relating to DSTs. For DST to be successful, certain capabilities must be shared among suppliers, customers, and intermediaries. Digitalization capabilities, a shared service-oriented mindset and interfirm system integration are key. Within digital service ecosystems digitalization can both boost complexity as well as facilitate co-creation and cross-company coordination.	SDL/Service Ecosystems TCA Dynamic Capabilities RBV Industrial Organization	Cenamor *et al*., 2017 Kohtamäki *et al*., 2019 Raddats *et al*., 2019b Sklyar *et al*., 2019 Tronvoll *et al*., 2020

2.2 A multilevel theory for DS

2.2.1 A multilevel approach as theoretical lens

Given that strategies are always embedded in a multilevel context (industry, market, organization, division, teams, individual – Matthyssens & Vandenbempt, 2003, p. 598), considering the context in which a DS strategy is developed and implemented can substantially add to the understanding of its success and/or failure (Pettigrew, 1992). Indeed, several authors have pointed out the need for a multilevel approach towards DS (Rabetino *et al*., 2017; Lenka, 2018).

According to Klein *et al*. (1999, p. 243), multilevel theory results in a deeper, richer portrait of organizational life in which the influence of the organizational context (macro) on individuals' actions and perceptions (micro) and vice versa is acknowledged. Adopting a multilevel perspective entails taking a holistic

approach to interdependencies between actors, resources and mechanisms which are studied at different levels of analysis. Gaining understanding of these levels and the interactions between them requires and enriches multidisciplinary knowledge (Partington, 2000; Hitt *et al.*, 2007).

Attention is required, however, to how multilevel theories are built, and insights are measured. Collective constructs such as strategy or organizational culture cannot be measured through mere addition of individual perceptions (Molina-Azorín *et al.*, 2019). Neither can constructs from one level of analysis simply be copied to or compared with another level (Paruchuri *et al.*, 2018). Developing multilevel theory holds potential for the realization of synergies through the synthesis of different organizational sciences (Klein *et al.*, 1999). Yet caution is advised upon merging knowledge and concepts from different streams of literature.

Partington (2000, p. 91) stated that multidisciplinary knowledge can be built through iterations between academics and managers who attempt to learn from one another in a virtuous cycle of understanding, explication, and action. Qualitative research, through which fine-grained data is collected, can contribute to this learning process by uncovering new elements which underwrite the success and/or failure of novel phenomena (Eisenhardt, 1989). Hence, this paper was developed in an abductive way in which literature and case study insights were integrated through systemic combining (Dubois & Gadde, 2002). In the next section, the preliminary multilevel framework from which the iterations started, is presented.

2.2.2 Introducing the multilevel framework for DS

A three-tier analytical framework (Table II) was developed based on literature on determinants of DS. The framework provides a multidisciplinary perspective (Partington, 2000) and brings together insights from among others ecosystem theory (network level), strategic management and organizational behaviour (organizational level), and psychology and behavioural sciences (microfoundational level).

Table II *– Preliminary multilevel framework on DST*

Level	Component	References
Network level *e.g. value partners, clients, suppliers, intermediaries*	Network and supply chain position Division of power and competition Trust throughout the network and interfirm dominant logic Interfirm system integration, digital maturity and readiness Co-creation and interactively developed capabilities Service platforms, ecosystems and governance	Helfat and Raubitschek (2018) Kohtamäki *et al*. (2019) Matthyssens and Vandenbempt (2008) Raddats *et al*. (2017) Sklyar *et al*. (2019) Vendrell-Herrero *et al*. (2017)
Organizational level *e.g. firm-wide processes and mechanisms*	Strategy and business model development Resource configurations, (dynamic) capabilities & resources Organizational identity, structure and culture Continuous internal and external alignment led by management	Alghisi & Saccani (2015) Bustinza *et al*. (2018) Coreynen *et al*. (2017) Kohtamäki *et al*. (2020a) Tronvoll *et al*. (2020)
Microfoundational level *e.g. mechanisms which affect managerial and team sensemaking and mobilization*	Microfoundations of organizational decision-making, routines and (dynamic) capabilities, among which: - Cognitive processes, such as managerial perception, cognition, sensemaking and sense giving - Affective processes causing collective and individual emotions such as emotion contagion	Felin *et al*. (2015) Helfat and Peteraf (2015) Hodgkinson and Healey (2014) Lenka *et al*. (2018a) Rabetino *et al*. (2017)

2.2.2.1 Microfoundational level

A microlevel perspective was incorporated following the call of Rabetino *et al.* (2017, p. 155) for the inclusion of psychological and sociological insights to increase understanding of servitization pathways based on individual perceptions, behaviours, and interactions among individuals. Within this level, microfoundations of organizational decision-making, routines and (dynamic) capabilities are comprised (Helfat & Peteraf, 2015; Hodgkinson & Healey, 2014) with the goal of understanding how actors, their interactions, and the mechanisms and context that influence such interactions, produce firm-level and collective heterogeneity (Felin *et al.*, 2015, p. 605).

Microlevel mechanisms consist of intertwined cognitive and affective processes which mediate organizational practices (Hodgkinson & Healey, 2014). They can be discerned at the individual level, between individuals of the organization or even at the unconscious level where basic cognitive processes are studied (Waldman *et al.*, 2019). Emotion contagion, for example, is an affective process in which emotions spread from one individual to the next, leading to the emergence of a group level mood or collective emotion (Barsade, 2002). Studies show that collective emotions can significantly influence managerial perception of the need for change, strategic decision-making, and change outcomes (Vuori &

Huy, 2016; Healey & Hodgkinson, 2017). Taking this level into account is therefore essential to understanding DS journeys.

According to Gioia and Chittipeddi (1991), a manager's main role in initiating strategic change consists of sensemaking and sense giving. This entails the reconceptualization of the organization to fit the strategic change (sensemaking) followed by the dissemination of this new company vision among stakeholders (sense giving). By effectively framing change initiatives in a way that connects with and reshapes the shared idea of what the organization stands for, managers can mobilize employees to align their actions and thoughts with the new organizational reality (Raffaelli *et al.*, 2019). Helfat and Peteraf (2015) also highlighted managerial cognition as a microfoundation of an organization's ability to sense, seize and reconfigure the organization's resources to fit the desired and/or required strategic change. Especially in radical innovation efforts, emotion too plays an important role in engaging key players. With the power to evoke strong commitment to novel choices, it is essential to the adaptive capacity of individuals and organizations (Hodgkinson & Healey, 2014, pp. 1310).

Since both servitization and digitization are described as disruptive and requiring radical organizational change (Vendrell-Herrero *et al.*, 2017), DS journeys are likely to challenge the '*cognitive maps* [1]' of managers (Helfat & Peteraf, 2015) and evoke strong emotions (Vuori & Huy, 2016). To date, however, microlevel perspectives on DS remain scant. Lenka *et al.* (2018a) showed how microfoundations can facilitate servitization transition by countering organizational resistance. Coreynen *et al.* (2020) found that differences in decision-makers' motivations – whether they were driven by the need for achievement, affiliation, or power – influenced organization's chances at pursuing servitization. Both studies offer a starting point for investigating how microlevel mechanisms can smoothen or interfere with DS pathways.

2.2.2.2 Organizational level

Since DS involves a change in business strategy, which is central to aligning the internal and market environment (Alghisi & Saccani, 2015), its implementation requires a revision of the entire organizational constitution (Vendrell-Herrero *et al.*, 2017; Bustinza *et al.*, 2018).

First, resource configurations must be rearranged to fit the digital strategy and business model (Coreynen *et al.*, 2017; Parida *et al.*, 2019). New capabilities are necessary to benefit from technological opportunities. Existing product-

related knowledge is essential yet insufficient for DS success (Paiola & Gebauer, 2020). Digital service capabilities, which facilitate knowledge absorption from customers and enhance an organization's ability to co-create value, are vital (Saunila *et al.*, 2019). Hasselblatt *et al.* (2018) further listed digital business model development, the building of scalable solution platforms, IoT (Internet of Things) value selling and delivery, business intelligence and measurements as key capabilities for DS. Additionally, organization-wide commitment and a better operational product-service configuration are required to making DS work. Some critical resources, among which strategic ability, might be acquired externally (Bustinza *et al.*, 2018).

Next, the organizational structure and its underlying processes must be reconfigured to support the digital service provision. According to Bustinza *et al.* (2018, p.112) DS requires an organizational structure with the capacity to constantly reconfigure the firm's strategic capabilities to meet continuously evolving customer needs. Shifting from centralized to decentralized operations and from physical products to dematerialized data not only challenges organizational structure (Tronvoll *et al.*, 2020). Role conflicts might emerge causing internal tensions. Organizational dissonance is expected to be fed by the ambiguity following the simultaneous focus on products and services and the accompanying conflicting behavioural and attitudinal expectations (Lenka *et al.*, 2018b, p. 813). Establishing a strong service-oriented organizational identity and a culture which endorse a synergetic relationship between manufacturing and service-orientation can help in managing this ambiguity and consolidating DS oriented organizational change (Tronvoll *et al.*, 2020).

Finally, flexibility and continuous internal and external alignment are key to realizing the necessary changes (Bustinza *et al.*, 2018). Misalignment between investments in digitization and the level of servitization could be detrimental to financial performance (Kohtamäki *et al.*, 2020). Literature has indicated that leadership and managerial commitment play a central role in aligning for DS (Yeow *et al.*, 2018; Bustinza *et al.*, 2018). Additionally, the presence of transparency, customer involvement, constructive relationships with partners and extra personnel can facilitate the DS journey (Hämäläinen, 2020).

2.2.2.3 Network level

Since collaborations with external actors are required to effectively realize advanced digital solutions, an examination of the DS context seems crucial

(Pettigrew, 1992; Sklyar *et al.*, 2019). Indeed, existing relationships and network dynamics are expected to be impacted by DS (Kamalaldin *et al.*, 2020; Kohtamäki *et al.*, 2019). Given that network and supply chain positions might change, firms are encouraged to actively explore new relationship equilibria (Adner, 2017) and exploit their difficult to imitate factors to preserve their relational power and competitiveness (Vendrell-Herrero *et al.*, 2017). Trust between value partners is key (Gebauer *et al.*, 2020a). Though traditionally not prevalent in the manufacturing industry (Matthyssens & Vandenbempt, 2008), trust has been shown to be essential to and follow from DS implementation. After all, digitization facilitates openness and operational transparency which both underwrites and necessitates a novel shared interfirm dominant logic (Tronvoll *et al.*, 2020).

Digitization also supports interfirm system integration which further enables cross-company collaboration (Sklyar *et al.*, 2019). To participate in and benefit from horizontal integration, however, digital maturity must be sufficiently high (Frank *et al.*, 2019). Customers should portray digital readiness in terms of IT systems, mindset, and capabilities (Vaittinen & Martinsuo, 2019). In fact, specific capabilities should be acquired by all network actors to stimulate collaboration and innovation (Raddats *et al.*, 2019b). Understanding partner needs is important as DS requires intensive collaboration between provider and customer (Kamalaldin *et al.*, 2020, p.2). Furthermore, co-creation practices in which complementary capabilities are exchanged can generate interactively developed capabilities enhancing among others knowledge and service development (Raddats *et al.*, 2017). Finally, being able to access customers and data (Grandinetti *et al.*, 2020) and actively involve clients in the co-creation process (Saunila *et al.*, 2019; Sjödin *et al.*, 2020) is essential too.

Digital platforms, technological infrastructures that allow firms to develop, configure and deliver advanced services efficiently (Cenamor *et al.*, 2017, p. 55), exemplify high interfirm system integration. Several parties can be involved among which suppliers, complementors and customers. For platforms to result in positive cross-side network effects, a governance structure must be designed specifying incentives for and rules on participation and interaction (Helfat & Raubitschek, 2018). This in contrast to traditional service ecosystems which are known as 'relatively' self-contained, self-adjusting system[s] of resource-integrating actors connected by shared institutional logics and mutual value creation through service exchange (Lusch & Vargo, 2014, p. 161).

The relational nature of ecosystems, which bring together unfamiliar actors with diverging interests, makes it impossible to analyse DS in isolation

(Kohtamäki *et al.*, 2019). Studies show that applying a multi-actor perspective might help in gaining deeper insight into challenges relating to the realization of advanced services (Kamalaldin *et al.*, 2020; Story *et al.*, 2017).

2.2.2.4 Cross-level interconnectedness

Additionally, literature hints toward the existence of cross-level interconnectedness. For example, organizational actions, such as trainings aimed at boosting servitization related knowledge, might influence motivations of decision-makers at the microfoundational level which in turn may enhance the chances of organizations pursuing DS (Coreynen *et al.*, 2020). At the same time, strategic involvement of customers and partners is required at the network level to effectively design servitization business models and implement the strategy at the organizational level (Bustinza *et al.*, 2018; Kohtamäki *et al.*, 2019). However, to benefit from network partner involvement organizations need to recalibrate their competences and mindset in the first place (Kamalaldin *et al.*, 2020; Tronvoll *et al.*, 2020). Actions and decisions on one level hence seem to influence the effectiveness of other levels simultaneously. Despite many studies suggesting such interdependencies, the phenomenon of cross-level interconnectedness has not yet been investigated in-depth.

3. Methodology

3.1 Method

CIT (Flanagan, 1954) was chosen as a central method based on the exploratory nature of our research question and our desire to challenge existing theory (Bott & Tourish, 2016). The qualitative method focuses on critical incidents in which people's behavioural response to practical challenges encountered in a specific situation, and the perceived consequences of these behaviours, are studied. Critical incidents are described as major events or a series of interlinked events that characterize the start of a next stage in a development process. They can be negative in nature resulting in an undesirable outcome, or positive, as in characterized by an opportunity or potentially causing a positive outcome (Durand, 2016). Semi-structured interviews are used to collect the behavioural data. By applying an open-ended approach in which data is gathered free from references to pre-existing theories, rich descriptions of key

incidents are generated which offer a greater opportunity to shed new light on old phenomena, and thus to challenge long-established theoretical accounts (Bott & Tourish, 2016, p. 277). Former research has proven CIT's value for providing deeper understanding of the intricacies and contextual factors surrounding behaviours (Bott & Tourish, 2016, p. 278) and for increasing understanding into and revealing "hidden" aspects of disruptive transitions (Durand, 2016, p. 87).

In this work, CIT was applied to two cases on which a comparative, longitudinal, multiple-case study was built (Eisenhardt, 1989; Yin, 2011). The reason for this is threefold. First, case studies have proven beneficial for theory development in dynamic contexts (Pratt, 2009; Matthyssens & Vandenbempt, 2003). Second, by purposefully selecting (Patton, 2005) two similar cases which are set in different geographical contexts, one in Italy and one in Belgium, their comparison may lead to the identification of differences in implementation logic and approach that could contribute to our understanding of what facilitates or hinders DS journeys. Furthermore, the longitudinal nature of the research supports increased understanding of process dynamics, a causal perspective on behaviour and comprehension of the evolution of the DS over time (Quintens & Matthyssens, 2010). Since it is our goal to gain clarity on what continues to challenge managers in their journey toward advanced DS, a longitudinal comparative case study seemed valuable.

Important to point out is that the case study is used as motivation for the developed multilevel framework rather than it being the focus of our paper (Siggelkow, 2007). It is not our intention to identify implications which can be generalized further. The case is used in iteration with the literature through systemic combining for theory development (Dubois & Gadde, 2002).

3.2 Data collection & analysis

Both the Italian and Belgian case followed their company throughout the years in which the DS initiative took place. In the Mectop [2] -case (IT), information was collected over a 4,5-year period. For Apitec [3] (BE), data was gathered over 10 years. Semi-structured interviews with diverse key actors were conducted with the aim of gaining insight into critical incidents (Table III). Individuals at the organizational and network level were questioned on managerial responses to DS barriers and the consequences of their behavioural choices for the consecutive DS journey. Interviewees were purposefully sampled based on their involvement with the DS initiative and/or their unique perspective

on its evolution (Patton, 2005). A snowballing technique was applied in which respondents were asked "Who else might have a unique perspective on the evolution of the DS?". Interviews were undertaken until saturation was reached (Bott & Tourish, 2016).

By gathering diverse viewpoints on the critical incidents, we were able to add nuance to our dataset and counter bias (Silverman, 2008). This allowed for the discovery of novel critical incidents where certain respondents had trouble recalling instances or felt reluctant to share sensitive information, common challenges to CIT. To motivate revelation of critical incidents, respondents were guaranteed full anonymization of the case. Additionally, generic probes such as "Who else was involved? What were the challenges? What was the impact?" were used to encourage dialogue whilst avoiding data contamination through leading questioning (Bott & Tourish, 2016).

Table III *– Overview of interviews for the Mectop case (left) and Apitec case (right)*

Mectop		**Apitec**	
Interviewees' Role	**Duration (min)**	**Interviewees' Role**	**Duration (min)**
Organizational Level			
Service Innovation Director	35	Chief Product Officer	60
CEO Assistant for Innovation	30	Former I4.0 Project Manager	70
MECSERVICE Ambassador	40	I4.0 Project Manager (2x)	70
MECSERVICE Project Manager	30	Focus group with Chief Product	60
Marketing Assistant	40	Officer, Vice President/Chief	
CEO Assistant for Innovation	30	Technology Officer and I4.0 Project Manager	
Network level			
Senior Project Manager Informa	50	Client of Apitec	75
MECSERVICE Responsible at client's site	30	MD of industry organization	30

Congruent with CIT, content analysis was used to examine the data. In a first step, critical incidents were discerned through conversations with key stakeholders and discussions between researchers. Next, a combination of data-driven and theory-driven coding took place, consistent with our abductive approach (Dubois & Gadde, 2002). Major incidents were scrutinized using the components outlined in the preliminary multilevel DS framework while we remained open to alternative interpretations of the empirical data. Engaging our empirical data in a critical dialogue with theory, supported our goal of challenging existing theory (Alvesson & Sandberg, 2013).

Comparing critical incidents between cases, enabled us to distinguish overarching patterns in their development. Four major events were acknowledged as pivotal to the DS evolutions. In the following section they are introduced for each case.

4. Case descriptions

4.1 Italy-based Mectop: From manufacturing excellence to smart service provision

Italian B2B company Mectop originated in the 1970s. The company specializes in producing industrial machineries for the manipulation of natural and advanced materials. After having known considerable growth, the family-business nowadays operates worldwide in 39 legal entities and 12 manufacturing sites, offering employment to nearly 4,400 employees.

In 2017, Mectop invested in an IoT based DS project, named MECSERVICE. With this new brand and platform, the firm provides and delivers digital and traditional services. Machineries are equipped with sensors that monitor their activities and technical needs. Based on these data, MECSERVICE offers clients services such as preventive maintenance and error notifications, video remote assistance and KPI measurements. The five-year project was realized in collaboration with international consultancy agency, Informa. In the year of MECSERVICE's launch, the Italian government presented the National Industry 4.0 Plan. The plan which intended to proactively support technological innovation of Italian firms, included interventions among which financial contributions, credit access and tax relief. It turned out to be a crucial factor in digital solution investments made by Mectop's customers.

Incident 1 – In 2016, Mectop became aware of rising technological opportunities. Its management understood that, to gain significant competitive advantage, they would need to seize the opportunities before everyone else did. In Europe, many manufacturing companies were looking for ways to recover from the economic crisis (2008-2011). The entire market experienced a need for innovation. The firm's innovation department travelled to Germany to learn from the country's main competitors in which direction Industry 4.0 was heading. The journey resulted in an innovation push toward first mover advantages and a shared perception of the need for change.

