Managing digital servitization toward smart solutions: Framing the connections between technologies, business models, and ecosystems

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MANAGING DIGITAL SERVITIZATION TOWARD SMART SOLUTIONS: FRAMING THE CONNECTIONS BETWEEN TECHNOLOGIES, BUSINESS MODELS, AND ECOSYSTEMS

Marko Kohtamäki, Rodrigo Rabetino, Vinit Parida, David Sjödin & Stephan Henneberg

Abstract

The present study extends the discussion on product manufacturers' digital servitization toward smart solutions by outlining and reviewing the existing literature on digital servitization and smart solutions. We focus on potential configurations based on technologies, business models, and ecosystems to understand how this transition can be managed through the process of reconfiguration. We define smart solutions as an advanced state of product-service-software systems, and we use moving vehicles as a case in point. We base our discussion on a configurational research approach, examining the role of advanced technologies (e.g., artificial intelligence), novel business models, and modern ecosystems (e.g., platforms and innovation ecosystems) in shaping digital servitization toward smart and autonomous solutions. We identify gaps in the literature, offer an analytical framework, suggest avenues for future research, and contribute by laying the theoretical foundations and proposing managerial directions for a digital servitization journey toward smart solutions. By so doing, we present the papers accepted to the current IMM special issue on "Moving toward autonomous solutions: The role of Product-Service-Software Systems", which this review article introduces.

Keywords: Digital servitization, business model configurations and business model innovation, smart product-service systems (PSS) and smart solutions, artificial intelligence and autonomous solutions, platforms and sustainability

1. Introduction

Rapid digitalization is creating radical changes in product-service-software technologies, business models, and the very nature of business activities in industrial ecosystems that embrace the logic of digital servitization (Iansiti & Lakhani, 2020; Sklyar, Kowalkowski, Sörhammar, et al., 2019). Specifically, we are witnessing a significant transformation in technologies, capabilities, strategies, business models, and ecosystems to create, deliver, and capture value from a broad range of enabling digital technologies such as the Internet of Things (IoT), big data, artificial intelligence (AI), and cloud computing (Sjödin, Parida, Kohtamäki, & Wincent, 2020: 478). The digital servitization literature describes the transition from product manufacturing toward offering smart solutions (product-service-software systems) by enabling value creation and capture through monitoring, controlling, optimizing, and autonomous functioning (Porter & Heppelmann, 2015). The advanced stages of digital servitization can be witnessed in industries such as shipping, transportation, and mining (e.g., ships, cars, trucks, haulers) (Thomson et al., 2022). For example, Kongsberg Maritime is developing large-scale autonomous shipping solutions, while Scania is testing autonomously operating trucks in closed-off industrial sites. This represents the most advanced stage of digital servitization. Nevertheless, remarkably little is known about the journey and practices of transforming toward smart solutions (Kohtamäki, Parida, et al., 2019).

Digital servitization as a transition has become prevalent in many industries, covering both for-profit firms and public and non-profit actors, who often collaborate to create an ecosystem that enables smart solutions – for example, extending to autonomous solutions such as self-driving vehicles and drones. Various industries, such as automobiles, logistics, manufacturing, forestry, farming, and design, currently develop or use products that already have some degree of autonomy and will continue to more complete autonomous functionalities that

enhance customer experiences and enable higher productivity and profitability. The transition toward such smart solutions is ongoing, and some would claim that the transformation is inevitable. Moreover, this transition will significantly impact business models – for instance, creating new opportunities for platform business models, such as car-sharing services that have lowered employee costs from driverless transport. Despite the apparent significance of this change, theorizing on this journey of digital servitization toward smart solutions remains limited (Rabetino, Kohtamäki, Brax, et al., 2021).

We seek to extend theory on the appropriate paths to smart solutions by reviewing the existing management literature. Much research exists on the concept of servitization, a literature stream that has now expanded to cover approximately 800 scientific articles (Kohtamäki, Baines, et al., 2021; Rabetino, Kohtamäki, Brax, et al., 2021). Our study focuses on a sub-stream of servitization: digital servitization, which includes 261 studies. The concept of digital servitization describes how a development toward smart solutions fundamentally changes the role of products, services, and software while changing industry structures and business models from a product logic to a service logic (Kowalkowski et al., 2017). The digital servitization literature stream has begun to uncover this interplay between product, service, and software components in smart solutions (Hsuan et al., 2021; Huikkola, Kohtamäki, Rabetino, et al., 2022a; Kohtamäki, Parida, et al., 2019), but there is an obvious lacuna in its coverage. This gap is problematic because theorizing about the journey of digital servitization is essential if the transformation to smart solutions is to be achieved.

We base our discussions on three interlocking content domains – business models, technologies, and ecosystems – to extend current theorizing on digital servitization and smart solutions. A vast amount of research exists on these concepts as separate fields of business research. Nevertheless, if considered in the context of smart solutions, these literature streams

remain scattered. Nonetheless, the digital servitization literature provides a solid ground on which to theorize about the various configurations of business models, technologies, and ecosystems (Kohtamäki, Parida, et al., 2019; Kohtamäki, Rabetino, et al., 2021; Thomson et al., 2022), as the interplay between the micro, meso, and macro dimensions of the economy shape the evolving landscape of product manufacturing companies. The divergence in the existing literature represents a significant drawback because the transition toward smart solutions (e.g., autonomous solutions) often requires effective collaboration between ecosystem actors to innovate and, thus, ensure their business models and technologies fit within the ecosystems so that smart solutions can be deployed successfully. Hence, a meaningful emphasis should be placed on how the ecosystem (business environment), the business model (strategy), and the product-service-software technologies (structure) are configured as part of an environment-strategy-structure fit (Kohtamäki, Henneberg, et al., 2019). Thus, providing this integrative perspective on smart solutions is the goal of our conceptual study.