Simultaneously, the company's relationship with Informa was reinforced. Previous collaborations between the firms had been positive. Informa had gained

experience in DS projects in among others the automotive industry and suggested Mectop to invest in DS.

Incident 2 – After the board of directors decided to adopt DS in 2017, the firm's business model was radically changed to fit this new strategy. Monetizing digital services was new to Mectop which had previously only provided customers supporting services free of charge. MECSERVICE was to guarantee a stable income complementary to the fluctuating sales of its long-life machines. The platform embodied a Product-Service System (PSS), a system in which the company's product offering was enhanced by a series of services which were strictly related to the sold products. Clients could use the platform to buy spare parts in the online store and to consult technical documents. Proactive services could be provided to prevent machines from failing. The project was kicked off by a pilot session in which customers were invited to test MECSERVICE. After positive results the official launch followed. A webpage devoted to MECSERVICE was introduced.

Initially, the project caused internal frictions. Departmental silo thinking led to resistance among managers who perceived MECSERVICE as an addition to their regular workload. Their opposition hindered cross-functional collaboration which produced a significant barrier to the DS. Different departments needed to be mobilized to realize the project among which IT, Services, Innovation, R&D and Marketing. Aligning them and fulfilling requirements in terms of human resources, competences, and capabilities, was a first challenge. Alleviation was found in the recruitment of new resources. The Service Innovation Director, responsible for leading MECSERVICE-staffed employees, was hired. Younger employees and technicians of the MECSERVICE project were particularly motivated. Working directly for the Service Innovation Director offered them clear visibility at top management level which was perceived a huge benefit for their future career.

Incident 3 – Faltering performances between the end of 2017 and the start of 2019 urged management to revise the initiative. This phase had been reserved for market roll-out, internationalization and adaptation of all machine models involved in the provision of digital services. Notwithstanding, deadlines and key performance indicators were not met. The project decelerated. Immediate improvements were required. Difficulties were encountered at different levels. First, not everyone inside the firm was committed to nor positive about the project. The strongly embedded product-based logic held back employees from transitioning towards a service-oriented mindset. Second, clients seemed to not fully perceive the value of MECSERVICE nor understand its potential benefits.

Third, Mectop struggled to effectively make use of big data collected through MECSERVICE. The overwhelming amount made it hard to extract value from it.

Mectop responded with actions at both the organizational and network level. Internally, training sessions were organized among employees to increase diffusion of capabilities and knowledge. A marketing campaign was dedicated to raising employee awareness of MECSERVICE and the benefits it brought. One of the actions entailed providing employees access to a dedicated project page on Mectop's intranet. Concurrently, the marketing department embarked on a mission to reconnect with the market. Training sessions were organized for customers to enhance their knowledge about MECSERVICE's functionalities. The strong, positive relationship with Informa supported Mectop throughout the challenges.

Incident 4 – From the end of 2019 on, the firm's strategy was continuously finetuned, resulting in Mectop becoming more services-oriented and connected with the market. The board of directors had realized a strategy revision was necessary to meet customers' needs and exploit the firm's key capabilities. They extended MECSERVICE from a PSS to a complete services platform which lent customers unified access to digital and traditional services against payment. A customer segmentation exercise aimed at the clear identification of customers' needs would later facilitate the offering of tailor-made service packages.

Leadership embodied by the Innovation Director, the Service Innovation Director and the Information Technology Director was crucial for continuous improvement. Bi-weekly, two meetings would be held among them. The first focused on business and organizational related challenges. The second, a technical meeting, was reserved for platform related and other analytical questions. (Operative) employees could attend the meetings to raise and discuss issues. At times, solutions would be discussed together with employees before final decisions were taken. Informa also attended the business meetings. Its participation lightened the load for managers who no longer perceived the project as stressful.

Managers and employees were strongly motivated to work on MECSERVICES, except for the sales team. Mectop's salespersons who benefited from product sales' commissions remained stuck in their product-oriented mindset. They considered selling machines more profitable and used MECSERVICE mainly to lure clients into buying extra products. In response to their lack of motivation, KPIs were drawn up to enable the rewarding of services sales. In a first meeting, those KPIs and the accompanying new way of evaluating were shared with the sales team. In a consecutive workshop, Mectop invited its

salespersons to share their ideas on the improvement of service sales and the digital tools which might support them in their effort. Additionally, management of the sales and service departments were merged to increase integration and alignment between both DS essential activities. This merger also confirmed and made visible the announced cultural change towards services.

4.2 Belgium-based Apitec: From servitization-savant to total digital solution provider

Recognized for its innovative nature, Apitec designs and produces solutions for the construction industry through installers, who customize the product to the specific installations in which they are integrated. The MNE with a family business character has known tremendous growth over a short period of time leading to its worldwide operations today. From the very beginning, services were included in the manufacturer's offer. In the 80s, Apitec started experimenting with programming and machine-to-machine communication. One could say that the company recognized the benefits of services and technology from very early on.

In the early 2010s, the company decided on expanding the digital services offer. The total solution coined AFLUX would consist of a manufacturing executive system supporting clients in the optimization of their own operations. A redesign of their workflow and the installation of a paperless production environment would boost clients' efficiency and competitiveness. In a later stage, a web-based dashboard was added to the application allowing clients to monitor their installation production projects 24/7 from anywhere.

Incident 1 – In the late-2000s, one of Apitec' clients approached the firm with an idea for a novel digital solution. The automation manager, who would become the project's main champion and Apitec's digitization lead (DL), agreed to explore the opportunity together in co-creation. Meetings with potential software partners were held and market interest was gauged. Inquiries into general interest, willingness to pay and desired features were made. The results were positive. Customer support and interest for the idea grew as the news spread via Apitec's sales representatives.

Simultaneously, the DL employed his/her influence to gain support internally. Unfortunately, management was not ready to invest in the solution. Lack of budget and pre-existing intricacies between the firm's systems and software supplier Ergon's application motivated the continuation of a co-creating

partnership between Apitec and Ergon, despite awareness of its suboptimal nature. Ergon held complementary capabilities, yet its developed general application did not entirely fit Apitec's local market requirements of customization and variability. The collaboration did however allow to immediately kick-off of the development of the new solution and save costs.

Incident 2 – At the beginning of the 2010s, Apitec experienced an innovation push toward first mover advantages. Belgian industry organizations were campaigning strongly for I4.0 implementation and the external buzz in combination with internal presentations held by people from the DL's network, quickly turned around managers' minds who ended up considering digitization as key to Apitec's future competitive position. Preparations which until then had mainly taken place under the company's radar, allowed the firm to quickly shift gears. The digital solution was given more visibility and was included into the strategy and budgeting cycle. The official start of the AFLUX-project was given.

Incident 3 – Around 2013/2014, internal and external tensions started to complicate the DS journey. Clients who had volunteered to test run the application were reporting problems. Pressure on the technical support team increased. A need for extra human resources and organizational structures that could facilitate the mounting feedback emerged. The search for additional team members was cumbersome. The job required a unique combination of technical knowledge, ICT-skills, social skills, and commercial flair which seemed hard to find. Furthermore, Ergon, European market leader in its own segment, was following its own course leaving technical issues unresolved, necessitating a ticketing system that supported following up on open issues. Organizational action in response to the situation was delayed.

Management's belief in the solution faltered with the accumulation of technical issues. Their commitment decreased which further hindered the allocation of resources necessary for remediation. Persisting delay in reinforcements and relief evoked frustration in the technical support team. Eventually, their distress and ensuing indifference started filtering through in conversations with customers. Clients themselves also experienced frustrations. Strong responses to malfunctioning of the application were common. AFLUX infiltrated deeply into clients' core businesses and could endanger their production process. Hence, sales representatives were confronted with dissatisfied customers. The salespersons, who had already shown resistance at the initiation of the project due to unfamiliarity with the technology and low involvement in the development of the application, felt lost when clients' questions were put to them, and frustration was laid down at their feet. The

continuation of bad news combined with deficient knowledge of ALFUX amplified their initial discomfort. The salespersons' belief in the solution decreased and discouraged them from selling the application.

Incident 4 – By the end of the 2010s, the unsolved technical issues resulted in a 50% success rate of the project. At some clients' sites, the application was working very well. International roll-out had commenced. For others, however, AFLUX's troubles continued. One of the clients, a long-term software tester for Apitec, presented the company with a formal notice of default in response to persisting problems on his site. Two years later, no solution had been received. Together with his own programmer, however, the client had continued exploring answers. In less than 12 months, they had succeeded in realizing a solution. Willing to share this knowledge, the client was discouraged by management's response, who seemed to perceive the solution as a threat rather than an opportunity to help Apitec's clients.

Internally, support for the application continued to fall making it increasingly hard for the DL to keep up morale in the support team and to continue working towards answers for clients. A ticketing system had been installed, yet solutions from Ergon remained absent. Continuing shortage of managerial support and proper organizational action eventually led to the DL leaving the organization of which he/she had been part for over 20 years. At the writing of this paper the future of the application is unsure.

5. Findings

Purposeful sampling caused us to select companies with a similar starting point, among which a shared family business background, experience with rapid growth, and digitization prior to the start of the DS projects. This common ground might have contributed to the initial stages of the DS journeys being rather alike, with both firms responding quickly to the external market push towards I4.0 aiming for a first mover advantage. Misalignment between strategy, market, and internal operations, however, ensued. Different responses developed in answer to these multi-level tensions put the companies onto different pathways leading to contrasting project outcomes. A confrontation between our data, critical incident analysis and the multilevel framework resulted in Table IV, which presents dissimilarities between the cases which span the network, organizational and microfoundational level. We highlight some of the key differences below.

***Table IV** – Dissimilarities between Mectop and Apitec's DST: A multilevel perspective*

	Mectop	Apitec
Network Level		
Network partners, trust and power	Arms-length relationship with customers. Previous positive collaborations with consulting firm Informa have established a relationship of trust. Informa suggests strategic DS change to Mectop.	Close relationships with customers. The AFLUX application idea is presented to Apitec by one of its customers. A previously difficult collaboration with software supplier Ergon sets the tone for the co-development of AFLUX.
Integrated systems	Low integration between Mectop's, its clients and supplier's system. The developed digital solution does not directly influence client's core processes.	Medium to high integration between Apitec's and its client's operations. High dependency on the software supplier's systems. The digital solution deeply integrates with and affects the core processes of Apitec's clients.
Organizational Level		
Strategy development and business model design	Services offered as a new product. Top down implementation of a mostly predefined business and action plan developed and executed in collaboration together with external partner Informa. Clear managerial commitment towards DS all throughout the implementation phase. Clearly defined project scope, budget, objectives and measurements.	Services offered to increase product sales. Bottom-up development of a client requested solution. Trial and error approach. No external partner present to structure the initiative. Management's commitment fluctuates throughout the project. Project scope, budget and objectives are unclear. Few measurements provided for project evaluation.
Resource configurations, (dynamic) capabilities & resources	Little experience with selling services. Basic supporting services are offered for free at the start of the project. Digital products have been sold before but this is the first time the digital product is linked to services. Little to no experience co-creating with customers. Project champions are situated at top management level.	Experience with advanced servitization. Another digital application has already been sold to clients. Some experience with co-creating digital solutions with software partner Ergon and Apitec's clients (testers). Project champions are situated at middle management level.
Organizational identity, structure and culture	Strong product-dominant logic at the start of the DST. Hierarchical and structured organization.	Strong service-dominant logic at the start of the DST. Less hierarchical. Less organizational structures in place to support activities.
Continuous realignment and change management	Clear, decisive organizational action is taken in response to distinguished misalignments. Management takes the lead in developing and implementing solutions.	Limited managerial involvement leads to low awareness of misalignment and the urge for action. Organizational responses are delayed. Digitization lead and customers take the lead in looking for solutions.
Microfoundational Level		
Microfoundations of organizational decision-making, routines and (dynamic) capabilities	Management perceives the success of MECSERVICES as intertwined with their own future (successful) careers. A shared perception of the need for change emerges early on in response to the external market push. Objectives from management and the innovation department are aligned. High commitment is shown throughout the entire project. Employees show initial resistance to the unfamiliar nature of the new service-oriented strategy. Trainings are organized to raise engagement and understanding of the tool. Together with Informa's support, Mectop succeeds at turning the situation around. Mectop's sales team considers selling services less profitable since it is not rewarded via their commission. The team does not comply with the new DS strategy until additional organizational measures (KPIs and training) are taken.	Management does not seem convinced of AFLUX's value for Apitec's future competitive advantage. Despite an initial mind shift in response to the external market push for innovation, managerial engagement and involvement quickly drop back to low levels of interest. Mobilization of top management and key influencers remains difficult throughout the project. Despite previous positive experience in co-creating a digital solution with clients, high stress levels are experienced by the support team. The increasing amount of unresolved technical issues in combination with delayed organizational action moves the team from initial engagement to frustration to indifference. Eventually, customer contacts start to get affected. Conversations with disgruntled clients, affect the sales team's attitude towards AFLUX. Their initial suspiciousness turns into a reluctance to sell the application. Sales of the application come to a halt.

A first distinction was found at the network level. The former positive relationship with co-creating network partner Informa instilled confidence in Mectop regarding its DS competencies and ability to support them through change. This trust-based relationship facilitated the development and realization of Mectop's digital solution at the organizational level. Conversely, Apitec's relationship with Ergon was troubled before AFLUX's development. The supplier held the power. Apitec's inability to effectively manage its supplier and push for timely solutions caused stress at the microfoundational level. Ineffective organizational responses followed which negatively affected the client relationships at the network level. The DS challenge of co-creation hence involved processes present at network, organizational and microfoundational level. Interdependencies and reciprocity between these processes facilitated Mectop's journey but complicated management of Apitec's DS issue – i.e., the realignment of co-created systems to match customer needs – hindering DS progress.

Another difference can be found in the process and content of the implementation of the DS strategy. Mectop's management perceived DS success as congruent with its own future career. This strong commitment toward DS at the microfoundational level spurred on an engaged, top-down approach which materialized into a well-defined, frequently revaluated business and action plan. Prompt recognition of misalignment was followed by decisive action which positively affected organizational mobilization. Contrarily, Apitec took a more bottom-up, trial-and-error approach without a clearly demarcated plan or budget. Misalignments at the organizational level were not as easily perceived by management which resulted in delayed organizational actions and increased tensions at the microfoundational level. The DS challenge of organizational mobilization was influenced by a complex interplay between among others individual motivations of leadership, managerial ability to perceive tensions and develop fitting, timely responses, and organizational structures which facilitated this process.

The critical incidents clearly illustrate continuous interactions between the different levels of the multilevel framework (Table II). Microlevel processes were abundantly present throughout both DS journeys with affective mechanisms underpinning key decisions, influencing organizational effectiveness and outcomes in a positive or negative way. Misunderstandings and choices made at one level visibly impacted the others.

Management's (un)responsiveness to DS barriers was one of the key differentiators potentially explaining the divergent organizational outcomes. Inaction caused the companies to become trapped in a state of misalignment. The

Mectop case showed that appropriate organizational action could move a company forward again. An example can be found in the mobilization of Mectop's sales team. Management noticed the reluctance of the team which stemmed from unfamiliarity with selling services and misalignment of incentives. They responded with a revision of organizational remuneration structures and trainings aimed at boosting salespeople's ability and willingness to sell digital solutions. The realignment with the new service-dominant logic at organizational level, flowed back to the microfoundational level where salespeople felt more inclined to sell services. In addition, Mectop's clear company-wide communicated strategic plan and cross-functional unit dedicated to the execution of I4.0 facilitated organizational mobilization in contrast to Apitec where plans remained vague and the initiative rather local.

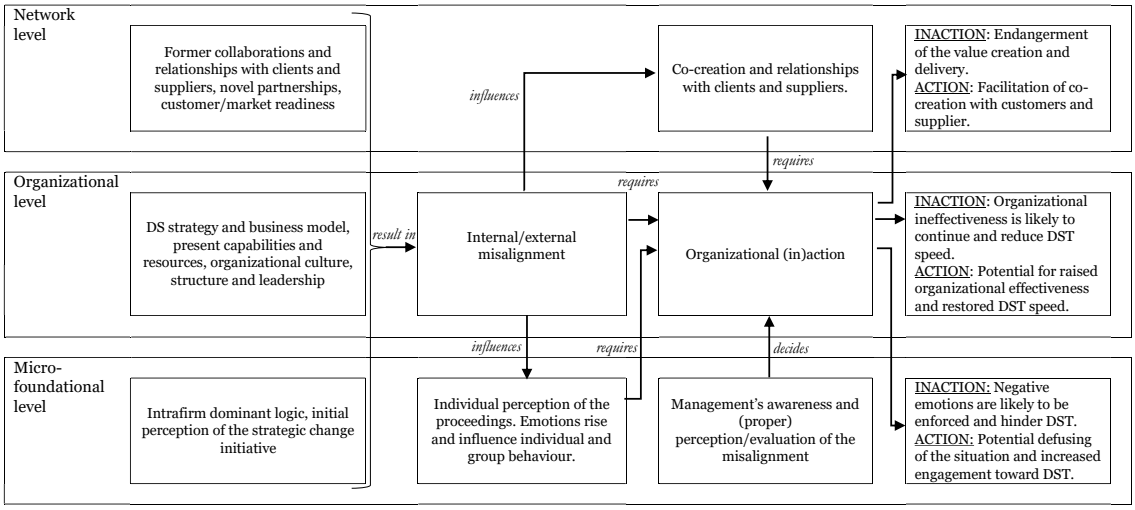
The Apitec case demonstrates how bottom-up initiatives without support from top management are likely to experience a more challenging DS path. Scaling up AFLUX required reconfiguring and increasing resources which could only be realized by top management. Outspoken management commitment at Mectop seemed to accelerate dedicating resources and managing change, illustrating enhanced strategic agility.

Finally, the comparative case study illustrates the importance of taking an incremental approach which is aligned with suppliers' and customers' readiness level. Apitec's total solution was too advanced for most of their client's systems. Capabilities held by Ergon were not up to par with customers' needs. Taking smaller steps towards implementing the integral solution might have helped to build momentum and effectively realize it.

6. Discussion

Based on the conception of increasing complexity in the content and context of DS and its implementation (Coreynen *et al.*, 2017; Sklyar *et al.*, 2019), a multilevel framework was conceived to facilitate exploring the perpetual DS challenge.

Figure 1 *– A multilevel process perspective on DST*



We found that different levels and elements of the multilevel framework were simultaneously involved in the identified critical incidents, confirming the need for a holistic approach to DS. Furthermore, strong interconnectedness between elements within and across levels emerged generating feedback loops between the microfoundational and organizational, organizational and network, and the network and microfoundational level (Figure 1). This 'domino-effect' seemed to particularly challenge the DS journeys. Managerial responses to barriers encountered at one level affected the 'health' of other levels. Ineffective organizational responses instigated by improper managerial perception of DS barriers caused multilevel alignment difficulties in consecutive DS stages. Application of the multilevel perspective highlighted the interconnectedness of DS challenges, which seem grafted upon one another, are situated at different levels of analysis, and involve a diversity of actors. These interdependencies significantly complicate DS. Hence, we propose DS to be a wicked problem.

Proposition 1: DS implementation is a wicked problem.

> *Proposition 1a: DS barriers consist of multilevel, multi-actor challenges which can be hard to discern and of which the definition depends on the observing party.*
>
> *Proposition 1b: DS barriers are interrelated, interdependent, communicating issues of which the source can be difficult to pinpoint, and which have reciprocal implications.*

Proposition 1c: No certain, conclusive answers exist to DS barriers since the challenges themselves change with every organizational response made.