The present study addresses this aim by scrutinizing the digital servitization literature and related literature streams in pertinent domains to provide an overview of the journey toward smart solutions. More specifically, our study addresses the following research question: How does the digital servitization path toward smart solutions unfold, and what are the business model configurations, technologies, and ecosystems on the path toward smart solutions? By answering this question, we contribute to the discussion on digital servitization business models by reviewing the digital servitization literature, scrutinizing the concept of digital servitization, and discussing the digital servitization journey. In consequence, we intend to advance the theoretical debate on digital servitization toward smart solutions by using the concepts of i) business model configurations, ii) product-service-software technologies, and iii) business ecosystems as the building blocks of a theory of digital servitization (Kohtamäki, Rabetino, et al., 2021; Thomson

et al., 2022). These three dimensions create a model that enables theorizing on the configurations required to move along the digital servitization path. Such a theory development allows us to address the macro-micro interplay between the institutional structures at the business environment level and the business-model-related socio-material practices at the firm level. In addition, we provide a critical perspective on the existing knowledge base and present ten suggestions for future research. Finally, we introduce the studies published in the IMM special issue on "Moving toward autonomous solutions: The role of Product-Service-Software Systems".

2. Literature analysis design

In our literature review, we searched for articles based on two search strings combined into one search – namely, servitization and digitalization. For the servitization search string, we used the keywords of "service infusion*", "servitization*", "servitisation*", "service transition*", and "service transformation*". For digitalization, we used the keywords of "digital", "internet-of-things", "internet of things", "IOT", "remote", "industry 4.0", "smart solution", "smart product", "autonomous solution*", "artificial intelligence", and "AI". The search was run using the Scopus database and all academic journals published in English. It produced 261 hits, which were to find which sources placed significant emphasis on digitalization in the context of the servitization of manufacturing companies. We complemented the search by adding seminal papers on servitization and product–service systems because they provide an important conceptual grounding for discussing business models and their transformation process.

For the conceptual analysis of the scrutinized papers, we used Leximancer™ 4.5 and a Bayesian learning algorithm that computes the "degree of semantical relatedness" (Wilden et al., 2019: 1574). The software allows complex relationships between concepts in the analysis to be

visualized. With the help of this semantic analysis, we have endeavored to obtain an initial understanding of the interplay between servitization and digitalization in the literature.

3. Conceptual findings

3.1. The evolution of digital servitization toward smart solutions

The roots of the digital servitization concept can be traced to the servitization literature, which was first conceptualized by Vandermerwe and Rada (1988). Since then, multiple related concepts have been proposed, such as product-service systems (PSS), integrated solutions, and customer solutions (Rabetino, Kohtamäki, Brax, et al., 2021). Both the (digital) servitization and the PSS literature streams start from the vantage point of the offering and its underlying value-creation logic and focus on the transition from a product logic (emphasis on the product) to a service logic (emphasis on value) (Kohtamäki, Baines, et al., 2021; Kowalkowski et al., 2017). The concept of product-service-software systems adds the software element to such considerations to emphasize the role of software in providing the core component of many offerings in the digital era (Kohtamäki, Parida, et al., 2019). The pivotal role of data has been evident in the servitization literature since its infancy (Vandermerwe & Rada, 1988). However, scholars have recently begun to reshape this emphasis on digitalization and software to reflect the rapid change in manufacturing companies toward digital architectures and solutions (Hsuan et al., 2021; Huikkola, Kohtamäki, Rabetino, et al., 2022a). For instance, Huikkola et al. (2022) highlight the alignment between the manufacturer's innovation processes related to products, services, and software. Figure 1 illustrates the evolution of the digital servitization literature from two integrating perspectives: i) digital (software on the left-hand side of the figure) and servitization (product-service systems on the right-hand side of the figure). The figure addresses the emerging

interplay between digitalization and servitization, the evolution from servitization to digital servitization, and the role of smart solutions in digital servitization in its advanced state.