By recognizing DS implementation as a wicked problem, we revoke the often-implicit assumptions of DS barriers being independent, clearly discernible, and definable issues to which explicit, definite answers exist. Wicked problems are unique, complex problems which are defined differently by different stakeholders making them particularly intractable. (Cox *et al.*, 2016, p. 3). They are distinguished from familiar challenges to which the solution is well-understood. According to Zuiderwijk *et al.* (2016, p. 223) a wicked problem is characterized by a lack of specific formulation, complex interactions amongst a variety of stakeholders, a lack of criteria determining a satisfactory solution, including what constitutes 'value', and uncertain outcomes.

This description matches the attributes of DS challenges. The successful realization of DS depends on an increasing number of widely varied actors (Sklyar *et al.*, 2019). Each one of them faces different challenges, is privy to only part of the picture and therefore interprets the DS journey differently. For DS to succeed, however, all actors involved must collaborate toward the same end goal. Unfortunately, in DS end goals can often be unclear. Advanced solutions are complex in nature and require co-creation with several value partners (Kohtamäki *et al.*, 2019), making it almost impossible to fully define a solution prior to its development. This, in turn, makes mobilizing partners in the 'right direction' extra difficult.

The 'wicked' nature of DS, uncovered by the application of the multilevel perspective, might explain why approaches to tackling individual DS barriers have proven insufficient in ensuring smooth transitions. Wicked problems are said to be insolvable by only considering part of the problem (Zuiderwijk *et al.*, 2016, p. 223). We expect a higher order capability to be essential to managing the interconnectedness within and across multiple levels and stages of the DS journey.

Higher order capabilities (Collis, 1994) are capabilities which do not affect profit directly but can affect other resources that in turn affect competitive advantage and profit over time. Since profit generation remains a challenge for DS and misalignment has been shown to hamper organizational efficiency (Chorn, 1991) and effectiveness of digital transitions (Yeow *et al.*, 2018), active management of misalignment seems desirable. By productively and proactively managing interdependencies of DS challenges, companies might, for example,

more easily overcome the digitization (Kohtamäki *et al.*, 2020) and servitization paradox (Gebauer *et al.*, 2005), resulting in higher DS profits.

Proposition 2: Effective management of DS challenges consists of an iterative process in which companies shift gears actively, quickly, and continuously between observing, analysing, and responding.

> *Proposition 2a (Observing): Companies implementing DS require advanced perception and recognition capabilities which enable them to properly and timely discern DS tensions at network, organizational and microfoundational level.*
>
> *Proposition 2b (Analysing): Companies implementing DS require proactive and continuous (r)evaluation of (potential) DS issues within the multilevel perspective in which they are embedded.*
>
> *Proposition 2c (Responding): Companies implementing DS require organizational structures, a flexible mindset and advanced coping strategies which support agile decision-making and responding to DS challenges present within and between the network, organizational and microfoundational level.*

The comparative case study demonstrates the importance of proper discernment of misalignment as a precondition for formulating adequate organizational responses. Actively observing changes in the internal and external environment can facilitate perception. Recognizing the multilevel nature of DS barriers when analysing challenges – as they occur and proactively – can boost a company's ability to timely develop answers befitting their complexity. As the Mectop case illustrates, having a structure in place for regular (r)evaluation and having access to advanced coping strategies – in this case embodied by Informa – can improve an organization's responding capability. Since companies gain insight into DS barriers by going through the observing, analysing, and responding cycle, we expect that the more companies run through this cycle, the better they will become at coping with DS barriers. Future research can investigate whether companies become more apt at managing the interconnectedness within and across multiple levels as they progress through their DS journey.

Our findings show that an important role is reserved for managers whose responses to the encountered barriers seemed to considerably shape DS outcomes. Certain leadership capabilities such as managerial commitment,

strategic agility (Bustinza *et al.*, 2018) and the use of regular measurements to make incremental DS progress visible (Hasselblatt *et al.*, 2018) were found to smoothen the Mectop transition, in line with extant literature. Yeow *et al.* (2018) already highlighted the distinctly essential role of management for the identification of internal and external tensions and the development of proper organizational responses. Recently, Wibbens (2019, p. 200) found that the quality of managers also contributed to the amount of higher order capabilities present in the organization, stating that managers can influence the company (and the broader world) beyond mere random variation.

The importance of decisive leadership for DS is expected to rise with the evolving nature of digital solutions which intensifies technological, organizational, and managerial complexity (Paiola & Gebauer, 2020). The more advanced digital solutions become, the more numerous the intrafirm and interfirm interdependencies (Sklyar *et al.*, 2019). In our case, despite limited prior capabilities relating to sales and delivery of services, product-oriented Mectop managed to transition more smoothly than the experienced and service-oriented Apitec. Apitec aimed for a comprehensive solution which integrated deeply into customers' production processes. Mectop developed a stand-alone solution which did not enter its clients' systems. Additionally, Mectop managed its DS more proactively.

For managers to effectively reconfigure organizational resources in response to DS barriers, accurate perception of the situation is key (Vanrullen & Thorpe, 2001). This necessitates understanding of all the crucial elements involved. The multilevel framework, though inexhaustive, can help raise awareness for 'blind spots'. Literature states that especially the importance of microlevel processes is often underestimated and insufficiently considered by practitioners and managerial researchers upon the investigation of strategic change (Hodgkinson & Healey, 2014). Our cases confirmed this. With this framework, we aim to inspire future research to increasingly pay attention to microlevel processes on the one hand, and the interdependencies across different levels of the multilevel framework on the other.

7. Conclusion

The goal of this article was to gain insight into why companies continuously struggle with their DS despite extensive knowledge on hurdles and approaches to overcome them. A multilevel framework was developed to structure the

investigation. From its application, a mid-range theory emerged which challenges the often-implicit assumptions about DS barriers being independent, clearly discernible, and definable issues to which explicit, definite answers exist.

Results show that companies implementing DS are faced with a wicked problem consisting of interconnected DS barriers that span across different levels of analysis, i.e., the network, organizational and microfoundational level. Responses to misalignment at one level inevitably impact the functioning of other levels which might lead to the generation of new blockades. Likewise, internal and external misalignments can arise from unawareness of existing tensions and the ensuing unresponsiveness of management. Frictions materialized in frustrations experienced by internal and external stakeholders, organizational inertia, and ineffectiveness spill over into the next step of the DS journey. This increases complexity. A higher order capability of managing the interconnectedness within and between levels, and across different steps of DS seems necessary for strategy effectiveness. Rather than treating DS barriers as isolatable challenges and dealing with them in a linear manner, companies would do well to evaluate them iteratively whilst considering their multilevel nature. By increasingly shifting gears quickly between observing, analysing, and responding, companies may smoothen their DS. Researchers are invited to test the developed mid-range theory and propositions to generate increased understanding of its applicability in different settings and further unravel DS complexity.

With this study, several theoretical contributions were made. First, we answer the call from Rabetino *et al.* (2018) for mid-range theories that address the organizational change aspect of servitization. Second, by recognizing DS as a wicked problem, we open a new avenue for future research in which the interconnectedness between and within DS barriers is explicitly recognized. Researchers are encouraged to further investigate what and who could contribute to shaping the proposed higher order capability. Additional inspiration regarding coping strategies may be found in wicked problem literature. Third, our study fits the DS research agenda drawn up by Paschou *et al.* (2020, p. 288) who pointed out the need for a more systemic and holistic approach to DS and models and frameworks that support decision-making. We developed and empirically tested a comprehensive multilevel framework which extends beyond the evaluation of traditional dyadic relationships and can be applied by DS practitioners and researchers alike. Finally, our comparative case study provides empirical data on the essential role affective processes play in strategy development and execution. By illustrating the impact perceptions and emotions have on strategic change, we

aim to inspire continuing research into this underdeveloped area (Hodgkinson & Healey, 2014).

Benefits are also available to DS practitioners wishing to use the multilevel framework. First, the framework can boost practitioner's awareness of the multilevel nature of their DS and its building blocks requiring attention. This might encourage continuous monitoring of essential elements which in turn facilitates timely and proper managerial perception of DS barriers. Secondly, the framework supports the proactive development of potential organizational responses and their multilevel impact evaluation. Finally, by deconstructing complexity of the DS journey and presenting the challenge in a neutral, overarching frame, the model might enhance communication among DS's diverse partners, accelerating the realization of a shared understanding and interfirm alignment. Hence, we believe the framework might be a first step to supporting manufacturers in the development of their higher order capability for managing multilevel DS interdependencies.

Despite significant contributions made, our research has its limitations. Data was gathered at the individual level in a mainly retrospective manner. This implies a risk for bias through misremembrance of facts and selective forgetting (Lind *et al.*, 2017). To counter this, we took a multi-actor approach and verified insights in consecutive interviews. Nevertheless, future research could benefit from a mixed methods approach (Molina-Azorín *et al.*, 2019). Additionally, researchers are encouraged to apply the multilevel framework to several settings in which both the context (environment) and the content (DS strategy) differ. This could help to validate our insights and uncover additional DS complexity. For example, in the Mectop case, Italy's national policy was found to have a strong positive impact on customer's willingness to embark on digitization. This facilitated Mectop's DS. Belgian customers, however, did not benefit from financial incentives aimed at Industry 4.0 projects. Though we assume that the role of (supra)national financial injections can smoothen DS strategies, no certain claims can be made based on this limited contextual data. Future research might investigate the role (supra)national initiatives play in the success of DS strategies. Finally, given leadership's important role for DS, research which dives deeper into leadership styles, characteristics and attributes which underwrite commitment and consonance among managers could be beneficial to furthering the field.

[1] Information structures and mental maps. Gary, M.S. and Wood, R.E. (2011), "Mental models, decision rules, and performance heterogeneity", Strategic management journal, Vol. 32, pp. 569-594.

[2,3] To ensure confidentiality the names of both companies, their partners as well as specific technologies and software programs have been changed. Some numbers and dates were altered for privacy reasons. Alterations in the display of the data, however, did not affect the interpretation of the data.

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Chapter IV - Intra and interorganizational tensions of a Digital Servitization Strategy. Evidence from the mechatronic sector in Italy*

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Abstract

This chapter analyses the Digital Servitization (DS) process with the paradox theory lens. The purpose is to catch how intra and interorganizational tensions generate complexity along a DS journey in order to find out 'where' and 'when' industrial companies can intervene to face them. The methodological approach is qualitative and consists in an in-depth single case study, which longitudinally explores the DS strategy of a manufacturer along three phases of development: design, implementation, and assessment. The analysis reveals six intra and interorganizational tensions in DS and provides insights on tensions' origin and how to face them. A theoretical framework on DS complexity and an empirical framework on tensions' origin are produced. An original perspective is provided within this chapter: it combines service and organizational paradox literature. Together with a longitudinal methodology, it results into a spatial and temporal analysis of DS, from which theoretical and managerial implications are drawn.

Keywords – Digital Servitization, Paradox Theory, Tensions, B2B, Complexity

1. Introduction

The Business to Business (B2B) context is experiencing a business model revolution towards the Digital Servitization Strategy (DSS). B2B firms are massively engaged in Digital Servitization (DS) shifting. The 60% of industrial companies that already undergone a digital transformation created new business models. In 10 years, 30% of revenues will come from digital projects, half of them involving new 'outcomes/solutions' (Morgan, 2019; Wellener *et al.*, 2020).

A DSS generates complexity for industrial firms. Challenges are identified at the intra and interorganizational level (Tronvoll *et al.*, 2020). Industrial companies chasing a DSS rethink the intraorganizational dynamics, adapt knowledge and capabilities, structure leadership and hierarchy. At the same time, they review the interorganizational processes and reinforce network relationships by accessing service ecosystems, adjusting interdependencies in the supply chain, and intensifying relationships with customers (Bustinza *et al.*, 2018; Ruiz-Alba *et al.*, 2019).

Intra and interorganizational impacts of a DSS can foster the development of paradoxical tensions (Vendrell-Herrero *et al.*, 2017; Harini and Thomas, 2020). Tensions as ambidexterity/ambivalence, territoriality, or the risk of service paradox result from servitizing activities (Lenka *et al.*, 2018; Wagstaff *et al.*, 2021; Gebauer *et al.*, 2005). The paradox theory can help in capturing the complexity involved in business strategies, and it has recently been adopted to describe servitization dynamics (Kohtamäki *et al.*, 2020; Wagstaff *et al.*, 2021; Burton *et al.*, 2016).

Notwithstanding the growing interest towards a paradox perspective on servitization, few studies address it in the context of DS (Kohtamäki *et al.*, 2020; Altmann & Linder, 2019). The digital component of servitizing strategies needs further analysis, since it has been acknowledged as facilitating or hindering some processes that require new skills and changes within the network actors (Matthyssens, 2019; Salo *et al.*, 2021).

Notably, the opportunity to further investigate DSS through a paradoxical perspective is twofold. It allows to fill a gap in academic DS studies, and it provides a concrete tool to facilitate DS implementation by managers. Understanding the nature of intra and interorganizational tensions of a DSS and their implications constitutes critical sparks for firms investing in it. A paradox theory approach can provide managers with in-depth knowledge of DS challenges and possible ways to address them effectively and reach better performances.

For such reasons, this paper investigates how manufacturing firms face their transitioning towards a DSS, adopting the paradox theory lens to gain insights on intra and interorganizational tensions. Notably, the paper aims to answer the following research questions (RQs):

RQ1 – How does the emergence of intra and interorganizational tensions generate complexity along a DSS?

RQ2 – Where and when can manufacturing companies intervene to dissolve such complexity?

By answering the RQs, the paper contributes to building new knowledge on DS. Notably, the paper adds insights about the role of intra and interorganizational circumstances in increasing the complexity of the DS journey. In this respect, tensions and new challenges for companies aiming at developing a DSS emerge with respect to previous literature. Important managerial implications are drawn; remarkably, strategic approaches to DS are provided at every stage of the DSS. In general terms, findings reveal the relevance of analysing DS taking a holistic overview on its tensions and of adopting an 'iterative approach' in developing solutions.

The remainder of the paper is organized as follows. Section two addresses the literature background and introduces a theoretical framework to disentangle DS complexity. The third section concerns the applied methodology. Section four introduces the case study and the main findings of the research. The fifth section presents the critical discussions of results. Section six provides concluding remarks, managerial implications of the study, limitations, and future research suggestions.

2. Literature review

2.1 A paradox theory approach to services

Paradoxes are *contradictory yet interrelated elements (dualities) that exist simultaneously and persist over time; such elements seem logical when considered in isolation, but irrational, inconsistent, and absurd when juxtaposed* (Smith & Lewis, 2011, p. 387). In case of a paradox, every choice seems inappropriate.

Paradoxes appear in various contexts and phenomena; this study focuses on paradoxes emerging from managerial actions. The higher expectations of

markets, the increased number and variety of stakeholders, and the quick pace of change of the business environment are pushing B2B companies toward new managerial paradoxes, especially in case of scarce resources and intense competition (Heidrick & Struggles, 2015).

Paradoxical literature in management mainly focused on the organizational level of analysis, trying to conceptualize managerial issues as paradoxes or organizational tensions (Putnam *et al.*, 2016; Smith & Lewis, 2011). In these studies, a variety of levels has been explored, such as tensions in human resource management, leadership, identity, creativity, teams, gender and diversity, sustainability, or innovation (Waldman *et al.*, 2019).

In the service field, paradoxes have been identified in relation to servitization strategies, which imply a service-oriented business model for manufacturers (Baines & Lightfoot, 2013). At the intraorganizational level, examples of paradoxes are the 'service paradox' (Gebauer *et al.*, 2005), which is the risk of having servitization expenditures higher than returns, or the organizational ambivalence between product and service orientation (Lenka *et al.*, 2018; Ashforth *et al.*, 2014). Taking the interorganizational layer, Burton *et al.* (2016) found empirical evidence for tensions in the service network, since servitizing firms try to appropriate value from other actors. The unpredictability deriving from servitization generates tensions in collaborating with external actors, sharing knowledge assets, balancing between proactivity and adaptation, managing different commitment levels and territorial behaviours (Colm *et al.*, 2020; Wagstaff *et al.*, 2021). Kohtamäki *et al.* (2020) identify paradoxes connected to customization levels and engineering efficiency, service organizational structure, and innovation.

2.2 Digital Servitization Strategies

The digital wave experienced from 2013 on, renamed as Industry 4.0 revolution, involves manufacturers towards DSS (Coreynen *et al.*, 2017). Unlike servitization strategies, DSS exploit digitalization to introduce advanced, technology-based services (Bustinza *et al.*, 2018). A DSS implies a complex change for industrial firms, where a product-centric business model is redesigned through a digital service-centric approach (Tronvoll *et al.*, 2020). Manufacturers investing in DSS focus on digitalized customers solutions, with the aim of achieving higher returns and enlarging their customers portfolio (Matthyssens & Vandenbempt, 2008).

Notwithstanding the opportunities a DSS can offer for industrial firms, it implies difficulties (Martìn-Peña *et al.*, 2019; Paiola & Gebauer, 2020; Coreynen *et al.*, 2017). From nearly 2010 on, literature about DS deeply explores such problems referring to intra and interorganizational challenges (Sjödin *et al.*, 2019; Frank *et al.*, 2019).

Intraorganizational implications of DS are challenges in the managerial, internal organization (Bustinza *et al.*, 2018); difficulties are identified in acquiring knowledge and capabilities to face a DSS, achieving convergence between digital and service innovation trajectories as well as between the product and the service orientation, aligning the value system position and the sales model to the DSS (Bustinza *et al.*, 2018; Hasselblatt *et al.*, 2018; Frank *et al.*, 2019; Lenka *et al.*, 2018; Paiola & Gebauer, 2020).

DS also impacts the relationship with customers, suppliers, and other stakeholders; the interorganizational level of analysis assumes high relevance (Vargo & Lusch, 2011; Vendrell-Herrero *et al.*, 2017). Interorganizational challenges of a DSS include difficulties in managing relationships with old and new actors, elaborating value co-creation processes with customers, distinguishing customers interested in advanced services to invest financial and technological resources (Sjödin *et al.*, 2020; Reim *et al.*, 2018; Grandinetti *et al.*, 2020).

The combined analysis of the intra and interorganizational dynamics of a DSS is required to catch the complexity of the phenomenon. As argued by Coreynen *et al.* (2017), a DSS is made of two organizational perspectives: the back-end perspective, involving operational efficiency, availability of resources and decision-making processes, and the front-end, about interactions with customers and network integration.

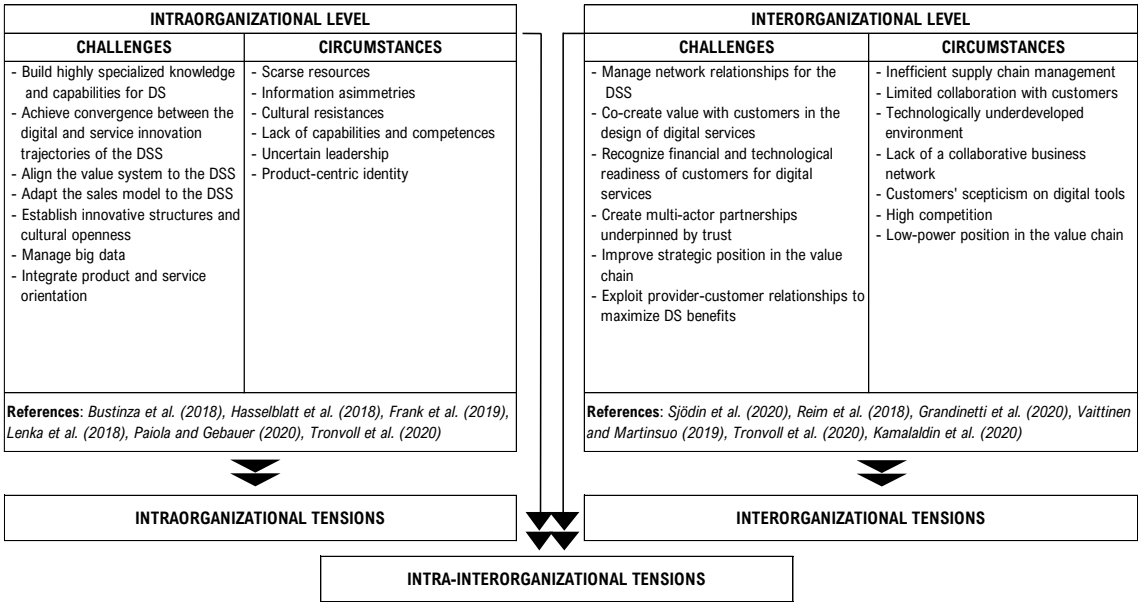
Paradoxes in DS have not been fully investigated yet, even though authors address the issue (Kohtamäki *et al.*, 2020). In our perspective, analysing DSS through the paradox theory lens offers a deeper knowledge of DS complexity, since the digital dimension can intricate the servitization journey in presence of specific external and internal conditions. This study aims at providing a theoretical model for the interpretation of tensions in DSS, which is introduced in the following section.

2.3 A theoretical framework for DS tensions

DS is a complex journey, made of continuous challenges and timely choices with impacts at the intra and interorganizational level (Struyf *et al.*, 2021). At the same time, paradoxes in management research need a multilevel analysis to be fully exploited (Waldman *et al.*, 2019). Therefore, the proposed theoretical framework (Figure 1) for the investigation of DSS tensions is structured around a double level of analysis, intra and interorganizational, to provide a complete understanding of the phenomenon.

The framework combines intra and interorganizational challenges imposed by DS with firm-specific circumstances: such elements together potentially give rise to tensions. It is based on the idea that the complexity of the servitizing process is increased by the presence of double-level challenges and circumstances, which foster the creation of tensions along the entire strategy development. For instance, integrating product and service orientations (challenge) could generate organizational tensions about the leadership model and hierarchical structure needed to limit resistances, especially in case of a strong product-centric identity (circumstance).

Figure 1. *Theoretical framework for DSS tensions*



To verify the validity of the framework the paper adopts an original perspective. The study is based on the in-depth analysis of a firm involved in a DSS. The entire project is built around the IIoT (Industrial Internet of Things) technology and its multifaceted applications. The adopted longitudinal

perspective highlights time- and space-related elements of the DSS, while a dual perspective, intra and interorganizational, completes the investigation of the phenomenon.

3. Research methodology

3.1 Research design

The applied method is a longitudinal, in-depth single case study, with an abductive approach for information coding and results elaboration (Dubois & Gadde, 2002). A single case study is relevant to build knowledge on under-investigated phenomena and get the complexity levels involved in the inquired relationships (Halinen & Törnroos, 2005). The chosen methodology depends on the contemporary events and the 'how' nature of the RQs. It is justified by the need to explore concepts, evaluate the role of context and history, and achieve a greater level of detail of the phenomenon (Yin, 2009; Meyer, 2001; Lindgreen *et al.*, 2021).

The case firm, Alpha, is a mechatronic manufacturer located in Italy. In 2016, the company invested in a five-year project of DS by implementing a IIoT-based platform called *Aura*. The project will be completed in one year, and it is developed in partnership with the consultancy agency Innoconsulting [1].

Specific criteria explain the choice of the company: *i)* the firm operates in a B2B context, *ii)* it is involved in a DSS – the ongoing status of the strategy helps having accurate data, since respondents' information are not influenced by unperfected memories (Lindgreen *et al.*, 2021), *iii)* the company extends the DSS to an international reference market. Given the research purpose, a sample '*theoretical and purposeful [...] and guided by saturation*' is relevant (Gummesson, 2003:488): Alpha is a successful digital servitizing firm and other cases are likely to add similar information.

The empirical research has been guided by literature. The DSS theoretical framework is the starting point to design data collection and analysis. Data has been continuously compared with information collected in literature to evaluate the validity of the framework.

3.2 Data collection

The firm has been observed for five years. The active observation happened from January 2019 until December 2020, while preceding years have been observed retrospectively. Data collection relies on two sources: participant observations and semi-structured interviews. Participant observations amount to 193,5 hours in the timeframe January 2019 – December 2020, distributed between 77 activities (see Appendix, Table II for details). They include different activities involving the service function: meetings, presentations, conferences, and others, mirroring in percentages their totality. Since observations were causal in nature, no formal protocol has been elaborated (Yin, 2009); the collected field notes were consulted and confronted with interviews' transcriptions.

After the first year of participant observation, interviews started to integrate data collected through the observations, triangulate information, reduce biases and validate findings (Jonsen & Jehn, 2009). Interviews were semi-structured, to guide the direction of the discussed topics. An interview protocol was designed (see Appendix, Table III for details) to collect focused data, standardize the interview approach, and maintain flexibility (Hunter, 2012). The protocol is based on literature insights and on the RQs of the study. It revealed purposeful to identify respondents, retrace the DSS, and recognize intra and interorganizational tensions. The protocol involves three thematic sets of questions: about the respondents, about the service area and the DSS, and about the implications of the DSS. Similar questions were raised to all respondents, even though adapted for specific roles. Respondents were provided with total freedom to answer questions and no direct connection to paradoxes or tensions was prompted, to avoid 'biased researcher's opinion' (Thirsk & Clark, 2017).

Interviews were conducted in the timeframe October 2019 – August 2020. Interviewees are significant persons in the DSS: they directly contributed to the deployment of the strategy and participated (nearly) from its beginning. They are more representative figures in the DS journey than the average (Yin, 2009). Table I shows interviews details.

To delineate the case context and implications, secondary sources have been used: the company website – and the website of other actors involved in the project - sectorial magazines/editorials, press briefings and corporate reports. Results are described in temporal order, highlighting the timeline in which the tensions emerged to guarantee clarity (Sandelowski, 1999).

***Table I**. Interviews data*

Respondent's Information	Date	Duration (min)	Main Research Topic	Transcription (# of Pages)[a]
Service Innovation Director - Alpha Group *Working in Alpha Group since 2017 (4 years)*	29/10/2019	45	Relevance of services and new investments	5
CEO Assistant for Innovation - Alpha Group *Working in Alpha Group since 2012 (9 years)*	08/11/2019	50	Impacts of Service innovation process	5
Senior Project Manager - Innoconsulting *Collaborating with Alpha Group since 2016 (5 years)*	14/11/2019	50	Idea, design, and development of *Aura*	7
Aura Ambassador - Alpha Group *Working in Alpha Group since 2019 (2 years)*	22/11/2019	40	Management of *Aura* renewal and contact with customers	4
Aura Project Manager - Alpha Group *Working in Alpha Group since 2018 (3 years)*	25/11/2019	55	Issues and criticalities in the development of *Aura*	4
Marketing Official - Alpha Group *Working in Alpha Group since 2007 (14 years)*	10/12/2019	45	Communication of *Aura*	4
CEO Assistant for Innovation - Alpha Group *Working in Alpha Group since 2012 (9 years)*	31/07/2020	40	Organizational issues in Service innovation	3
Maintenance Manager - Alpha Group's Customer *Collaborating with Alpha Group since 2017 (4 years)*	05/08/2020	40	Customer perspective about *Aura*	3

[a] ***Single space, Times New Roman, 12.***

3.3 Data analysis

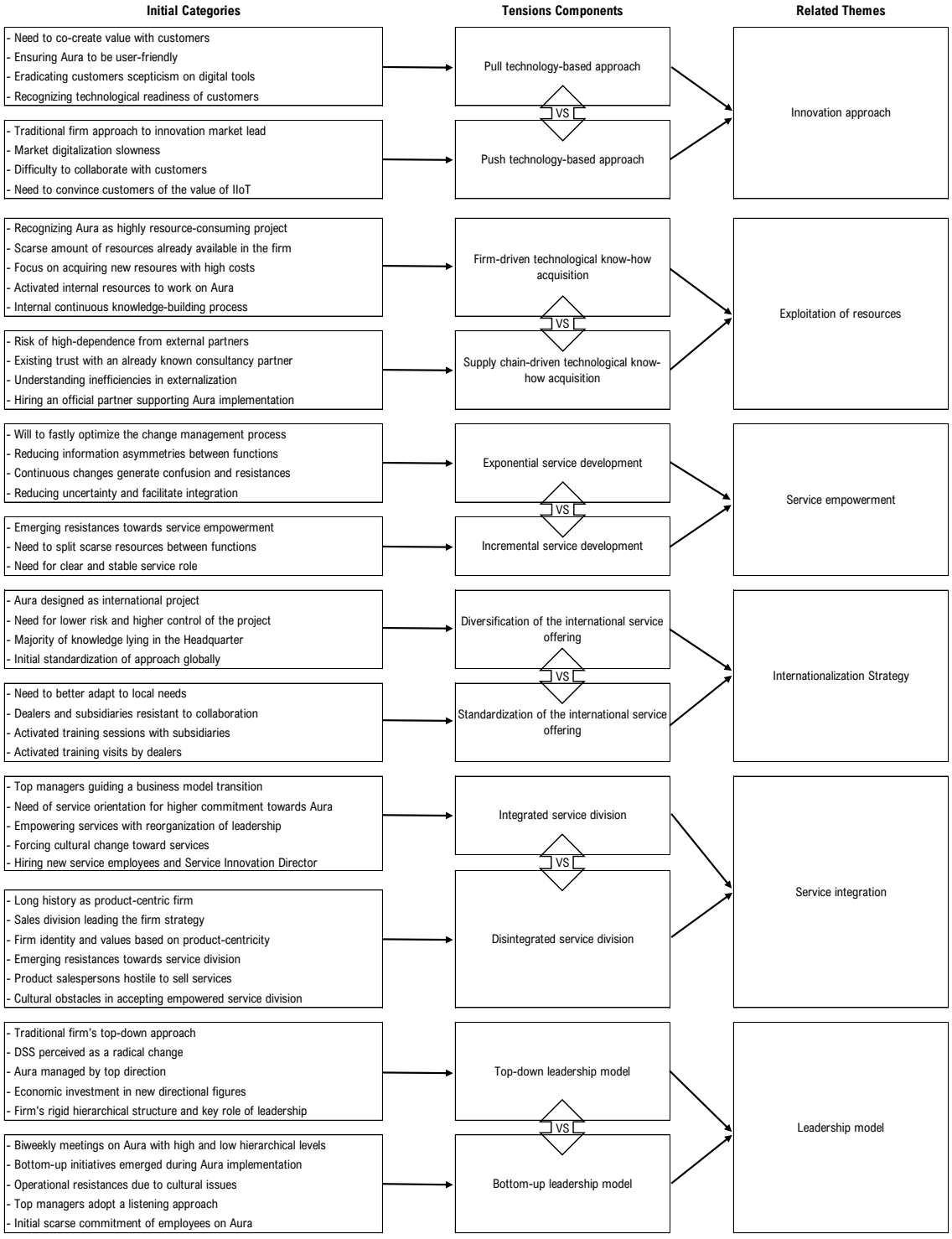
To answer the RQs, the DS process was retraced iteratively. Findings are the outcome of a continuous interrelation and triangulation between the perspectives captured through interviews, observations, and secondary sources (Denzin, 1978). Going back and forth between the analysed literature and case findings provides a complete view on the DS and its context to build theoretical considerations (Dubois & Gadde, 2002).

Data analysis followed the theoretical framework: information was explored to identify DS challenges and intrinsic circumstances intriguing the DS path of Alpha. Attention was thus posed to distinguish the nature of challenges and circumstances, if intra or interorganizational (see figure 1). In doing this, a coding process (figure 2) was activated to structure data, elaborate the case tensions, and identify their origins.

The first coding step was creating categories from data collected through participant observation notes. Categories were assigned labels in the form of short sentences, using as much as possible the lexicon adopted by the informants. Duplicates were removed; the resulting 53 categories include challenges and circumstances of the firm DSS. Afterwards, categories were condensed into 12 tensions components. Finally, 6 themes were identified that aggregate the tensions components. Every theme represents a tension, and every tension

component stands for its two alternative options. No software was needed to code information given the simplified data structure typical of single case studies (Lindgreen *et al.*, 2021). This coding procedure allowed to detect intra and interorganizational connections and the emergence of tensions causing increasing complexity in DS, in line with the adopted theoretical approach.

Figure 2. *Coding Scheme*



4. Findings

Alpha is a B2B company specialized in the production of industrial wood-working machineries in the furniture sector. Being a family run company, Alpha experienced a considerable growth. Today it operates worldwide with nearly 4,000 employees and its revenues amounted to over 900 million euros in 2020.

In 2016, Alpha invested in a DSS by implementing sensors to the produced machineries, which monitor their activities by customers and generate real-time information. The IIoT project is called *Aura*, which indicates Alpha's service platform launched in collaboration with the consultancy partner Innoconsulting. *Aura* provides services as KPI indication, preventive maintenance and error notifications, video remote assistance, maintenance calendar or contracts purchase.

The DSS of Alpha happened by three temporal phases: project design, implementation, and assessment. The design stage involved shaping the DS idea and defining its technical features; the implementation stage was about technical and organizational developments at the international level; the assessment stage concerned adjustments on the platform and the development of additional features. The latter is not concluded yet.

4.1 Project Design

At the beginning of 2016, Alpha decided to invest in a DSS. It aimed at responding to market dynamism and gain competitive advantage by a first-mover strategy. To accomplish such aim, recognizing financial and technological readiness of customers for digital services was as relevant as complex. Relevance concerned establishing the type of technology to make *Aura* valuable and user-friendly. Complexity was generated by the company's limited experience in co-creating value with customers and the digitalization slowness of many of them. Such situation triggered a tension:

T1: Pull vs Push technology-based innovation

A cooperative, pull innovation fosters the adoption of technologies which are familiar and of value for customers, while answering the collaborative call of DS. A push technology-based approach, instead, embraces the core innovative modus operandi of Alpha, with apparent reduced complicacy.

The need to engage customers collided with Alpha's approach, characterized by innovation market lead, with limited customer involvement. The firm adopted a push technology-based approach to innovation:

> *Customers were not essential in deciding if to invest in digital servitization… they were totally in the dark about IIoT technologies and their potential…maybe a few big customers were starting to consider new technologies, but nothing more… [CEO Assistant for Innovation – Alpha]*

They implemented a DSS based on the IIoT technology for the supply of Product-Service Systems solutions via computer, smartphone, and tablet applications.

Once the technology was established, its implementation required the planning of resources, competences, and actors. The choice of developing the technology internally rather than turning to external suppliers ended up being a tension:

T2: Firm-driven vs Supply chain-driven technological know-how acquisition

Alpha's challenge was achieving IIoT-specialized capabilities, as the ability to exploit big data, to protect the DS competitive advantage:

> *A DS barrier for us is the development of competences to analyse big data coming from machines and manage them through dedicated functions… [Service Innovation Director – Alpha]*

Specialized DS knowledge available inside the firm was limited, as well as human resources to commit to *Aura*. The necessity to cooperate along the supply chain emerged:

> *Most part of the required competences to implement the project were to be found on the outside…Alpha needed to work on the integration of new competences through innovation along the supply chain to guarantee the technological advancements of the entire industry [Service Innovation Director – Alpha].*

Frictions arose between top managers; they recognized a lack of resources in their teams but manifested some hesitancy in relying on external actors. The involvement of an external supplier meant directly accessing qualified competences, but also reducing process control and limiting the development of internal knowledge. Moreover, Alpha was operating in a highly competitive market, where multi-actor partnerships were not excited and collaborative approaches inhibited. Nevertheless, preceding collaborations with the

consultancy agency Innoconsulting made it a trusted supplier. This relationship facilitated the solution of the tension: Alpha nominated Innoconsulting official partner for *Aura*:

> *We had no doubt that a company of that size and capacity [Innoconsulting] would have accompanied us not only in the technical part, but in the business and change management…and so it was [CEO Assistant for Innovation – Alpha].*

The participation of Innoconsulting in the project revealed of paramount importance. However, Alpha engaged resources and spread knowledge capital between managers and employees inside the firm to reduce the risk of dependence from its partner.

4.2 Project Implementation

In July 2016, a pilot session of *Aura* was performed; positive results pushed *Aura* implementation. For *Aura* to be launched in the market, a reorganization of Alpha's service function was required. The function was not structured enough to lead the DSS independently. The top management should decide whether to invest in the fast growth of the service function or to draw resources from other divisions and expand the service function gradually. This choice transmuted into a tension:

T3: Exponential vs Incremental service development

The firm strived for equal distribution of power between divisions and consequent service empowerment, with the optimized control of the change management process:

> *What we tried to do was creating a new business model more oriented towards services, but in harmony with the firm identity [Aura Project Manager – Alpha].*

The limited willingness of resources called for an incremental service development. It gives employees time to adapt to the revisited organizational structure. At the same time, a swift service growth should facilitate the DSS implementation, thanks to the application of stable roles and clear responsibilities.

The firm opted for an incremental service empowerment. Unexpectedly, resistances emerged due to the continuous changes and adaptations of the service strategy. The slow, unsure extension of functionalities, professional figures, tools,

and procedures in service, generated confusion and resistances, revealing information asymmetries between functions.

In November 2016, *Aura* was delivered to customers in Italy. In nearly one year, it was distributed also worldwide through the group's network: subsidiaries and dealers. During *Aura* internationalization, technological advancements were settled and the international digital service offering designed. A new tension emerged:

T4: Diversification vs Standardization of the international service offering

Alpha's challenge was to provide customers with a flexible service offering adaptable to local needs. Therefore, diversification was suitable. Some circumstances obstructed its realization. Limited resources, information asymmetries, subsidiaries and dealers' lack of DS knowledge entailed a standardized approach. Contextually, Italian customers showed hesitant responses to the service offering. Alpha missed the ability to collaborate with customers and eradicate scepticism on digital tools.

The first solution to T4 was standardization. The headquarter centralized decisions: it arranged tools and infrastructures, communication plans and the go-to-market strategies for every country. In 2019, issues with subsidiaries and dealers started. Subsidiaries perceived a lack of DS competences, while dealers interpreted *Aura* as a threat of channel cannibalization. Moreover, *Aura* faltering performances internationally revealed customers' apathy about digital services:

> *Many customers, especially the small ones, do not catch the potential of Aura and the advantages that it can bring in the long term…they perceive new services just as a cost… [Aura Ambassador – Alpha].*

Top managers were pushed toward a reconsideration of their choices. Flexibility to subsidiaries was enhanced by the design of local service packages and contracts. Local visits and training sessions with subsidiaries and dealers improved the collaboration:

> *We need to achieve a higher level of flexibility for subsidiaries…we will intensify training sessions and transfer knowledge about Aura on subsidiaries… [Foreign Branch Manager – Alpha].*

4.3 Project Assessment

From 2019 on, Alpha managed *Aura* assessment. The firm promoted initiatives trying to solve issues raised by T3 and T4. Internal communication actions about *Aura* were implemented. A new organizational figure was introduced with the role of connector between sales, service, and IT. Internal workgroups were established to facilitate cross collaboration between sales, marketing, and service. Ad-hoc rewards were introduced for service salespersons based on selling indicators. Marketing campaigns stimulated *Aura* discovery towards customers.