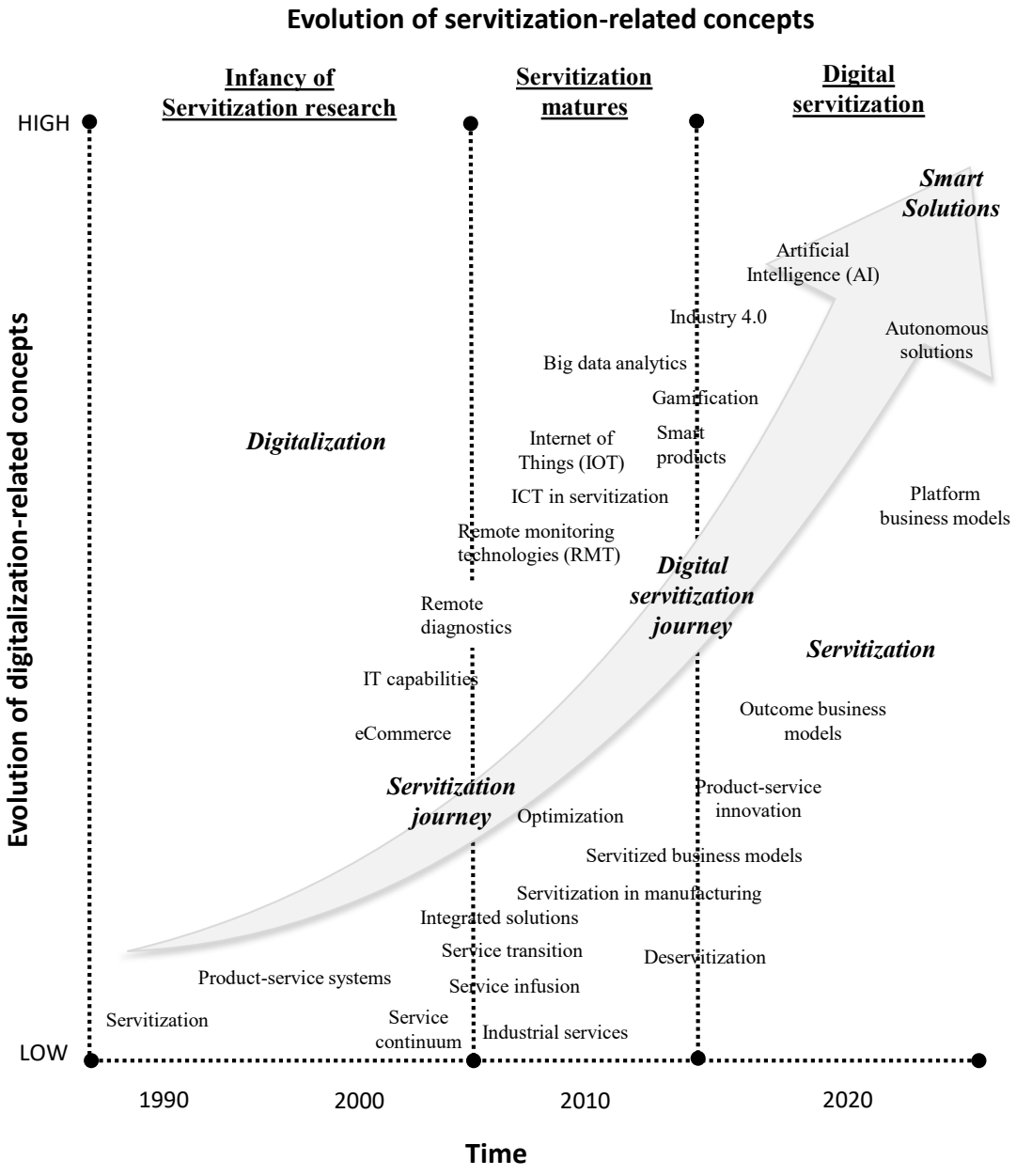

Figure 1. The evolution of the digital servitization concept

3.2. Defining digital servitization and smart solutions

The concept of digital servitization has been evolving as part of the interplay in discussions over digitalization and servitization. While digitalization provides a critical technological enabler for new types of smart solutions (e.g., via smart sensors, digital twins, and digital threads), servitized business models provide the logic and strategies for capturing value from digital technologies (Gebauer et al., 2020). These positive interactions between means (digitalization) and ends (servitization) are envisioned to increase sales and profits in the manufacturing sector.

Earlier studies of digital servitization show the conceptual richness or, in other words, provide no clear and agreed definitions of the concept. However, most studies populate the conceptual sphere of digital servitization by referring to product technologies, software and data, and infusion of services into the offering. The roots of the digital servitization discussion are found in the servitization research, where studies have increasingly analyzed the role of software – for example, in remote monitoring technology and remote diagnostics – to enable preventive maintenance services (Brax & Jonsson, 2009; Grubic, 2018). Porter and Heppelmann (2015) used smart products while others have suggested the concept of smart solutions to encapsulate the resulting product-service-software systems for servitization (Kohtamäki, Parida, et al., 2019). Figure 1 suggests that the concept of smart solutions represents one kind of future state for advanced product-service-software systems. Table 1 offers an overview of definitions of digital servitization and related concepts.

Table 1. Defining digital servitization and related concepts (see Kohtamäki, Baines, et al., 2021).

Researchers	Definition
Kohtamäki, Parida, et al. (2019)	<u>Digital servitization</u> The transition toward smart solutions (product-service-software systems) enables value creation and capture through monitoring, controlling, optimizing, and automatic functioning. Digital servitization emphasizes value creation through the interplay of products, services, and software.

Porter & Heppelmann, (2015: 4)	Smart product *"… smart, connected products, from home appliances to industrial equipment, share three core elements: physical components (such as mechanical and electrical parts); smart components (sensors, microprocessors, data storage, controls, software, an embedded operating system, and a digital user interface); and connectivity components (ports, antennae, protocols, and networks that enable communication between the product and the product cloud, which runs on remote servers and contains the product's external operating system)."*
Baines et al., (2007: 3)	Product–service system (PSS) PSS is *"an integrated product and service offering that delivers value in use. A PSS offers the opportunity to decouple economic success from material consumption and hence reduce the environmental impact of economic activity."*
Sawhney (2006: 369)	Customer solution *"…an integrated combination of products and services customized for a set of customers that allows customers to achieve better outcomes than the sum of the individual components."*
Brady et al., (2005: 572)	Integrated solutions *"…bringing together of products and services in order to address a customer's particular business or operational requirements."*
SAE International (2013: 26)	Autonomous solutions *"…that have the ability and authority to make decisions independently and self-sufficiently. Over time, this usage was casually broadened to not only encompass decision making, but to represent the entire system functionality, thereby becoming synonymous with automated. This usage obscures the question of whether a so-called "autonomous vehicle" depends on communication and/or cooperation with outside entities for important functionality (such as data acquisition and collection). Some driving automation systems may indeed be autonomous if they perform all of their functions independently and self-sufficiently, but if they depend on communication and/or cooperation with outside entities, they should be considered cooperative rather than autonomous."*
Gartner glossary (2020: 1)	Digitalization *"Digitalization is the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business."*
Coreynen et al., (2017: 3)	Digitization *"Digitization refers to the increasing use of digital technologies for connecting people, systems, companies, products and services (Hsu, 2007), a trend which offers a number of opportunities for manufacturers."*
Grubic & Peppard (2016: 157)	Remote Monitoring Technology (RMT) *"Remote monitoring technology is a combination of principle software and hardware technologies which enable remote collection of data about the performance and usage of a product in the field to determine its current and predicted condition and health."*
Sjödin, Parida, Kohtamäki, and Wincent (2020: 478)	Digital servitization *"… the transformation in processes, capabilities, and offerings within industrial firms and their associate ecosystems to progressively create, deliver, and capture increased service value arising from a broad range of enabling digital technologies."*