Concurrently, a tension emerged about the relation between service and other functions:

T5: Integrated vs Disintegrated service function

Top management longed for the integration of the service function within the organization to stimulate efficiency and inter-functional synergies, especially on the commercial side. Vision, objectives, and resources alignment between functions helps reaching customer engagement in the aftersales and before. Nevertheless, service integration is risky since it partially destroys the group's values, residing in machines offering and product-centricity.

Top management strived for service integration. It helps reaching a less product-oriented mindset, innovate the hierarchical structure, and establish cultural openness in terms of (digital) services. Cultural resistances in the commercial area contrasted this vision:

> *The fact that Aura is an intangible product means that the commercial network did not see its saleability…commercials are used to seeing, talking about, and selling just physical assets… this is a completely different business model [Aura Project Manager – Alpha].*

Resistances in the product function, which concentrated power and strategic relevance, extended to other functions. However, top management forced service integration, as underlined by the Service Innovation Director:

> *…we work on the transversality of service as a value through business processes, integrating change into everyday life…*

Enhanced collaboration with customers and a deep customers' analysis incited service integration: reduced market's scepticism and improved *Aura* performances let the service function gain credibility. Integration efforts are not concluded yet:

At a strategic level, Alpha does not intend to retreat in the development of the platform [...] we are experiencing an alignment of the platform with its competitors and a slow conversion of customers towards digital services...the effort we must make today for the healthy development of the project is to integrate Aura with the other solutions of the company [Service Innovation Director - Alpha]

The role of top management was crucial in the assessment phase of *Aura*. However, internal conditions changed throughout the project: new directors arrived, an *Aura* department with new employees was created, digital services were offered and sold. A revision of the hierarchical and leadership structure became essential, shedding light on an additional tension:

T6: Top-town vs Bottom-up leadership model

At this point of *Aura* fulfilment, the organizational layout of Alpha was still quite rigid and related to an inflexible mindset. The product-centric identity of the firm was present, as well as a hierarchical framework:

The organizational management of the platform is led at a high level by a formalized change management procedure... [Service Innovation Director – Alpha].

The group could endure with the top-down approach to DS or converge toward a bottom-up model with strengthened responsibilities toward lowest hierarchical levels.

Alpha's solution resided in a hybrid approach. Since its beginning, *Aura* was supervised by the top management. With time, employees struggling to modify routines and to catch the value of the DSS pushed the top direction towards a listening approach. A mix of top-down leadership and bottom-up initiatives was activated. The DSS was supported by a formalized change management approach, while commitment was stimulated. A series of bottom-up initiatives were provided:

Different initiatives started [...] For example, we created an internal competition [...], because we wanted people to be stimulated and involved with Aura...everyone could share their Aura implementation proposals...the best proposal won and was actually implemented [Marketing Official - Alpha].

Between hybrid initiatives, the biweekly meeting with managers and employees to check the *Aura* status. Directors and employees share progress, doubts and difficulties and collaborate to solve issues. Innoconsulting is responsible for moderating the meetings. Its constant presence along the project

significantly helps Alpha in overcoming DS barriers and improving the implementation of *Aura*.

5. Discussions

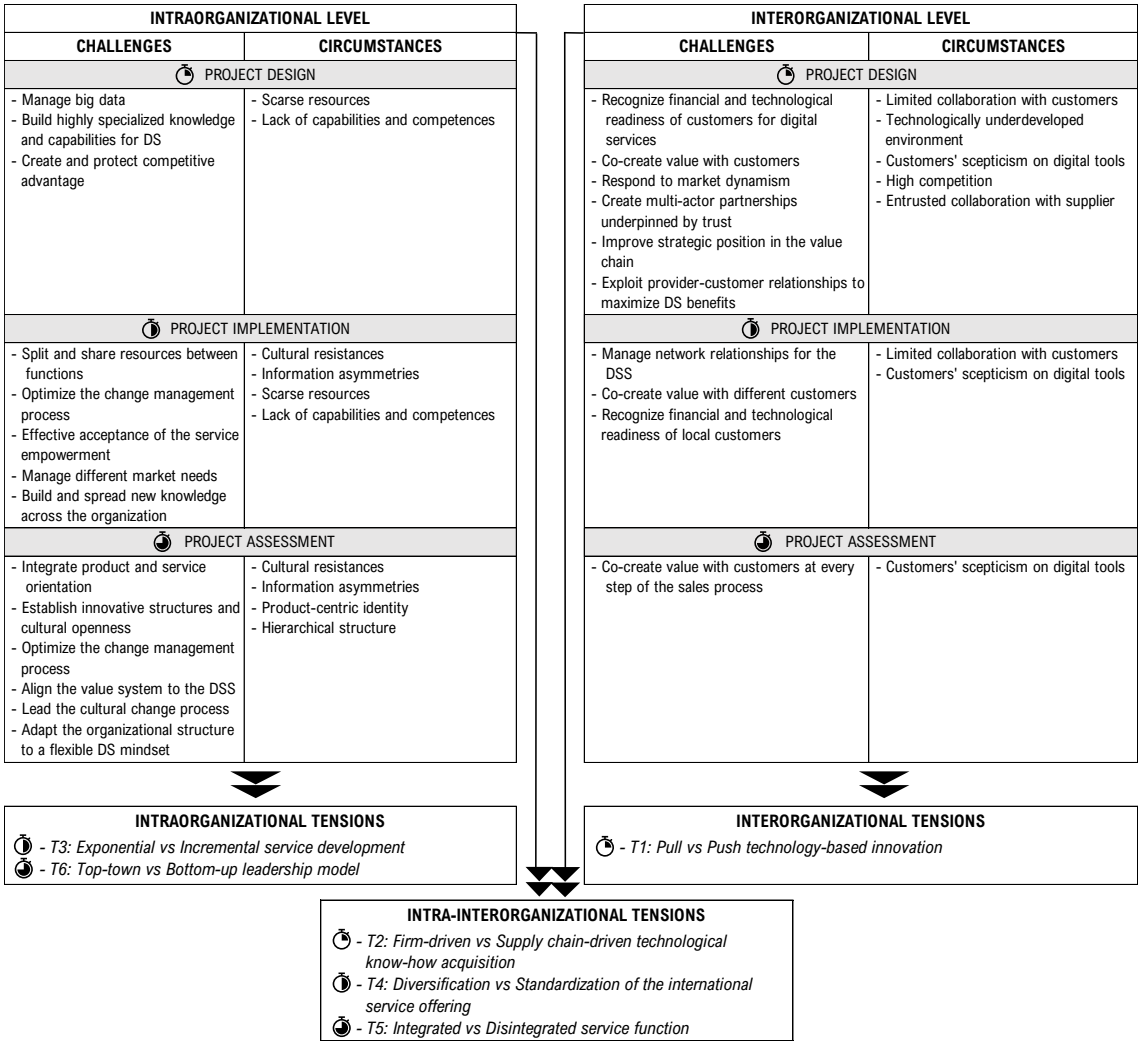
Existing literature on DS explores its intra and interorganizational challenges in depth, adopting fragmented approaches (Sjödin *et al.*, 2019; Frank *et al.*, 2019). Nevertheless, the reasons behind DS complexity for manufacturers are still unclear. This study approaches DS with an original perspective, adopting the paradox theory lens (Smith & Lewis, 2011) to explore DS tensions at the intra and interorganizational level.

The study provides a theoretical model which explains the origin of complexity in DSS as the result of combined intra-interorganizational challenges and circumstances. The empirical analysis of Alpha highlights the emergence of six paradoxical tensions. Every tension is triggered by the collision between the firm's DS challenges and the arbitrary circumstances in which it operates. Starting from the conceptualization of the DS phenomenon and the empirical investigation of Alpha, an empirical framework figure is provided (figure 3).

The empirical framework depicts the tensions experienced by Alpha, which in turn validate concepts and structure of the theoretical framework. Compared to it, the empirical framework includes an additional dimension to space: time. Every tension comes from a specific temporal phase and organizational level: T1 and T2 emerged in the design phase; T3 and T4 belong to the implementation phase; T5 and T6 to the assessment phase. T1 is the only tension that originated purely at the interorganizational level. Conversely, T3 and T6 arose as intraorganizational. T2, T4, and T5 are simultaneously intra and interorganizational in nature since challenges and circumstances that determined them can be found at both levels.

Thanks to the time- and space-related focus of the framework, it is possible to observe elements of complexity in the DS path of Alpha. Findings reveal how one element of complexity resides in the multilevel component of tensions and in the presence of 'hybrid' tensions. DS complexity arises from the combination of multiple, interrelated elements. Not only DSS is embedded in a multi-level perspective, which involves network, organizational, and microfoundational levels (Struyf *et al.*, 2021). Also, at every level paradoxes arise from the strategy, with implications that mix and switch between them.

Figure 3. *Empirical framework*



Another element of complexity is the multiplicity of tensions appearing across time. In Alpha, tensions originating at one level in one phase intertwined with other levels and phases. Firms must deal with DS while preserving their business-as-usual; the significant and increasing number of DS challenges adds to the firm's daily hurdles. Moreover, results show how inefficient choices in the first phases of the DSS enhance the risk of tensions accumulation over time: an action can be effective to solve one tension while it triggers inefficiency for others. Being DS a journey, time is crucial in leading the organizational change (Mento *et al.*, 2002). If not properly managed, the risk of accumulating tensions increases.

The case study analysis confirms the relevance of the context for the success of DS; coordination is required among strategy, environment, and organization (Feng *et al.*, 2021). In addition, it underlines the importance of monitoring

organizational changes caused by DS as a univocal process. In Alpha, intertwined tensions result from the lack of a holistic overview on all tensions. Missing the big picture on DS tensions leads to the development of individual solutions, effective for one tension but ineffective for others. This is what happened in T1, where the reduced customer orientation implied difficulties in conveying value to the market (T4), which on its turn led to internal resistances due to uncertain *Aura* performances (T5). Similarly, the acquisition of external know-how solved T2; however, it reflected into resistances and scarce collaboration of employees, especially in the sales function, while solving T3. Imposing the service growth worked as a solution to T3, but it created internal frictions still visible when T6 emerged.

Summarizing the path of Alpha, relevant considerations can be drawn in terms of actions to limit DS complexity. Alpha adopted an iterative approach with the continuous revaluation of choices, which demonstrated effective. Each implemented action reduced part of the complexity; interventions during the implementation and assessment phases became key to dissolve issues accumulated from the project start. The service integration efforts and the hybrid leadership approach in the assessment phase solved organizational frictions appeared in the design and implementation phases. Recent attempts to be more customer oriented and less dependent from Innoconsulting solved previous interorganizational issues. Research findings suggest the relevance of an iterative, continuous improvement approach to destroy DS complexity, together with the ability to establish a detecting system to promptly recognize new tensions. To facilitate manufacturers in achieving an overarching view on the DS journey, the empirical framework can be a valid tool. Creating and integrating an empirical framework with tensions encountered throughout the DSS empowers the awareness of firms on the DS process.

The research also facilitates the observation of elements of convergence and divergence between servitization and DS paradoxes. In general terms, our findings suggest that DS is more complex than servitization; its digital dimension hinders the entire process because of the required skills not only at the network level (Matthyssens, 2019; Kamalaldin *et al.*, 2020), but even at the organizational one. In relation to service integration, T5 can emerge in both servitization and DS (Lenka *et al.*, 2018; Kohtamäki *et al.*, 2020) since the tension is not directly linked to digital aspects. Conversely, the tension on the leadership model calls for further elucidation (Kowalkowski *et al.*, 2017; Kim & Toya, 2019). This study underlines how T6 becomes more complex in DSS. The digital dimension requires technological infrastructures and the service delivery system to be

understood, internalized, and diffused within and outside the firm. The relevance of the leadership model in guiding servitizing projects is confirmed for both strategies (Ahamed *et al.*, 2013). However, the inefficacy of an autocratic and autonomous leadership for DS is questioned (Kim & Toya, 2019). Findings reveal how a DSS needs balance between autonomous and charismatic leadership models and how decisions involving the service empowerment should be imposed before being accepted.

6. Conclusions

Firms involved in DSS face complexity at the intra and interorganizational level, which can take the shape of paradoxical tensions (Vendrell-Herrero *et al.*, 2017; Harini & Thomas, 2020). The inability to manage such complexity can undermine the success of the strategy. This study aims at pinpointing the origin of complexity in DSS to feel a gap in literature. It answers the call of Kohtamäki *et al.* (2020) for further research on the topic, while providing managerial implications. By answering the two RQs, this research advances knowledge on DSS through the combination of servitization literature with the paradox theory lens (Bustinza *et al.*, 2018; Smith & Lewis, 2011).

RQ1 investigates how the emergence of intra and interorganizational tensions generates complexity along a DSS. This research confirms the high complexity of DSS (Tronvoll *et al.*, 2020). Moreover, it disentangles DS complexity into tensions at the intra and interorganizational level. Six tensions result from the study: *Pull vs Push technology-based innovation, Firm-driven vs Supply-chain driven technological know-how acquisition, Exponential vs Incremental service development, Diversification vs Standardization of the international service offering, Integrated vs Disintegrated service function, Top-down vs Bottom-up leadership model*. Our findings emphasize how the multiplicity and interrelatedness of such tensions intricates the DS journey of manufacturers. Complexity reveals even enhanced by the digital component of the DSS, calling for specific organizational and network capabilities. Time becomes a determinant variable in the DS process: tensions accumulation across the DS phases seriously undermines the strategy efficacy.

RQ2 looks at where and when manufacturers can intervene to dissolve DS complexity. The interrelated analysis of tensions across space and time unveils DS criticalities (Paiola & Gebauer, 2020; Coreynen *et al.*, 2017). Specific actions emerge, which can support firms in unravelling DS complexity. In the DSS design,

context analysis, networking exploitation, and focus on customer needs and expectations are required. During the DSS implementation, attention should be devoted to the iterative adjustment of organizational issues, with an autonomous leadership style. In the assessment phase, external knowledge dependence and leadership rigidity are to be reduced.

6.1 Managerial implications

By disentangling where and when complexity originates in DSS, this research provides insights and practical solutions for managers investing in this path. Suggestions on how to approach a DSS appear for each phase of the DS journey.

In the DSS design, a monitoring activity of the surrounding context reveals vital. Managing purposeful network interactions is functional to identify potential DS partners and detect market's aptitude towards digital services. The type of technology to link to the DSS should be defined at this stage. A push technology-based approach is not mandatory, especially for small and medium enterprises (SMEs) with limited access to resources. A pull approach, better suiting customer infrastructures, can be more appropriate. However, it should go hand in hand with the early integration of human resources, development of specific skills and cultural change management. Managers should consider the best DS journey given the organizational circumstances, as well as the best balance between the service and the digital prevalence in the strategy (Ciasullo *et al.*, 2021).

At the implementation stage, two dimensions will need a particular focus: the customer perspective and organizational issues. An adaptive approach to market is required to guarantee the dissemination of digital service value. At the same time, the continuous revaluation and assessment of organizational circumstances, such as resistances, cultural obstacles, or the leadership model, will guarantee the effective DS development. Between the organizational capabilities required in a DSS there are the ability to iterate within the process and make continuous adjustments, to make non-exclusive choices in front of paradoxes (Kohtamäki *et al.*, 2020), and to keep problems-detection systems active throughout the process. In this sense, the proposed empirical framework can work as a monitoring tool of DSS complexity. Managers can fill in the framework skeleton with challenges and circumstances they me*et al*ong the DSS. This helps identifying DS tensions and their origin and design solutions which are functional for all the encountered tensions. The empirical framework provides a wider perspective on the strategy and avoids unilateral, silo-thinking

(Struyf *et al.*, 2021). A decisive and autonomous leadership style is suggested during the implementation phase.

In the assessment, the leadership model should experience a twist. A hybrid approach, combining top-down directives and bottom-up initiatives can be integrated. It helps reducing internal resistances and facilitating cultural openness towards digital services. Moreover, in case of collaboration with external partners, it is crucial to internalize capabilities coming from the relationship. Managers could strengthen the internal know-how at this stage to better defend the competitive advantage in future. However, the preservation of key relationships is still consistent to face market dynamism and improve knowledge acquisition (Runfola *et al.*, 2021).

6.2 Limitations and future research directions

This research is not without limitations. First, the longitudinal, in-depth single case study methodology restricts the area of investigation to a firm operating in one sector. Even if this allowed a detailed configuration of DSS complexity, future research could benefit from comparative case studies within multiple firms operating in different industrial branches. It could enrich knowledge on DS complexity and provide additional perspectives on the phenomenon. Moreover, quantitative studies can help testing the framework for DS complexity, validating results, and facilitating their generalizability.

Second, the influence of the external context can impact on the strategic complexity: customers could not be ready to buy digital services as well as providers could not be collaborative on innovation dynamics (Vaittinen & Martinsuo, 2019; Vendrell-Herrero *et al.*, 2017). This aspect needs further exploration, which was not possible to achieve with the available data. Future research could address the objective of disentangling the role of external actors in the success of DSS. Interestingly, it could involve the investigation of customers' readiness for digital services, supplier-buyer relationships in DS, or the impact of policies and institutional networks in the success of DSS.

[1] The name of the case study firm, as well as the name of its project and the name of the official partner, has been anonymized to ensure confidentiality.

Appendix

Table II *– Participant observation data*

Date	Place	Activity Type	Area of interest	Topic faced	Functions involved	Number of participants	Duration (h)
15/01/2019	Service Dept	Meeting	Progress in *Aura* Project	Go-to-market *Aura* in France	Marketing, *Aura*, Innoconsulting	5	2
16/01/2019	Service Dept	Presentation	Progress in *Aura* Project	*Aura* project, main object, and design	*Aura*, Innoconsulting	3	6
24/01/2019	Headquarter	Meeting	Progress in *Aura* Project	*Aura* communication plan for the Ligna fair	Marketing, *Aura*, Innoconsulting	6	1,5
26/02/2019	Headquarter	Presentation	Implementation of Service ICT	Introduction of new ERP Section for Service	IT, Sales Intelligence, Service	4	1,5
27/02/2019	Headquarter	Meeting	Subsidiaries Performance on Services	Definition of managerial guidelines to compare subsidiaries' Service performance	Service, Foreign branch office, HR	5	2,5
04/03/2019	Headquarter	Meeting	Strategy for selling Services	Definition of service sales force structure	Sales Intelligence, Service, Innovation	4	2
06/03/2019	Headquarter	Update	Clusterization of Service customers	Evaluate progress and next steps in clusterization of Service customers project	Service, Innoconsulting	3	2
29/03/2019	Service Dept	Presentation	Subsidiaries Performance on Services	Overview on Service Business Review of Subsidiaries	Service, Foreign branch office	4	2
03/04/2019	Headquarter	Meeting	Clusterization of Service customers	Definition of a new project: Clusterization of Service customers	Service, Innoconsulting	5	3
18/04/2019	Headquarter	Update	Clusterization of Service customers	Evaluate progress and next steps in clusterization of Service customers project	Service, Innoconsulting	4	2
08/05/2019	Headquarter	Meeting	Clusterization of Service customers	Evaluate progress and next steps in clusterization of Service customers project	Service, Innoconsulting	5	2
17/05/2019	Headquarter	Update	Clusterization of Service customers	Evaluate progress and next steps in clusterization of Service customers project	Service, Innoconsulting	5	2
06/06/2019	Headquarter	Meeting	Management of Service Contracts	Definition of a new digital process to map active contracts in ERP	IT, Service	6	4
16/07/2019	Headquarter	Call conference	Clusterization of Service customers	Debate with French subsidiary on clusterization of Service customers	Service, Innoconsulting	6	2
22/07/2019	Headquarter	Presentation	Implementation of Service ICT	Introduction of new CRM Section for Service customers	IT, Sales Intelligence, Service, Marketing	5	2,5
24/07/2019	Headquarter	Call conference	Clusterization of Service customers	Debate with Service sales force for clusterization of Service customers - understanding salesforce needs	Service, Innoconsulting	8	3
31/07/2019	Headquarter	Call conference	Clusterization of Service customers	Debate with Service sales force for clusterization of Service customers - identification of commercial drivers	Service, Innoconsulting	8	3
10/09/2019	Headquarter	Update	Clusterization of Service customers	Evaluate progress and next steps in clusterization of Service customers project	Service, Innoconsulting	5	2
08/10/2019	Service Dept	Workshop	Subsidiaries Performance on Services	Global Service Meeting - *Aura* and digital services	Service, Foreign branch office	25	8
09/10/2019	Service Dept	Workshop	Subsidiaries Performance on Services	Global Service Meeting - Selling services and Service product catalogue	Service, Foreign branch office	25	8
03/12/2019	Headquarter	Meeting	Clusterization of Service customers	How to introduce the clusterization of Service customers project in the firm's CRM	Service, IT, Sales Intelligence, Innoconsulting	9	2,5
10/12/2019	Headquarter	Meeting	Strategy for selling Services	Management of Service visits in the firm's CRM	Service Intelligence, IT, Sales Intelligence, Innoconsulting	6	2
18/12/2019	Service Dept	Meeting	Clusterization of Service customers	Mapping data fields to introduce in firm's CRM to add clusterization of Service customers	Service, IT, Innoconsulting	6	2,5
07/01/2020	Headquarter	Presentation	Strategy for selling Services	Overview on new Service sales activities to map in the firm's CRM	IT, Sales Intelligence, Service	7	2,5
15/01/2020	Headquarter	Meeting	Clusterization of Service customers	How to introduce the clusterization of Service customers project in the firm's CRM	Service, IT, Sales Intelligence, Innoconsulting	9	2
23/01/2020	Headquarter	Meeting	Clusterization of Service customers	How to introduce the clusterization of Service customers project in the firm's CRM	Service, IT, Sales Intelligence, Innoconsulting	9	2
29/01/2020	Headquarter	Update	Progress in *Aura* Project	Business work progress of *Aura* Project	Service, *Aura*, IT, Innoconsulting	18	2
13/02/2020	Headquarter	Call conference	Clusterization of Service customers	Debate with French subsidiary on clusterization of Service customers	Service, Innoconsulting	6	1,5
13/03/2020	Online Virtual Meeting	Meeting	Clusterization of Service customers	Definition of a specification file about clusterization of Service customers	Service, IT, Innoconsulting	6	3
12/05/2020	Online Virtual Meeting	Update	Progress in *Aura* Project	Business work progress of *Aura* Project	Service, *Aura*, IT, Innoconsulting	15	1,5
04/06/2020	Online Virtual Meeting	Meeting	Service Intelligence Implementation	Definition of a new function in the firm: Service Intelligence	Innovation, Service, Sales Intelligence, Service Intelligence	4	1
23/06/2020	Online Virtual Meeting	Presentation	Service Intelligence Implementation	Introduction to Service Intelligence	Sales Intelligence	3	3
24/06/2020	Online Virtual Meeting	Presentation	Service Intelligence Implementation	Introduction to Service Intelligence	Sales Intelligence	3	3
25/06/2020	Online Virtual Meeting	Presentation	Service Intelligence Implementation	Introduction to Service Intelligence	Sales Intelligence	3	3
29/06/2020	Online Virtual Meeting	Presentation	Service Intelligence Implementation	Introduction to Service Intelligence	Sales Intelligence	3	2
30/06/2020	Online Virtual Meeting	Presentation	Service Intelligence Implementation	Introduction to Service Intelligence	Sales Intelligence	3	3
01/07/2020	Online Virtual Meeting	Presentation	Service Intelligence Implementation	Introduction to Service Intelligence	Sales Intelligence	3	3
02/07/2020	Online Virtual Meeting	Presentation	Service Intelligence Implementation	Introduction to Service Intelligence	Sales Intelligence	3	3
03/07/2020	Online Virtual Meeting	Presentation	Service Intelligence Implementation	Introduction to Service Intelligence	Sales Intelligence	3	2,5
15/07/2020	Online Virtual Meeting	Meeting	Service Intelligence Implementation	Definition of how to map Service commercial activities in the firm's CRM	Sales Intelligence, Service Intelligence	4	3,5
17/07/2020	Online Virtual Meeting	Meeting	Strategy for selling Services	Go-to-market Service in Italy	Service, Marketing, *Aura*, Innoconsulting	8	3
23/07/2020	Online Virtual Meeting	Presentation	Clusterization of Service customers	Brainstorming on clusterization of Service customers project	Service, Innoconsulting	4	2
24/07/2020	Online Virtual Meeting	Meeting	Strategy for selling Services	Definition of reports about Service sales performances	Sales Intelligence, Service Intelligence	3	2
31/07/2020	Online Virtual Meeting	Call conference	Service Intelligence Implementation	Introduction of new Service sales performance reports to international Service sales force	Sales Intelligence, Service Intelligence	3	1,5
04/08/2020	Online Virtual Meeting	Call conference	Service Intelligence Implementation	Introduction of new Service sales performance reports to Italian Service sales force	Sales Intelligence, Service Intelligence	3	2
23/09/2020	Online Virtual Meeting	Update	Service Intelligence Implementation	Work progress of Service Intellingence function	Sales Intelligence, Service Intelligence	5	2

Date	Place	Activity Type	Area of interest	Topic faced	Functions involved	Number of participants	Duration (h)
29/09/2020	Online Virtual Meeting	Update	Service Intelligence Implementation	Work progress of Service Intellingence function	Sales Intelligence, Service Intelligence	5	2
06/10/2020	Online Virtual Meeting	Update	Service Intelligence Implementation	Work progress of Service sales force performance monitoring	Service, Sales Intelligence, Service Intelligence	3	1,5
08/10/2020	Online Virtual Meeting	Meeting	Subsidiaries Performance on Services	Definition of a dashboard to show Service performances of subsidiaries	Service, Foreign branch office, HR	6	2
12/10/2020	Online Virtual Meeting	Update	Service Intelligence Implementation	Work progress of Service Intellingence function	Sales Intelligence, Service Intelligence	5	2
13/10/2020	Online Virtual Meeting	Workshop	Strategy for selling Services	Find eventual correlation in the sell of Maintenance contracts and new spare parts	Service, Service Intelligence	4	3,5
14/10/2020	Online Virtual Meeting	Meeting	Clusterization of Service customers	Evaluate progress and next steps in clusterization of Service customers project	Service, Innoconsulting	5	3
14/10/2020	Online Virtual Meeting	Workshop	Strategy for selling Services	Find eventual correlation in the sell of Maintenance contracts and new spare parts	Service, Service Intelligence	4	3
22/10/2020	Online Virtual Meeting	Update	Service Intelligence Implementation	Work progress of Service Intellingence function	Sales Intelligence, Service Intelligence	5	2
22/10/2020	Online Virtual Meeting	Meeting	Service Intelligence Implementation	Definition of indicators to evaluate Service sales performance	Sales Intelligence, Service Intelligence	3	2,5
22/10/2020	Online Virtual Meeting	Update	Clusterization of Service customers	Evaluate progress and next steps in clusterization of Service customers project	Service, Innoconsulting	3	2
27/10/2020	Online Virtual Meeting	Update	Progress in *Aura* Project	Business work progress of *Aura* Project	Service, *Aura*, IT, Innoconsulting	19	2
27/10/2020	Online Virtual Meeting	Workshop	Strategy for selling Services	Definition of a formula to evaluate the Service potential of each market	IT, Service, Innoconsulting	8	4
27/10/2020	Online Virtual Meeting	Update	Service Intelligence Implementation	Work progress of Service sales force performance monitoring	Service, Sales Intelligence, Service Intelligence	3	2
28/10/2020	Online Virtual Meeting	Update	Service Intelligence Implementation	Work progress of Service Intellingence function	Sales Intelligence, Service Intelligence	5	2
02/11/2020	Online Virtual Meeting	Presentation	Implementation of Service ICT	Introduction of new ERP Section for Service	IT, Sales Intelligence, Service	3	2
05/11/2020	Online Virtual Meeting	Call conference	Service Intelligence Implementation	Debate with Italian Service sales force to improve reports on their Service sales performance	Service Intelligence, Service	7	2
10/11/2020	Online Virtual Meeting	Update	Service Intelligence Implementation	Work progress of Service Intellingence function	Sales Intelligence, Service Intelligence	5	2
16/11/2020	Online Virtual Meeting	Update	Service Intelligence Implementation	Work progress of Service Intellingence function	Sales Intelligence, Service Intelligence	5	2
16/11/2020	Online Virtual Meeting	Workshop	Strategy for selling Services	Definition of a formula to evaluate the Service potential of each market	IT, Service, Innoconsulting	8	4
17/11/2020	Online Virtual Meeting	Workshop	Strategy for selling Services	Definition of a formula to evaluate the Service potential of each market	IT, Service, Innoconsulting	8	4
23/11/2020	Online Virtual Meeting	Update	Service Intelligence Implementation	Work progress of Service Intellingence function	Sales Intelligence, Service Intelligence	5	2
30/11/2020	Online Virtual Meeting	Update	Service Intelligence Implementation	Work progress of Service Intellingence function	Sales Intelligence, Service Intelligence	5	2
01/12/2020	Online Virtual Meeting	Update	Progress in *Aura* Project	Business work progress of *Aura* Project	Service, *Aura*, IT, Innoconsulting	18	2
02/12/2020	Online Virtual Meeting	Update	Service Intelligence Implementation	Work progress of Service sales force performance monitoring	Service, Sales Intelligence, Service Intelligence	3	2
03/12/2020	Online Virtual Meeting	Workshop	Strategy for selling Services	Definition of a formula to evaluate the Service potential of each market	IT, Service, Innoconsulting	8	4
14/12/2020	Online Virtual Meeting	Call conference	Service Intelligence Implementation	Debate with Italian and French Service sales force to evaluate their Service sales performance	Service Intelligence, Service	12	1,5
15/12/2020	Online Virtual Meeting	Presentation	Implementation of Service ICT	Introduction of Data Extensions for Service marketing activities	IT, Sales Intelligence, Service, Marketing	4	1,5
16/12/2020	Online Virtual Meeting	Update	Service Intelligence Implementation	Work progress of Service Intellingence function	Sales Intelligence, Service Intelligence	5	2
16/12/2020	Online Virtual Meeting	Meeting	Service Intelligence Implementation	Presentation of CRM to map Service activities to German subsidiary	Sales Intelligence, Service Intelligence	7	1,5
16/12/2020	Online Virtual Meeting	Presentation	Implementation of Service ICT	Introduction of Data Extensions for Service marketing activities	IT, Sales Intelligence, Service, Marketing	4	1,5
17/12/2020	Online Virtual Meeting	Presentation	Implementation of Service ICT	Introduction of Data Extensions for Service marketing activities	IT, Sales Intelligence, Service, Marketing	4	2

Table III *– Interview protocol.*

Section	Topic	Questions
1	**Identification of the respondent**	What is your position inside the company today?
		What are the main responsibilities connected to your working position?
		Does your current working position include transversality between organizational functions? If yes, which ones?
		Does your current working position involve direct contact with external actors? If yes, which ones?
		Is this your first role in the company? If not, which role(s) did you perform previously?
		How long have you been working in the company?
		Do you have working experiences in other firms? If yes, which ones?
2	**Description of the DSS**	Can you describe the DSS of the firm? What have been the main phases, or stages, experienced along the DSS? In your opinion, what are the critical events characterizing the DSS?
		In temporal terms, when did the firm start considering the option of a DSS? When did the official implementation of the DSS start? What are the main events that followed the official start?
		Was the firm involved in service strategies before officially investing the DSS? If yes, how?
		How would you define the service orientation of the firm before the DSS? Would you define it differently today, after the initiation of the DSS?
		Which stage of the DSS process do you think the firm is experiencing today?
		What do you think will happen next? What are your expectations about the future developments of the DSS?
3	**Implications of the DSS and solutions**	Could you identify the conditions that triggered the idea of the DSS?
		While evaluating the DSS idea, what were the main concerns and perceived barriers? What were, instead, the facilitators in choosing to invest?
		After the initial decision to invest, what were the main changes? Internally, what happened at the organizational level? What were the main organizational criticalities? Did some resistances emerge? If yes, of what kind? How have they been managed? Which functions were mostly involved in the DSS at this stage? What did you perceive as the main advantage of the DSS at this stage? How was the leadership involved in this stage? Did you need the support of external actors? If yes, what actors? For what purposes? Did some existing relations with external actors modify because of the DSS? If yes, which ones and why? What were the main difficulties in the relation with external actor at this stage, if any? How have they eventually been managed?
		During the official launch of the DSS, what were the main changes? Internally, were some changes in the organizational structure required? If yes, of what type and why? What were the main barriers that you perceived during this stage of the DSS? How have they eventually been managed? What advantages of the DSS did you perceive in this stage, if any? What was the reaction of employees? How was the leadership involved in this stage? Towards the external actors, what happened? Were new actors involved at this stage? If yes, which ones and why? What barriers did you perceive in the relation with external actors? If any, which ones and in relation to which actor? How have they eventually been managed? How did customers react to the introduction of digital services?
		What are the main activities led today in relation to the DSS? Do you feel there are still internal criticalities related to the DSS? If yes, which ones? What strategies of the firm do you think were the most effective to solve previous criticalities, if any? What is today the response of employees to the DSS? What are the perceived advantages acquired from the DSS today? How is the leadership involved in the DSS today? How is now the response of the external actors to the DSS? How do customers react to the DSS today? How is the relationship with suppliers managed? What is the institutional and public response of the market to the DSS?

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Chapter V - Concluding remarks and future research avenues

1. Discussions

This research project is built around the observation of two, interrelated phenomena, i.e., digitalization and servitization. It strives at contributing to build new knowledge on the two investigated topics and clear the way for new research avenues. At the same time, embracing a problematization approach, this work aims at supporting industrial firms along the digitalization and servitization paths. Therefore, this thesis posits the following, overall research aim:

> *Investigate how business-to-business companies embrace I4.0-related digitalization and Digital Servitization and how such phenomena are transforming intra and interorganizational dynamics in international industrial markets.*

Trying to pursue this aim, this thesis deployed a qualitative methodology, based on both single and multiple cases studies. Data collection has been based on interviews and participant observation as primary data source, and data analysis was based on the systematic combining technique (Dubois & Gadde, 2002).

Firstly, the aim of this research is to understand if and how industrial companies embrace digitalization and servitization. In this regard, the research registers a general interest gravitating around the two phenomena. Our analysis shows that industrial companies are demonstrating a high level of engagement in digitalization, and many are the firms that invested (or interested to invest) in it (Brancati & Maresca, 2017). For example, many companies of the industrial district analysed in Chapter II are investing in the digital transformation. Not only, the industrial district shows various ways in which the transformation happens, confirming the flexibility and adaptability of I4.0 technologies to multiple needs (Mohamed, 2018). New business models emerge within the cluster, and all of them are dragged by cooperation and mutual influencing. The digital twist is perceived by many firms as a necessary change, which contributes to increase resilience, especially given the current uncertain times (Kala'lembang, 2021; Brem *et al.*, 2021). The same is true for servitization, which is perceived as a help to differentiate the offering, enhance competitiveness, and reduce fluctuating returns (Rapaccini *et al.*, 2020). Chapter III and Chapter IV provide examples of industrial companies that believed in the value of a Digital Servitization strategy. However, in some cases, a sense of scepticism diffused about the real chances of success inherent in the Digital Servitization application. This can be partly justified by the conflicting economic performances obtained by

some pioneering companies that undergone a Digital Servitization strategy (Valtakoski, 2017). Most importantly, it could depend on the existing challenges involved in the development of digital solutions (Bustinza *et al.*, 2018; Frank *et al.*, 2019; Tronvoll *et al.*, 2020). Chapter III puts light on the multiple and interrelated difficulties that both Mectop and Apitec experienced along the servitizing journey. Indeed, notwithstanding the interest of industrial firms toward digitalization and servitization, their implementation implies great complexity exhibited within a multilevel context. Both internally and outside the firm's boundaries, digitalization and servitization put industrial companies under stress by requiring deep changes and the ability to take timely decisions, adapt them to the ongoing situation and convey value toward the market. How it is evident in Chapter IV, challenges of servitizing activities emerge both inside and outside Alpha, with implications that intertwin the intra and interorganizational layers.

Secondly, this research aims at observing if and how digitalization and servitization are transforming industrial markets. To this end, this research provides evidence of some ongoing changes. In particular, the I4.0 revolution clears the way for solution-oriented business markets (Gaiardelli *et al.*, 2021). Industrial markets are moving in the direction of constituting a servitized value chain, where service platforms and digital solutions are offered to customers (Freije *et al.*, 2021; Jovanovic *et al.*, 2021). A confirmation of this is provided in Chapter II, which shows multiple industrial companies addressing I4.0 technologies to build a service-oriented business model: it is the case, for example, of Pedini, Scavolini, and Biesse. Not only, this trend is also confirmed by Mectop and Apitec in Chapter III and Alpha in Chapter IV. Moreover, business-to-business companies put the focus on customers through the help of digital tools. They strive at achieving a digitally-based, customized, exclusive relationship with customers, where I4.0 technologies guarantee real-time services and a nonstop exchange of information between solution providers and the market. Chapter IV underlines this direction; a cooperative relationship with customers revealed to be a fundamental requirement of the Digital Servitization success of Alpha. Indeed, fluctuating revenues coming from the service offering stabilized only after the firm seriously invested in value co-creation practises. In such context, the entire value chain becomes integrated and interconnected. Therefore, a networking approach to digitalization and servitization assumes relevance to guarantee the alignment of all the participating actors in terms of digitalization levels and servitization objectives (Kamaladin *et al.*, 2021; Sklyar *et al.*, 2019). A network-based approach to Digital Servitization is required both at

the managerial level, to smoothen the complexity of the strategy, and at the research level, to guarantee the full observation of the phenomenon.

In general terms, this research constitutes a valid opportunity to provide an in-depth analysis of digitalization and servitization and untangle their main influences on industrial markets. Some overall considerations can be drawn, which are depicted hereafter.

A tight link connects digitalization and servitization

Digitalization has always been at the centre of industrial markets' attention, but this is particularly true since the advent of the I4.0 technologies, which offer greater opportunities for product and process innovation (Kagermann *et al.*, 2013). A rejuvenating process has been experienced also by servitization, toward which the attention of practitioners and researchers converged as a result of its digital twist (Frank *et al.*, 2019).