We identified the central themes (clusters) and concepts in the literature by using Leximancer™ 4.5 to understand how the existing articles conceptualize the digital servitization field. This analysis reveals the primary dimensions of the rapidly growing digital servitization literature. The five emerging themes include digitalization, servitization, service delivery,

performance, and ecosystem concepts. Indeed, these clusters of concepts show three main critical dimensions in digital servitization and the transition to smart solutions (dimensions of Figure 2 in brackets): i) technology (digitalization); ii) business models (servitization, service delivery, and performance), and iii) ecosystems (ecosystem) (Figure 2). Notably, digitalization (technology) and ecosystems emerged separately, emphasizing their role in digital servitization toward smart solutions. First, the technology and data-related concepts can be found under the theme of digitalization. It shows how the literature includes a specific discussion on technical aspects, such as installed base data, remote monitoring, diagnostics, control and optimization, and smart connected products and solutions, among others (e.g., IoT, information, analytics, sensors, data-driven, database, cloud, online, real-time, communication, intelligence, computing, internet, automation, and autonomous). The technical discussion is complemented by considering the business models required to exploit the potential of digital technologies. In doing so, the literature reflects the broader debate on the transformation toward a digital business model and the transition of a manufacturer toward a software-enabled company.

Second, three clusters portray the business model notion based on Gassmann et al.'s (2014) conceptualization (who, what, how, and why): servitization, service delivery, and performance. This emphasis shows the centrality of this concept in the digital servitization literature. The servitization theme includes different concepts that stand for the strategy (e.g., strategy, BM) concerning alternative pathways to create a competitive advantage (e.g., advantage, opportunities, pathways, transition, transformation), the need for fit (e.g., configuration, fit) and organizational transformation (e.g., culture, identity, and boundaries), and the main barriers during the transition (e.g., barriers, paradox, paradoxes, and tensions) (Kohtamäki, Einola, et al., 2020; Korkeamäki et al., 2022). Notably, these strategies increasingly meet environmental concerns (e.g., sustainability, circular, environment). Instead, service

delivery captures the terms related to service operations (e.g., operations, implementation, management, resources, capabilities, modular, planning, coordination, platform, back end, front end, and efficiency). Alternatively, the performance cluster shows how (digital) servitization research is likely to emphasize performance explicitly, including a first stage on whether digital servitization relates to performance and a later study on that relationship. Indeed, the cluster includes concepts related to firm financial performance as an effect of digital servitization (e.g., profit, revenue, costs, margin, risk, financial, price, economic, and returns). It also links the performance-related concepts to the outcome-based business model, among the more advanced value-capture mechanisms (e.g., outcomes, output, contracts, agreements, availability, incentives, pay, and ownership).

Finally, as recounted earlier, the mere existence of the separate cluster for ecosystems communicates the prominence of the ecosystem concept in the digital servitization literature. This reflects the surrounding business environment as a macro-level dimension, which has become key in digital servitization in determining how emerging digitally-enabled business models can exploit value-creation and appropriation opportunities. The relevance of the ecosystem concept is manifested in the thematic clusters of various related concepts emphasizing the role of different types of stakeholders (e.g., ecosystem, orchestration, network, collaboration, co-creation, cooperation, actors, players, partners, institutional, and public).

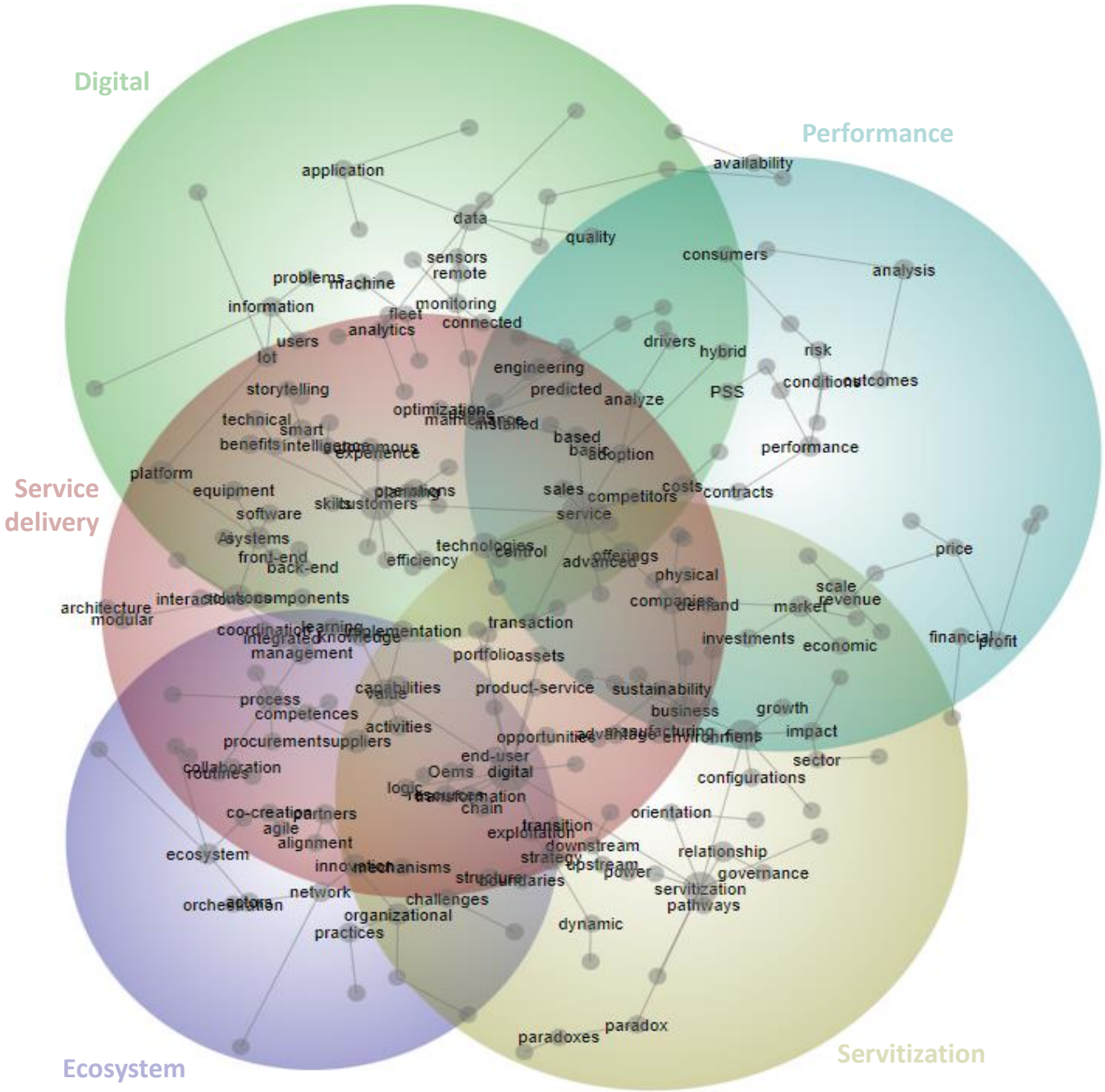

Figure 2. Conceptualizing the digital servitization literature.

In short, the literature on digital servitization has been articulated by building on the servitization literature and emphasizing digitalization and the enabling role of software (Kohtamäki, Parida, et al., 2020; Rabetino, Kohtamäki, Kowalkowski, et al., 2021). For an

extensive analysis of the tribes in servitization, see Rabetino et al. (Rabetino, Kohtamäki, Brax, et al., 2021). In this context, we define digital servitization as a *transition toward smart, sustainable product-service systems that enable value creation and capture through monitoring, controlling, optimizing, and autonomous functioning.* In this definition, smart refers to the software, whereas sustainable product-service systems refer to the solution, suggesting that product–service-software systems = smart solutions.

4. Digital servitization – technologies, business models, and ecosystems

4.1. Role of product-service-software technologies in digital servitization transformation

In research on product manufacturing firms' digital servitization toward smart solutions, the literature on various technological applications is extensive. We can scrutinize major studies that link technological concepts to the broader field of business models and ecosystems. The vast quantity of literature covers a variety of sensors and radars, data processing techniques, and location technologies that offer a variety of smart solutions, including autonomous vehicles, ships, cranes, and other types of solutions (e.g., moving objects to determine their location and achieve situational awareness). Each specific technological application involves a particular field of research and, hence, these fields cannot be adequately covered here. Instead, we will concentrate on a technical overview of the landscape and its relation to business models and ecosystems.

Digital servitization research provides valuable guidance on developing technologies for the digital servitization journey. Table 3 illustrates a set of studies under the label of digital servitization, which furnishes some examples of the technological development in digital servitization toward autonomous solutions. Grubic and Peppard's (2016) study explains the

concept of remote monitoring technologies in digital servitization. Thomson et al. (2022) provide a maturity framework and the primary technological components for autonomous solutions as part of technology, business model, and ecosystem framework. Sjödin et al. (2016) identify capability configurations of viable advanced services, Cenamor et al. (2017) pinpoint critical technological investments, and Hasselblatt et al. (2018) emphasize IoT-related technological capabilities in digital servitization. Sjödin et al. (2021) underline the role of various AI-related technological capabilities. Jovanovic et al. (2021) emphasize digital platform-related technological solutions. Overall, digital servitization is ubiquitous from a technological standpoint, including many different emerging technological streams of research.

Table 2. Studies on technologies related to digital servitization.

Study	Identified digital capabilities	Findings
Grubic and Peppard (2016)	1) Sense, 2) Acquire, 3) Transfer, 4) Analyze, 5) Act	The study identifies multiple factors that shape the exploitation of remote monitoring in servitization.
Thomson et al. (2022)	1) Assistive solutions with real-time information, 2) High-volume, low-complexity tasks, remote operation and operator capabilities, 3) Advanced traffic control with AI managing high-complexity tasks	This study contributes by conducting an empirical study of autonomous solutions and capturing many components related to technology development, ecosystem configuration, and business model design.
Sjödin, Parida, and Kohtamäki (2016)	Identifies capability configurations of advanced services of product manufacturing companies: 1) digitalization capabilities, 2) service development capabilities, 3) network management capabilities, 4) mass service customization capabilities	The study uses fuzzy-set qualitative comparative analysis to identify four capability configurations that enable the successful provision of advanced services.
Cenamor, Sjödin, and Parida (2017)	1) Invest in building intelligent and connected IT functionalities, 2) Automate basic data analysis and support for advanced service offerings, 3) Build internal skills to support new platform functionalities, 4) Form a digital bridge between back-end and regional front-end functions, 5) Develop tools for real-time decision making and market intelligence, 6) Enable front-end actors to develop and offer locally relevant functionalities	This study identifies critical technology investments for leveraging a digital platform approach in servitization.
Hasselblatt, Huikkola, and Kohtamäki (2018)	1) Digital business model development, 2) Platform scalability, 3) IOT selling and 4) Value delivery, 5) Business intelligence	The study identified the capabilities required for internet-of-things, emphasizing value creation and capture when creating the IoT in digital servitization.
Sjödin, Parida, Palmie, and Wincent (2021)	AI capabilities relating to 1) Data pipeline capabilities, 2) Algorithm development capabilities, and 3) AI democratization capabilities	This study emphasizes the critical role of interdependent AI capabilities in advancing to higher levels of digital servitization.
Jovanovic, Sjödin, and Parida (2021)	Identifies vital components of digital platform technology architecture: 1) product	The study focuses on digital platforms in manufacturing contexts, integrating platform

	data collection, 2) analytics utilization, and 3) AI enablement	services, platform architecture, and platform governance into a frame of platform value creation.