This thesis confirms the emerging interest in Digital Servitization both in literature and within business-to-business markets, while it provides evidence of a tight link between digitalization and servitization under multiple perspectives. On the one side, manufacturing companies that embarked on (or are embarking on) digitalization processes are willing to invest in the development of advanced solutions, with the aim of not only having a remunerative return from the investment in new technologies, but also stimulating a deeper cooperative relationship with customers and enhancing their level of trust and loyalty (Bonamigo & Frech, 2021). This is what happened, for example, to Alpha in Chapter IV. The company boasted great expertise in digital tools and I4.0 technologies application, which determined the choice of exploiting them to design and deliver service-based offerings. Indeed, the firm recognized the value of a service-centric approach to gain new market shares and saw in digital tools the viable route to achieve them.

On the other side, manufacturers that already undergone a servitization process and offer traditional solutions to customers could not exempt from a digital transition. The level up from base or intermediate services to advanced services is easily made possible by I4.0 technologies (Baines & Lightfoot, 2014; Ardolino *et al.*, 2018). This was the case of Apitec in Chapter III, which presented a long history in developing customized solutions; still, the firm felt the need to adopt digital tools to design, develop, and supply new solutions. Apitec saw in digitalization the chance to be a market first-mover and improve its competitive position. Indeed, the possibility to offer advanced, digitally-based solutions can

improve the chances of gaining a defendable competitive advantage and enhance firms' resilience (Agrawal *et al.*, 2021).

It follows that, in many cases investments in digitalization stimulate the adoption of servitization strategies and vice versa. In other cases, the development of digitalization and servitization happens in a simultaneous and combined way. The latter is, for example, the case of Pedini illustrated in Chapter II: the firm always realized products in a traditional market, and quickly turned to Digital Servitization via a high-tech collaboration with an external digital partner.

The evident and strong link between digitalization and servitization, recently flowing into Digital Servitization, determined a dual reaction of firms in terms of adoption levels. If it is true that some manufacturing companies, especially large firms, are intrigued by the outstanding business opportunities outlined by Digital Servitization strategies and invest in them, it is likewise true that other manufacturers, mainly small firms with reduced access to financial, human, and intellectual resources, can be frightened by them (Osservatorio Industria 4.0, 2018). For example, Berloni Bagno, a firm belonging to the observed industrial district in Chapter II, did not invest in I4.0 technologies adoption so far because of the perceived lack of resources and the scepticism on the potential advantages coming from them. The considerable number of resources and the know-how building process required for accessing and exploiting I4.0 technologies generate ambiguity in the digital component of servitization strategies.

In conclusion, it could be argued that the tight link between digitalization and servitization is widely recognized and internalized by industrial markets. Yet, this awareness is a double-edged sword: it contributes to diffusing Digital Servitization strategies in some cases, while it distances manufacturers from them in others.

Digitalization and servitization drive business model innovation

This research partly contributes to understanding if and how digitalization and servitization act on the business model innovation process of industrial companies. Through the observation of in-depth case studies, indeed, this work allows to draw some first considerations on business model innovation.

Firstly, this research emphasises the crucial role of digitalization in determining new business models. The study displayed in Chapter II, which allowed for the favourite observation of an industrial district, brings the attention on how digitalization processes let companies consider and sometimes adopt

innovative business models (Rachinger *et al.*, 2019; Klos *et al.*, 2021). In this sense, the digital transformation process works as 'enabler' of business model innovation, which appears in various forms. Many of the observed companies, as Biesse Spa, Scavolini, or LC Spa, at first invested in digitalization and then, as a result, they exploited new technologies to innovate their business models, achieve competitiveness and size upcoming opportunities (Weking *et al.*, 2020).

Secondly, the overall research explored the ways in which a business model can be innovative via the application of digitalization and servitization. What emerges from the analysis of the district in Chapter II is that innovation of the business model happens via actions undertaken along one (or more) of the dimensions constituting business models, i.e., value proposition, value creation, value delivery, value networking, and value appropriation (Cortimiglia *et al.*, 2016). In Chapters III and IV it was possible to see how servitization per se can be interpreted as a business model innovation for manufacturing companies who were previously product-oriented (Kohtamäki *et al.*, 2019; Paiola & Gebauer, 2020; Frank *et al.*, 2019). The transition from a product-centric to a product- and/or service-centric revenue model constitutes a business model innovation based on the value appropriation dimension. Some of the firms analysed in Chapter II, instead, innovated the business model along the value delivery and networking dimensions. For instance, Scavolini operated in the direction of a business-to-business e-commerce platform dominated by the interactive approach between producer and dealer, therefore exploiting business model innovation through value delivery. At the same time, firms participating in the REVYTA project refreshed their business model via innovation in the value networking dimension. The result is a circular economy-based productive process which exists thanks to the exploration of relationships with new partners.

Essentially, this research addresses some preliminary considerations on if and how business model innovation can happen through digitalization and servitization. What emerges clearly is that the two phenomena can stand for both new business model objects (Paiola & Gebauer, 2020) or enablers of innovation in industrial business models (Klos *et al.*, 2021). Instead, concerning the forms and applications of business models innovation, some examples can be extracted from this research, even though future studies are needed to achieve completeness and generalizability of results.

A multilevel approach supports digital services

The deep investigation of both single and multiple case studies of companies directly involved in digitalization and Digital Servitization shows how the two

processes require long times and consistent changes to be accomplished. In particular, changes are required both inside the company, within its varied organizational dimensions, and outside it, along the network dynamics. What emerges is that Digital Servitization can be defined as a multilevel phenomenon, for two main reasons.

First, multilevel is the range of actors involved in the Digital Servitization process (Raddats *et al.*, 2019). Indeed, three layers of actors actively participate in and are influenced by the launch of a Digital Servitization strategy, i.e., the individual, organizational, and network layers. This is evident in Chapter III, where the comparative analysis of Mectop and Apitec highlights the involvement of external partners along the entire servitizing journey. At the individual (or microfoundational) level, persons inside the organization are involved in the strategic change, with both operative and emotional engagement (Healey & Hodgkinson, 2017; Barsade, 2002). Individual reaction of employees should be carefully considered to avoid dangerous oppression. For example, in Mectop a potential threat to the strategy evolution was constituted by the negative reaction of salespersons to operational changes; similarly, the underestimated stress fallen into the technical teamwork discouraged the Digital Servitization transition in Apitec. At the organizational level, every unit composing the firm's structure directly participates in the strategy and must overcome a deep cultural change in order to smoothly support the Digital Servitization transition (Tronvoll *et al.*, 2020; Vendrell-Herrero *et al.*, 2017; Bustinza *et al.*, 2018). Following the Mectop and Apitec examples, particularly challenging was the integration of the Sales and Service departments in the former, and of the ICT and Marketing departments in the latter. At the network level, other firms, institutions, and social actors become integral part of the digital servitizing process and participate in re-defining equilibria along the entire value chain (Kamalaldin *et al.*, 2020; Kohtamäki *et al.*, 2019).

Second, the implications deriving from the Digital Servitization strategy are displayed in a multilevel context. As observed in the Alpha case along Chapter IV, Digital Servitization effects display at a twofold level: intra and interorganizational. Indeed, challenges and hurdles faced by Alpha emerged at the intraorganizational level, by imposing a revision of the hierarchical structure, of the adopted leadership model, of the sales approach, of the operational routines and cultural habits. At the same time, the network management withstands changes to effectively face Digital Servitization issues, as adjustments in power distribution along the supply chain (Vendrell-Herrero *et al.*, 2017) or

the need to compensate for missing technological knowledge and capabilities (Matthyssens, 2019).

Significantly, the empirical investigations carried out within Chapter III and IV facilitate the understanding of Digital Servitization strategies by highlighting a strong interconnectedness between the layers composing them. Actors, effects, and implications of Digital Servitization are intertwined. Actions undertaken at one level have repercussions on actors and choices at other levels and vice versa. This contributes to making the capability of managing the interconnectedness between the multiple layers of Digital Servitization essential.

External actors are key in digitalization and servitization

As digitalization and servitization fit perfectly in an (intra and) interorganizational context, the continuous exchanges with actors along the servitized value chain constitute a core activity. The deployed empirical investigation depicts how industrial companies pursuing Digital Servitization find themselves in the position to relate with both new actors and known ones in a new way.

Regarding the interaction with new actors, some key figures emerge. In particular, when considering the digitalization process, the acquisition of new knowledge is deeply enhanced by the support of external partners. Chapter II reveals the relevance of actors as I4.0 technologies providers, suppliers of technical support, or digital consultants to facilitate digitalization. Many of the observed companies took advantage of new relationships to adopt I4.0 technologies; Pedini exploited the relationship with Microsoft and IoMote, Biesse the one with Accenture, or Scavolini the one with Websolute. Also, universities revealed to be a favourable meeting point between academy and industrial markets to obtain a technology-related know-how, develop mutual competences, and search for new approaches to exploit digital technologies.

Even when focussing on the business model transition toward services, new actors emerge. Organizations as Knowledge-Intensive Business Services (KIBS) firms or consultancy agencies specialized in change management can contribute to first approaching and developing a Digital Servitization strategy. This was the case for both Mectop with Informa in Chapter III and Alpha with Innoconsulting in Chapter IV, where the consolidated relationships helped in smoothening the servitization complexity. In case of companies interested in Digital Servitization but missing awareness on its requirements and implications, participating in collective activities could be essential (Hervas-Oliver *et al.*, 2019). As it was possible to notice within Chapter II, the effort of firms for being included in a

servitized value chain starts with taking part into collective projects. In this way, firms are integrated into a precious network of companies and institutions which triggers 'collective cooperation' (Camuffo & Grandinetti, 2011; Belussi & Sedita, 2012). It facilitates building awareness on new topics as digitalization and servitization and the local establishment of the related knowledge and diffusion mechanisms.

For what concerns the relationships with already known actors, some dynamics within them should be revised while investing in a Digital Servitization strategy. For example, in the relationship with trusted suppliers, it could be valuable to embark on a common digitalization path, which leads both parties to invest in I4.0 technologies. This is, for instance, what happened with the REVYTA Project analysed in Chapter II. The project involved organizations in traditional sectors as Effebi Spa or DIFE Spa to embark on a mutual digitalization path by developing a new product based on the robotics technology. The aim was to align the technological level of every actor and better satisfy final customers with innovative products. With dealers and external partners an alignment is needed under the technological point of view, but also in relation to the cultural foundations of Digital Servitization. This is essential to convey customers in international markets a coherent brand image, which supports digital solutions and, at the same time, does not contrast the value of products.

Essentially, the empirical investigation confirms how relationships become powerful along a process of digitalization and servitization (Kamalaldin *et al.*, 2020; Pagani & Pardo; 2017). Launching a project of Digital Servitization requires 'openness' to strategic networking, which helps in strengthening existing relationships and becoming part of a purposeful net of contacts. Additionally, this research shows that collective forms of cooperation can facilitate closeness of industrial firms to digitalization and servitization. It can be of particular support for companies that need to build awareness and know-how on them. Such context clears the way for 'open innovation' logics (Leckel *et al.*, 2020) and for the establishment of cooperative knowledge-building processes within digitalization and Digital Servitization studies.

Customers become the focal point in digital solutions

An important consideration arising from this research concerns the relationship between providers of digital solutions and their customers. Industrial firms investing in digitalization and Digital Servitization inevitably accomplish a level up from the technological point of view. By investing in I4.0 technologies, they are somehow 'forced' to know such technologies and

understand how they work. They need to become confident about their functioning and able to fully recognize their potentialities. On the contrary, their customers, especially small companies or organizations displaced in technologically underdeveloped geographical areas, could not mature such awareness.

An underlying risk is the emergence of a misalignment between solution providers and customers concerning the achieved digital level (Huikkola *et al.*, 2021). The path of Alpha in Chapter IV proves that not only the risk of a technological misalignment is concrete, but it can seriously undermine the profitability of digital solutions. Indeed, during the initial stages of its Digital Servitization, Alpha underestimated customers' acceptance of the IIoT technology. This resulted into fluctuating selling of IIoT-based solutions. Similar situations lead customers to struggle in understanding the value of digital solutions. At the same time, they contribute to suppliers' scepticism about the solutions' sales potential. Therefore, investing in the improvement of the relationship with customers within a process of Digital Servitization seems of paramount importance for three main reasons.

Firstly, it has the aim to better depict and decode customers' real needs. Increased communication with customers helps mutual understanding and the development of ad-hoc solutions of which customers perceive the intrinsic value (Eggert *et al.*, 2018). Secondly, it drastically contributes to avoid faltering solutions selling. Indeed, strengthened partnership with customers is critical to avoid technological misalignments. Thirdly, it contributes to triggering value co-creation processes (Parida & Jovanovic, 2021). Through value co-creation, customers and providers achieve a cooperative approach in the design of digital solutions. This is valuable to realize solutions based on customers' expectations and to enhance loyalty and trust in the relationship.

Digital Servitization implies complexity

The analysed case studies shed light on the level of complexity perceived and endured by manufacturers along Digital Servitization. Some of the drivers entailing such complexity have been traced during this research activity.

The first one is to be found in the possible challenges at the intraorganizational level. Digitalization per se requires a consistent change within the firm and its ability to adapt to new procedures, infrastructures, tools, and habits (Kuusisto, 2017). Such difficulty emerged clearly in Chapter II with some cluster's resistant firms, as Berloni Bagno. The business model orientation towards services makes the process even more complex, given the necessary

changes in terms of culture, organizational structure, procedures, and offerings (Coreynen *et al.*, 2018). This is evident in Chapters III and IV, where the investigated companies encountered several organizational challenges. Between them, it was possible to observe how resources and the hierarchical structure needed to be rearranged to fit the new business model shape; technological capabilities were required to face the digital component of the strategy; a service-related culture was to be built and diffused among employees at every organizational level; productive workflows needed adjustments while a service team necessitated to be created or empowered; higher flexibility and alignment capability should be achieved, especially in the leadership model and managerial commitment.

A second driver of complexity is represented by the challenges emerging at the interorganizational level (Sklyar *et al.*, 2019; Kohtamäki *et al.*, 2019). Part of the complexity is related to the digitalization process. It includes the challenge of becoming active part of a collective network on I4.0 technologies (visible in Chapter II), the challenge of balancing power relationships along the supply chain (observed in Chapter III) and manage the technological advancement of customers and other stakeholders (emerged in Chapter IV), or the challenge of balancing between the processes of outsourcing and internalization of I4.0-related know-how (evident in Chapter IV). Remaining complexity derives from the servitizing activity included in Digital Servitization. Servitizing challenges involve, between others, difficulties to manage the internationalization of the service offering conveying the value of services to external actors, or difficulties in adjusting the relationship with customers with a higher level of cooperation, as noticed along Chapter IV.

The intra and interorganizational challenges imposed by digitalization and servitization generate such complexity that they can transform into paradoxical tensions. Since the challenges springing from Digital Servitization are so intricate to solve to become paradoxical, this research contributes to argue that digitalization and servitization imply a high level of complexity. Such complexity is even enhanced by the interrelation between challenges emerging at different levels of analysis and in different moments along the process.

Digitalization and Servitization are 'journeys'

The empirical analyses deployed within this thesis include case studies that have been observed for wide temporal periods, in both an active and retrospective way. This choice is not accidental; instead, it derives from digitalization and

servitization being highly complex and articulated phenomena; the chance to verify the development of them along a large timeframe seemed valuable.

The results of this research allow to focus on both the temporal and spatial aspects of digitalization and servitization. Concerning time, Chapter III and Chapter IV contribute to registering evolutions of Digital Servitization dynamics across years. For instance, Apitec (in Chapter III) experienced a modification of the relationship with Ergon, which swifts from a more to a less collaborative partnership, and a decline of the managerial commitment. Concerning space, Chapters III and IV witness an evolution in the contexts touched by digitalization and servitization, switching continuously from intra to interfirm and vice versa, and at more than one level of analysis, i.e., microfoundational, organizational, and network.

Based on this result, it is possible to affirm that digitalization and Digital Servitization can be considered as 'journeys'. Under a research-related perspective, it allows an observation of the phenomena with a longitudinal and processual approach, keeping in consideration the volatile implications appearing in time and space. From a managerial point of view, industrial firms undergoing digitalization and servitization should be aware of the extended times necessary for their full realization and of the extensive environment in which they happen. Therefore, paramount importance is acquired by the decisional process: it should be iterative and oriented toward a constant re-evaluation of choices. The capability for managers to continuously question choices and re-adapt them to changing times and spaces in which the strategy happens seems critical to its success.

Considering the overall aim of the research and the research questions addressed along this work, Table I provides a synthetic recap of the main results emerged from the study.

***Table I**. Main results of the research*

Research Question(s)	Main results
Understand if and how industrial companies embrace digitalization and servitization	
	- High level of engagement with digitalization, often interlinked with servitization - Great flexibility and adaptability of I4.0 technologies to multiple needs - Digitalization and servitization help incresing resilience and competitiveness - Scepticism is diffused due to complexity of digitalization and servitization
How is Industry 4.0-related knowledge spread in IDs active in traditional industries and what are its main implications?	- Acquiring digitalization knowledge is leveraged by new, digitally-advanced partners - Forms of collective cooperation and open innovation logics stimulate digitalization spread - I4.0-related knowledge is spread cross-sectorially and regardless the geographical proximity - Dissemination is fragmented and combines formal and informal initiatives - Digitalization and servitization contribute to innovate business models via value proposition, appropriation, delivery, and networking
Why do companies continuously struggle with DS despite extensive knowledge on hurdles and approaches to overcome them?	- Digital Servitization exists only within a multilevel context - Multilevel is the range of actors involved in Digital Servitization (microfoundational, organizational, network) - Each level is interconnected with the others and implications are intertwined - Challenges derive from the management of a multilevel phenomenon - No certain, exclusive answer exists to Digital Servitization barriers - Iterative processes support the effective management of Digital Servitization
Understand if and how digitalization and servitization are transforming industrial markets	
	- Industrial markets are becoming more solution- and customer-oriented - Value chains are more and more servitized, integrated, and interconnected - Interactions with customers are digitally-based and intensified
How does the emergence of intra and interorganizational tensions generate complexity along a DSS?	- Technological misalignments can appear between customers and service providers leading to undermined profitability - Challenges of Digital Servitization emerge simultaneously at the intra- and inter-organizational level - Time and space dimensions impact on the intra- and inter-organizational challenges and their interconnectedness - Digital Servitization challenges are paradoxical and difficult to solve - The digital dimension of servitization adds further intricacy
Where and when can manufacturing companies intervene to dissolve such complexity?	- Relying on trusted suppliers helps smoothening Digital Servitization complexity - Achieving balance between I4.0 knowledge outsourcing and internalization prevents risks of suppliers co-dependence - Digital services should rely on an intensified relationship with customers based on value co-creation - New, intermediate professional figures facilitate cross-functional communication - Useful are a flexible decisional process and a hybrid leadership style

2. Theoretical contributions

On the theoretical level, by addressing an exploratory research question and adopting a qualitative methodology based on single and multiple case studies, this work provides evidence on the effects of Digital Servitization in industrial markets, therefore contributing to enriching the current literature in multiple ways.

A first objective of this research was to investigate the diffusion mechanisms of I4.0-related knowledge within digitalization processes and observe the business model transformations led by the spread of I4.0 technologies.