4.2. Understanding digital servitization business models

Table 4 outlines existing business model typologies from servitization and digital servitization research. The analysis shows that 58 out of 221 studies on digital servitization use the business model concept as a central focus of their argument, underlining its importance in the literature. To understand the variety of uses of the business model concept in the literature, we decided to synthesize the 58 studies according to the business model dimensions, the "ideal-typical" business models they outline[1], and their primary findings. Our approach is based on a configurational inquiry system and the idea of equifinality, which suggest that various (but not infinite) configurations of specific business model dimensions may lead to optimal outcomes. Hence, the key is to find an appropriate fit between the dimensions (Fiss, 2007; Forkmann, Henneberg, et al., 2017; Kohtamäki, Henneberg, et al., 2019).

Table 3. Business model typologies from servitization to digital servitization research.

Study	**Business model dimensions**	**Ideal-typical business models**	**Findings**
Frank, Mendes, Ayala, and Ghezzi (2019)	Servitization: smoothing, adapting, substituting services Digitalization: low, moderate, high level of digitalization	Two business model types: 1) Process and customer-oriented, 2) Customer-oriented	The study identifies nine digital service configurations and two business model innovation types.
Kowalkowski, Windahl, Kindström, and Gebauer (2015)	1) Business growth, customer loyalty, stable revenues 2) Customer demand, differentiation, partnership potential, customer lock-in 3) Scale economies, in-house resources, potential to address a more extensive customer base	1) Availability provider, 2) Performance provider, 3) Industrializer	Firms need to balance growth and standardization. Firms should also manage the co-existence of different roles.
Huikkola and Kohtamäki (2018)	1) Process ownership 2) Product vs. process 3) Primary customer segments 4) Examples of services 5) customer value proposition	1) Product business model, 2) Service-agreement business model, 3) Process-oriented business model, 4) Performance-oriented business model	The paper depicts four ideal-typical business models and describes their basic characteristics. Paper uses solution providers as illustrative case examples.

[1] The concept of ideal type is drawn from Max Weber, who used the concept of ideal-typical to denote a concept – in this case, a business model – to describe something that is an ideal description of a specific type in an empirical reality, to create a series of types – called a typology.

	6) Profit formula 7) Key resources 8) Rationale 9) Examples of solutions 10) Time frame for deals		
Kohtamäki, Parida, et al. (2019)	1) Digitalization, 2) Pricing logic, 3) Level of solution customization	1) Product provider, 2) Industrializer, 3) Customized integrated solution provider, 4) Outcome provider, 5) Platform provider	The paper depicts how digital servitization business models in ecosystems vary in strategic positioning, strategic identity, strategic capabilities, and transaction costs.
Paiola and Gebauer (2020)	1) Services type, 2) Service orientation toward technology	1) Product, 2) Process, 3) Outcome	Paper identifies opportunities and challenges of the process and outcome-oriented business models in digital servitization.
Parida, Sjödin, and Reim (2019)	1) Value creation, 2) Value delivery, and 3) Value capture	1) Add on services, 2) Optimization service, 3) Digital platforms, 4) Outcome-based services	The paper identifies current knowledge and future research directions for digitalization-enabled business model innovation.

Based on earlier research, the ideal types identified by earlier studies also exist in the empirical world and, consequently, are viable. The underlying equifinality assumption of these ideal types holds in the servitization and digital servitization literature – that is to say, various business model configurations can lead to optimal outcomes. There is no one path or trajectory to success (Fiss, 2007; Forkmann, Ramos, et al., 2017; Sjödin et al., 2016) or failure, suggesting that a company can succeed or fail in many ways. Thus, when building a business model, a company should align not only the dimensions of customer need, strategy, and structure but also the business environment (Kohtamäki, Henneberg, et al., 2019). One of the current challenges of business model theorizing in digital servitization is the tendency to neglect the business environment. The literature outlines five business model configurations as ideal types, which we refer to as (Kohtamäki et al., 2019) i) product provider, ii) industrializer, iii) customized integrated solution provider, iv) outcome provider, and v) platform provider. We develop the previously established BM typology from the perspective of autonomous solutions, suggesting particular opportunities for platform orchestrators, such as driverless car-sharing services. Obviously, autonomous operation would greatly benefit a variety of outcome business models, as well as provide additional features for more product-focused, value-creation models.

Table 4. Crafting business model configurations in digital servitization.