For what concerns the investigation of the I4.0 diffusion mechanisms, this thesis answers the call of Babkin *et al.*, (2020) for a deeper investigation of it within industrial districts. By looking at how I4.0-related knowledge is spread between local firms and what are the mechanisms underlying such process, Chapter II contributes to increasing understanding on the impacts of I4.0 technologies within industrial clusters (Götz & Jankowska, 2017; Hervas-Oliver *et al.*, 2019). Building on previous literature on the topic (Lazzeretti & Capone, 2016; Leckel *et al.*, 2020), empirical findings contribute to prove that I4.0-related knowledge is disseminated at a cross-sectorial level between industrial companies and regardless of the geographic proximity. Dissemination mechanisms are characterized by high fragmentation in terms of initiatives and projects activated, and both deliberate and structured initiatives determine the activation of new, formal and informal interactions.

About the impacts of I.40 technologies in terms of new business models, results of Chapter II confirm previous literature. In particular, it is underlined that I4.0-related business model innovations are various (Mohamed, 2018) and they can be exploited by both SMEs and large firms (Müller *et al.*, 2018). Digital Servitization is confirmed as one of the major business model trends connected to I4.0, mainly via the application of IIoT technologies (Paiola & Gebauer, 2020). Digitalization and servitization work as 'enablers' of innovative business models (Klos *et al.*, 2021), via the exploitation of value appropriation, proposition, delivery, and networking.

A second objective of this thesis was to search for a holistic and more systemic approach in Digital Servitization studies.

In this sense, Chapter III and Chapter IV answer the call of Paschou *et al.* (2020), which addressed the issue of a way too fragmented Digital Servitization literature. On the one side, what derives from the two chapters is confirming the need for a comprehensive Digital Servitization perspective (Oztemel & Gursev, 2020; Paschou *et al.*, 2020). The performed literature review revealed a substantial fragmentation in terms of contents and theoretical approaches adopted to describe the phenomenon. Also, a silo-thinking approach emerged in depicting the main challenges of Digital Servitization at the intra and interfirm level.

On the other side, the empirical chapters contribute to experimenting innovative approaches to provide a systemic perspective on Digital Servitization.

Indeed, in Chapter III a theoretical multilevel framework for the investigation of Digital Servitization is defined and empirically tested. The framework originally combines a microfoundational, organizational, and network approach to define Digital Servitization as a multilevel phenomenon. Similarly, Chapter IV provides evidence of Digital Servitization tensions emerging clearly at the intra and interorganizational levels. It contributes to further building a multilevel approach in Digital Servitization, while offering an empirical framework to observe and analyse tensions deriving from it. By providing theoretical and empirical frameworks for the investigation of Digital Servitization strategies, this research contributes to widening the vision on the phenomenon and clearing the way to a multi-level approach, with the aim of building a strong awareness on the multifaced implications of servitizing activities.

A third objective of this research was related to understanding and disentangling the complexity levels inherent in Digital Servitization strategies. Trying to accomplish this aim, this thesis expands the existing knowledge on the Digital Servitization phenomenon in various ways.

Firstly, it addresses the calls of Rabetino *et al.* (2017) and Lenka (2018) for multilevel research on servitization strategies, as well as the call of Rabetino *et al.* (2018) for a deeper observation of organizational hurdles in servitization journeys. Chapter III provides a mid-range theory on Digital Servitization. Beyond confirming the high complexity of the strategy (Tronvoll *et al.*, 2020; Chen *et al.*, 2021), the developed theory witnesses how Digital Servitization barriers are interrelated, complex issues to which finding a unique, definite answer is unrealistic. By empirically demonstrating that Digital Servitization is a wicked problem made of interconnected hurdles that move along three different levels of analysis, an original perspective on Digital Servitization complexity is provided.

Secondly, this thesis addresses the call of Kohtamäki *et al.* (2020), who stress the need to deepen research on servitization challenges and add clearness on the paradoxical tensions deriving from them. Chapter IV, by combining servitization literature with the paradox theory lens (Bustinza *et al.*, 2018; Smith & Lewis, 2011), discerns Digital Servitization complexity into six intra and interorganizational tensions, for which finding proper solutions implies a challenging and intricate decisional process. The interrelatedness of tensions and their simultaneity of appearance is underlined by the study, contributing to trace an increasing complexity in the strategy development.

Thirdly, by untangling digitalization and servitization from a multilevel perspective, this thesis elaborates on the complexity that derives from paying

attention to both the organizational- and the context-related dimensions of the two phenomena.

In relation to the organizational aspects, this research contributes to expanding the existing knowledge in the Digital Servitization research stream. As it arises from the empirical analyses, between the organizational adaptations required to allow the functional development of a Digital Servitization strategy there is the achievement of a deep cultural change. Transitioning from a product-centric to a service-centric business model calls for the individual recognition of the value of services, and the consistent adaptation of organizational habits and routines. The sales model needs to be revised to include a service offering, while the salesforce incentives require to be aligned with it. The service department must be integrated into the firm's organigram and empowered. Roles and positions could be re-evaluated with a service-driven focus. The leadership model endures changes in relation to the individual and organizational response to the mutating environment.

For what concerns the interorganizational dimension, the role of external actors in determining the digitalization and servitization paths of industrial firms is underlined. Chapter II posits the attention on new forms of 'collective cooperation' in I4.0-related projects. It shows how they can stand for innovative mechanisms that directly contribute to the technological advancement of local organizations and the exploitation of social links in learning processes. A collective dimension in digitalization can become the key driver to rejuvenate local interaction processes and facilitate I4.0 innovation (Hervas-Oliver *et al.*, 2019). However, learning how to achieve networking 'openness' and a collaborative approach with external partners can be challenging. Chapters III and IV stress the paramount role of external actors in facilitating the transition toward a service-centric business model based on I4.0 technologies (Sklyar *et al.*, 2019), while highlighting the complexity deriving from the appearance of networking issues. Indeed, the investigated case studies manifest a common pattern of outsourcing when it comes to digital competences and managerial knowledge on the business model change. For all firms, outsourcing constituted a critical support to develop the servitizing business model, but also an origin of tensions related to relationship management.

Fourthly, the research contributes to identifying Digital Servitization complexity as linked to the digital dimension of the strategy. Indeed, Chapter IV underlines how the digitalization process inherent in Digital Servitization hinders its adoption by adding further complexity. Previous literature noticed how the digital component of servitization could both facilitate and hinder the fulfilment

of the strategy, since it expands the solutions offering with innovative and unique propositions (Solem *et al.*, 2021), but it also calls for new skills and changes within the network actors (Matthyssens, 2019; Salo *et al.*, 2021). Chapter IV supports the thesis that enhanced complexity throughout the Digital Servitization journey partly comes from the digital requirements, which include the development of specific organizational and network capabilities.

A fourth objective of this thesis was to further decompose Digital Servitization complexity by providing a processual view on it. The fruitful combination of a multilevel and longitudinal perspectives on digitalization and servitization helps in accomplishing such aim.

A simultaneously spatial and temporal analysis of Digital Servitization unveils an original view on the challenges and tensions emerging along the processes based on the concept of 'interconnectedness'. As both Chapter III and Chapter IV demonstrate, the obstacles in Digital Servitization strategies emerge at multiple levels and at various temporal stages of the strategy evolution. The journey of industrial firms is further intricated by the multiplicity and interrelatedness of such obstacles. Resistances or misalignments emerging from changes at one level of analysis inevitably impact on the other levels, potentially leading to new resistances arising in a vicious cycle dynamic.

Further building on the concept of 'interconnectedness', this research allows to underline how two managerial capabilities are essential in dealing with the complexity of Digital Servitization, therefore contributing to the expansion of literature on servitizing capabilities (Hasselblatt *et al.*, 2018; Coreynen *et al.*, 2020). The first one is the higher order capability of managing the interconnectedness within and between multiple levels. Each challenge posed by Digital Servitization should be evaluated in a multilevel perspective, avoiding unilateral thinking. The second one is the ability to iteratively take decisions and maintain flexibility in the decisional process. This is particularly relevant in consideration of the situational changes happening with time. Indeed, time has been proven to have a determinant role in the process, since the accumulation of varied obstacles from one stage of the strategy to the successive ones seriously undermines the strategy efficacy. Therefore, the consideration of time and space dimensions is crucial to understand Digital Servitization criticalities (Paiola & Gebauer, 2020; Coreynen *et al.*, 2017).

3. Managerial contributions

By contributing to expanding the existing knowledge on digitalization and servitization streams of research, this study entails relevant implications also at the managerial level. Suggestions for practitioners can be driven by this research from diverse points of view.

A first practical implication of this thesis concerns recognizing the paramount importance of networking activities to stimulate the diffusion of I4.0-related knowledge and facilitate the adoption of I4.0 technologies. As it was possible to observe within the case studies, involving an external partner to support I4.0 adoption can be crucial in smoothening the perceived complexity of technologies. However, choosing the right partner is far from easy. I4.0 knowledge providers should be recruited after an accurate selection process and in relation to the real digital needs of the company. Not only, 'openness' to other networking opportunities should be considered as a necessary firm capability. Even in case of stable partnerships in digital projects, new ventures and collaborations could emerge at any time, adding value to the project itself and strengthening the firm visibility and reputation. Managers should always seek for new collaboration opportunities with relevant actors, which can involve not only other organizations but also societal and institutional actors. Universities, for example, demonstrated to be an interesting partner to develop high-technical competence and gain the chance to co-participate in complex, knowledge-intensive business projects.

Despite the paramount role of partners supporting the digital transition, industrial companies should also internalize know-how derived from the key relationships to build a defendable competitive advantage and avoid co-dependence. It could be claimed that companies should make the effort to build new capabilities and reinforce the existing ones while transitioning toward I4.0 technologies. In this perspective, the ability to purposefully network relationships with external actors and the absorptive capacity to internalize technology- and business-related know-how are particularly valuable.

Secondly, empirical evidence emerged from this research highlights how establishing a cooperative relationship with industrial customers drastically helps in succeeding in Digital Servitization paths. It revealed of paramount importance within the examined case firms. Through a value co-creation approach, indeed, servitizing firms together with their customers can choose the I4.0 technology to invest in, design service offerings, and personalize them.

Concerning the choice of the technology underlying digital solutions, it should be partly based on what customers are 'ready' to accept and able to access. Otherwise, the risk of investing in an unsellable technology is increased. In particular, during the Digital Servitization strategy design, the firm can adopt a push technology-based approach consisting in choosing the technology that best suits the solutions provider necessities and skills. On the contrary, a pull technology-based approach relies on choosing the technology based on customers infrastructures, skills, and interests. Between the two options, managers should invest in the best technological approach given the intrafirm organizational circumstances, the best balance between service and digital prevalence (Ciasullo *et al.*, 2021), and the adaptability of the technology to the market scenario.

For what concerns the design and personalization of the service offering, cooperation with customers is effective to stimulate engagement, enhance the intrinsic value of the service offering and develop solutions which are effectively useful and supportive for customers. If managers underestimate the power of co-creation practices, they expose to the risk of 'self-referential' digital solutions, perceived by the market as empty in value.

Thirdly, this thesis provides both a theoretical framework (in Chapter III) and an empirical framework (in Chapter IV) to disentangle complexity inherent in Digital Servitization strategies. The application of such frameworks could support managers interested to invest in (or struggling with) it. A multilevel perspective on Digital Servitization helps in increasing the awareness of practitioners about the varied and interrelated impacts of the strategy. Within servitizing firms, an effort should be made to both enhance communication with supply chain partners and avoid informational asymmetries at the organizational level, to improve the firm's ability to manage interconnectedness between challenges and smoothen the transition toward digital services.

Since Digital Servitization involves simultaneously firm's employees (at the microfoundational level), its various functions (at the organizational level), and external actors (at the network level), the need for intermediate figures able to facilitate cross-functional communication arises. At the individual level, managers could acquire new resources in charge of mediating needs and requests of the functions involved in the digital servitizing change. New middle managers with a coordination role become highly relevant. They contribute to reduce the emergence of resistances at the organizational level. Supporting them, the establishment of a transversal team or even function supports the process of accepting a service-oriented business model. For example, constituting a Digital Services function made of professional figures (new or readdressed ones) with

multifaced abilities and different backgrounds will help smoothening hurdles emerging at the three Digital Servitization layers.

Moreover, while recognizing that Digital Servitization is a journey which requires long time before leading to an effective service-oriented business model, managers should constantly monitor the challenges and tensions emerging from the strategy and apply an iterative decisional process. Avoiding unilateral, silo-thinking is critical to facilitate the Digital Servitization development and limit the appearance of additional obstacles, especially at the organizational level. Between them, there is the risk of services reluctance coming from the individual level and hindering the Digital Servitization cultural change. As a consequence, accepting the empowerment of the service function could become challenging and give rise to severe oppositions. Resistances can also emerge in relation to the adopted leadership model, especially when it embraces a top-down direction without engaging the lowest hierarchical levels.

To effectively deal with such resistances, managers can activate specific solutions, as the balanced combination of top-down and bottom-up initiatives within the adopted leadership model, the gradual empowerment of the service function supported by a well-designed internal communication campaign, or a calendar of initiatives to stimulate employees' engagement and a cooperative approach. Most importantly, managers should assimilate two critical capabilities to handle Digital Servitization. One the one side, they should work on what we defined as the 'higher order' capability of managing interconnectedness within and between the multiple levels of Digital Servitization implications. On the other side, it is critical to achieve the capability of maintaining a flexible and iterative decisional process while dealing with Digital Servitization tensions.

4. Limitations and future research avenues

After the in-depth investigation of digitalization and servitization provided along this research study, it is possible to depict new research avenues. Some of them can be derived from the limitations of this research, while others emerge while reflecting on the provided results.

On the one side, this research presents some limitations, and they can encourage future research. The first limitation is related to the adopted methodology, which relies on a qualitative approach. The choice of a qualitative methodology is justified by the exploratory research question and the recent nature of the investigated phenomena. Indeed, qualitative research is suitable to

analyse contemporary, under-explored phenomena (Crick, 2021) with a wide perspective including the context surrounding them (Yin, 2009; Meyer, 2001; Lindgreen *et al.*, 2021). Nevertheless, additional studies on digitalization and servitization could provide a quantitative methodological approach to support the empirical findings of the qualitative studies and their generalization (Paiola & Gebauer, 2020). Also, a mixed methods approach could be consistent with the aim of both investigating the topics in-depth and with a contextual analysis and achieving generalizable results.

A second limitation of this research links to the explored contexts in which digitalization and servitization happen. Indeed, the chosen empirical case studies involve companies that recently embarked on the digitalization or Digital Servitization journeys. In all cases, the transition toward a digital, servitized business model was still ongoing at the time of investigation. Although this allowed to provide accurate data and avoid information biased by unperfected memories (Lindgreen *et al.*, 2021), future research could benefit from studies evaluating the phenomena ex-post, i.e., after their full development. Considering the challenges and implications of Digital Servitization with a shrunken focus on the initial stages of change could be limiting; an ex-post analysis is likely to add precious information to disentangle the implied complexity (Chen *et al.*, 2021).

A third limitation links to the sectors investigated. Indeed, along this research project it was possible to convey a limited number of empirical analyses, which involved mainly the wood-furniture sector. It would be interesting to research a wider variety of contexts and sectors, with the aim of witnessing eventual differences and understanding their causes (Gebauer *et al.*, 2021).

Lastly, a further limitation of the study relates to the impacts of digitalization and servitization in terms of business model innovations. Indeed, notwithstanding the interest this research addressed toward the issue, it was not the primary aim of the study and therefore it has been analysed partially and from a limited perspective. Considering the high level of diffusion of digitalization and servitization and the wide range of innovation possibilities they offer to manufacturers, it is of great interest to deepen the topic with future research.

On the other side, building from the empirical evidence provided in this research, it is possible to glimpse future research streams that it was not possible to deepen within this study.

The first element of attention arising from this research is connected to what already highlighted by Paschou *et al.* (2020), i.e., the high fragmentation in the theoretical approaches adopted to investigate Digital Servitization. The effort of this research to elaborate on a multilevel and multi-actor perspective on the

phenomenon contributes to partly addressing this issue; however, further improvements are possible and necessary. Particularly, we observed as the Digital Servitization path presents several implications at the network level. Nevertheless, the available approaches to inquire relationships within the network are multiple and varied. For instance, Digital Servitization has been in some cases framed in the context of service ecosystems (Sklyar *et al.*, 2019; Kohtamäki *et al.*, 2019), which flow into the Service Dominant Logic (SDL) approach (Vargo & Lusch, 2017). In few cases, it has been defined within the context of business networks (Raddats *et al.*, 2019; Kamalaldin *et al.*, 2020) belonging to the Industrial Marketing and Purchasing (IMP) studies (Håkansson & Snehota, 1995; Håkansson *et al.*, 2009). We believe that the business networks approach can constitute a valid framework to rely on when investigating Digital Servitization. Additional research would contribute to elaborate more on this.

A second emerging research area is related to the institutional and societal environment in which digitalization and servitization happen. The multiple case study deployed in Chapter III includes two firms operating in different contexts, where various institutional aids and networking opportunities could influence the two firms' transition path. Unfortunately, it was not possible to observe in detail the differences characterizing the environment surrounding the two case studies, but it could constitute a remarkable objective for future research (Gomes *et al.*, 2021). Not only the environment per se is an interesting research focus, but also the role of the actors populating it. Institutions, no-profit organizations, competitors, and other stakeholders could be involved in digitalization and servitization and contribute to determining their diffusion levels in specific geographical areas. Collective actions could happen, and it would be useful to investigate more on them (Hervas-Oliver *et al.*, 2019).

A third contribution for future research gathered from this thesis concerns the adoption of a customer perspective. The provided empirical results highlight how the customer perspective is of critical importance within a Digital Servitization journey. Vaittinen and Martinsuo (2019), in the attempt of untangling the customer perspective on servitization processes, elaborate the concept of customer 'organizational readiness for advanced services' to indicate the organizational effort required by customers to accept, adopt, and benefit from advanced services. The authors identify the aspects influencing customers' readiness: the service context, the nature of the relationships with suppliers, the organizational habits, and the internal culture. Interestingly, literature on this topic is still very limited. Future studies could address this issue and try to shed light on the role and perspective of customers in Digital Servitization transitions.

A fourth aspect of Digital Servitization that deserves further attention is related to the emergence of innovative, cross-functional professional figures and the role of middle management in leading the transition. As it was possible to observe within Chapter IV, middle management acquires a central position in managing resistances and acting as a 'filter' between the scepticism of employees on the one side, and the imperative approach of the top management on the other. At the same time, introducing new, cross-functional professional figures as a Service Innovation Director can support the transition toward a service-oriented business model. Future research could benefit from an in-depth analysis of the rejuvenating role of middle management (Stathakopoulos *et al.*, 2019) and from the investigation of new professional figures emerging as a result of digitalization and servitization. Such contribution would be of paramount importance in enhancing new knowledge on the topic and address relevant implications for practitioners.

Finally, one last element that could still be investigated within digitalization and servitization studies is related to the exploration of new technologies and their implications in wider terms. Given the broad variety of technologies belonging to the I4.0 field (Oztemel & Gursev, 2020; Pereira & Romero, 2017), it would be interesting to discover the potentiality of all of them and their different implications, in order to support practitioners in choosing the best technology to implement. With regard to the implications of I4.0 technologies, it will be useful to clear the way for innovative studies in digitalization, which answer the main calls of contemporary markets. Since sustainability is becoming the centre of major business decisions (Sharma, 2020), analysing the various impacts of different technologies on the sustainability report of industrial firms is determinant. Practitioners could benefit from future research on sustainability-related issues in digitalization and servitization to take more aware choices within the current race for competitiveness.

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