Dimensions	Business models				
	Product provider	**Industrializer**	**Solution provider**	**Outcome provider**	**Platform orchestrator**
Description of the business model	Provision of standardized products and add-on services	Modular product offerings and service agreements	Customized /modular product-service systems with some performance guarantees or operational services. Provision of availability.	Customized /modular product-service systems owned by the manufacturer, performance pricing predominantly.	Services-dominant business model, where the platform provider enables provider–customer interactions and sharing services.
Integrating concepts/models from the literature	Products + add-on services, equipment supplier	System supplier	Availability provider, system integrator	Performance provider, outcome business model (OBM)	Platform business model
The role of technology development	Some smart features based on remote diagnostics	The efficient use of some remote diagnostics features, typically related to monitoring, diagnostics, and proactive maintenance	Remote diagnostics enable the provision of availability, requiring effective monitoring, control, and optimization—using new data sources.	Remote diagnostics enable monitor, control, optimization, and autonomous operation	The digital platform enables effective interactions. The operator may monitor, control, optimize, and provide ecosystem enabling autonomous products (e.g., vehicles). Intention to utilize autonomous solutions
The role of the evolving business ecosystem	Traditional vertical product supply system	Modularity assists in more efficient product-service customization through the supply chain.	Networked forms of collaboration for constant innovation regarding complex integrated solutions	Integrated relationships between outcome providers and their customers	Strong ecosystem leadership from the platform leader company (e.g., Apple, Airbnb), a large volume of customers attracting a volume of suppliers, two-sided market approach
Who is the customer?	A traditional product customer who wants to own and maintain the products.	A conventional product customer who needs a service agreement with the manufacturer. Buys relatively standard product(s) and maintenance.	A customer who appreciates extensive customization of the solution. May buy availability as part of the maintenance agreement.	A customer who buys purely availability, not the product, appreciates a fully operational fleet and pays for performance, outcome, and availability.	A customer who buys an outcome and may not care who delivers the outcome as long as the value meets expectations.
What is the value proposition and strategy of the ideal-typical firm?	The manufacturer offers products + add-on services. Strategy based on products. Cost or differentiation strategy.	The manufacturer offers modular products and maintenance agreements. Modularization / standardization. Cost strategy	The manufacturer provides customized products supported by maintenance agreements and availability offerings (e.g., performance guarantees). Customization strategy. Differentiation strategy.	The manufacturer provides an outcome or performance instead of a product. Strategy based on data analytics. Differentiation strategy.	Provider operates a platform that suppliers and customers can use to engage in transactions. For instance, instead of offering products and maintenance, the provider offers a platform for transportation. Strategy based on platform ownership and development. Differentiation strategy
How is the value proposition delivered? What is the structure of the firm?	The manufacturer needs a competitive product value chain, sales, product engineering, manufacturing, and delivery.	In addition to a capable value chain, particular emphasis is required on mass-customization solutions. Remote diagnostics, analytics, and preventive	Capable customization and delivery of integrated solutions. Also, digital/analytics capacity to provide availability.	Strategic capability to offer outcomes and manage risk through remote monitoring technologies. Capability to keep up to speed with technological development.	Requires different capabilities from manufacturing, e.g., platform creation, operation, and management, network capabilities for managing the ecosystem. Software capabilities and

		maintenance.			branding.
Why does the model enable profits?	Profits are based on product features and differentiation, and/or low production costs. Spare parts can add to margins.	Service agreements support higher margins and protect spare parts exchanges. Mass customization lowers production costs.	Solutions customization differentiates and generates high project costs (incl. transaction costs). Effective project management enables margins.	By reducing the customer's risk, the provider can charge a premium. Provides growth opportunities for the customer.	Profits are based on the large volumes in the platform. Platforms should generate the scale and scope needed to generate profits.
Challenges of the business model	Product commoditization, increasing competition, and lowering margins in standard products	Difficult to mass-customize and enforce customers to use standard components. Many managerial challenges when trying to standardize.	Difficult to evaluate the costs of customization when projects vary significantly. Difficult to standardize. A few risky projects may destroy profits.	Product ownership increases capital costs and transfers risk to the manufacturer. Customers do not want an outcome but a product.	Challenge to change buyer behavior and achieve a market position with a new business model. Expensive and risky platform development/launch.
Illustrative case examples		Hilti (e.g., on track & tool service)	Wärtsilä lifecycle solutions	Rolls-Royce Power-by-the-Hour	Alibaba (in industrial goods)
Studies	(Helander & Möller, 2007; Kohtamäki, Parida, et al., 2019)	(Kohtamäki, Parida, et al., 2019; Kowalkowski et al., 2015)	(Helander & Möller, 2007; Kohtamäki, Parida, et al., 2019; Kowalkowski et al., 2015)	(Helander & Möller, 2007; Kohtamäki, Parida, et al., 2019; Kowalkowski et al., 2015)	(Kapoor et al., 2021; Kohtamäki, Parida, et al., 2019; Zhu & Iansiti, 2019)

4.3. The ecosystems of digital servitization

The ecosystem is a concept that is often used in the academic management literature, yet the concept is rarely defined (Adner, 2017; Moore, 1993). Here, we separate the concepts of industry, cluster, value system, ecosystem, network, and platform since these are all related though sometimes difficult to specify and dissect. We define the concepts from a macro to a micro perspective in the interests of clarity.

Table 5. Exemplary definition of some key concepts relating to ecosystems.

Authors	Concept	Definition
Porter (2008)	Industry	The industry is defined as a group of firms making particular products or services.
Porter (1998: 78)	Cluster	*"Clusters are geographic concentrations of interconnected companies and institutions in a particular field."* (Firms may be involved in different ecosystems)
Porter (2001: 74)	Value system	*"…value system, that is, the set of value chains in an entire industry, encompassing those of tiers of suppliers, channels, and customers."*
Adner (2017: 40)	Ecosystem	*"…the alignment structure of the multilateral set of partners that*

		need to interact in order for a focal value proposition to materialize."
Thorelli (1986: 38)	Network	*"…network is the intermediary between the single firm (hierarchy) and the market."*
Ozalp, Cennamo, and Gawer (2018: 1230)	Platform	A business model that uses a multi-sided market approach creates network effects through increasing customers and suppliers, including complements.

An industry is defined as a group of firms making a particular offering (Merriam-Webster). Whereas industries have assigned codes (e.g., SIC code), the industry concept in strategizing is far more complex than an industry code. Taking our lead from Powell (1996), industries are complex and subject to change. Thus, too broad a definition of an industry is very little help in any strategic analysis, whereas too narrow a definition leaves too many blind spots regarding related products or services (Porter, 2008). Sectors can be understood as sub-sections of industries – for example, meat products in the food industry sector. A cluster can be defined as a concentration of certain companies from related industries. Companies may be involved in a cluster without being engaged in the same ecosystem. For instance, in Silicon Valley, companies may be engaged in a meaningful cluster of software companies, but they do not have to be involved in Apple's ecosystem. The value system refers to the system that produces products or services from raw materials to the end customer, in the separation of the value chain, the value-adding chain within one firm (Porter, 1980). In contrast to the concept of a value system, the ecosystem concept assumes the interdependency and alignment between the ecosystem and the firms engaged. An ecosystem involves related actors as part of the same value-creating system. For instance, Apple's ecosystem (Apple serving only as a case in point) involves operators, system suppliers, service providers, and software suppliers interconnected through Apple's product-service systems. Compared to the concept of ecosystems, an inter-organizational network (here synonymous with network, value network, and strategic network), or network, is defined as an organizational form between market and hierarchy – a more integrated form than the market

and less integrated than the hierarchy (Thorelli, 1986). Hence, an ecosystem can be organized as a hierarchy (one organization), a market (market-based transactions) (Williamson, 1975), or a network. Finally, a platform is a business model created through multi-sided transactions between multiple suppliers and customers, often connected by a shared technology (Gawer & Cusumano, 2014).

Manufacturers face blurring company and industry boundaries (Sklyar, Kowalkowski, Sörhammar, et al., 2019; Sklyar, Kowalkowski, Tronvoll, et al., 2019) and the need for new competencies (Lütjen et al., 2019a) as they organize for digital servitization to deliver novel digitally-enabled product-service-software offerings. Although digitalization enables resource reconfiguration (Huikkola, Kohtamäki, & Ylimäki, 2022; Lütjen et al., 2019b; Sklyar, Kowalkowski, Tronvoll, et al., 2019), this transition is challenging and alters power interdependencies, value system positions, and roles (Huikkola et al., 2020). Newcomers often disrupt the competitive landscape by entering the market from adjacent industries and technology sectors, and different players cooperate and engage in alternative forms of co-creation logic. Some actors become orchestrators of emerging ecosystems (Lütjen et al., 2019; Parida, Burström, Visnjic, & Wincent, 2019; Sjödin, Parida, & Visnjic, 2022) shaped by specific multi-actor collaboration structures (Bustinza et al., 2019; Kamalaldin et al., 2021), governance rules, and institutional mechanisms (Solem et al., 2021; Spring & Araujo, 2017). Indeed, it is important to note that, in smart solutions, development may often involve public organizations, providing some critical infrastructure required for the operation, as in the case of autonomous vehicles. When mapping the ecosystem actors and defining their roles and business models, these more loosely coupled institutional actors should be mapped. Perhaps, we can conclude that it is not too difficult to define the concepts above, but it must be done.

5. The digital servitization journey toward smart solutions

5.1. Mapping the digital servitization journey

Figure 2 incorporates the components of business configurations, technologies, and business ecosystems into the path toward autonomous solutions and AI. To extend the maturity framework previously introduced (Thomson et al., 2022), we address its development, in which the transition from less complex to more complex phases of digital servitization would ostensibly require the integration of business model components, technologies, and ecosystems. Figure 2 shows this integration by the primary arrows, which close in and meet in the future as an aspect of enabling autonomous solutions. We add the proviso that reality is much more complex than any model can capture. This presentation is neither comprehensive nor conclusive but merely suggestive, providing propositions and a framework for integrative digital service transition toward autonomous solutions. Thus, Figure 3 provides a simplified depiction of possible configurations, including business model characteristics, technologies, and ecosystems. Potential configurations are many. Their development may also be discontinuous (Chen et al., 2021), and companies are likely to mix characteristics from different layers when creating configurations (Kohtamäki, Henneberg, et al., 2019).

Figure 3, in the top right corner, depicts the end state of the digital servitization process – namely, autonomous solutions. Hence, the arrows are pointing to this end. The three separated streams include the evolution of ecosystems (macro-level), business model components (micro-level), and product-service-software technologies as a specific case of one business model component. Technologies are described separately (not directly in the business models) to emphasize their role, central in digital servitization toward autonomous solutions. We describe each stream's maturity levels (levels of evolution) followed by the components of ecosystems,

business models, and technologies employed. Concerning the maturity levels of the technology, we use development from assisted operation to optimized operation (perhaps to semi-autonomous operation), and finally to fully autonomous operation. We divide the maturity of the business models (aligned with Table 2) into a progression from a product provider, industrializer, solution provider, and outcome provider to a platform provider (Kohtamäki, Parida, et al., 2019; Kowalkowski et al., 2015). To describe the evolution of ecosystems, we separate them into traditional manufacturing supply chains, innovation networks, and, finally, platform ecosystems (Kapoor et al., 2021). The components in each stream represent the relevant components or capabilities at each stage of maturity related to technological capabilities, business model capabilities, and those capabilities needed to orchestrate the ecosystem (Töytäri et al., 2018). Finally, the horizontal arrowheads denote the interplay between micro, meso, and macro levels. These emphasize the configurational interplay between technology, business model, and ecosystem, and highlight the firm's agency in shaping the ecosystem and the institutional environment rather than just playing the role of "passive bystander". Hence, the interplay between the technology, the business model, and the ecosystem emphasizes the nature of the digital servitization as a multi-level transition from the micro to the macro-level (Kohtamäki, Parida, et al., 2019; Kohtamäki, Rabetino, et al., 2021; Struyf et al., 2021). Overall, this conceptualization serves to enable theory building on the digital servitization path toward autonomous solutions.

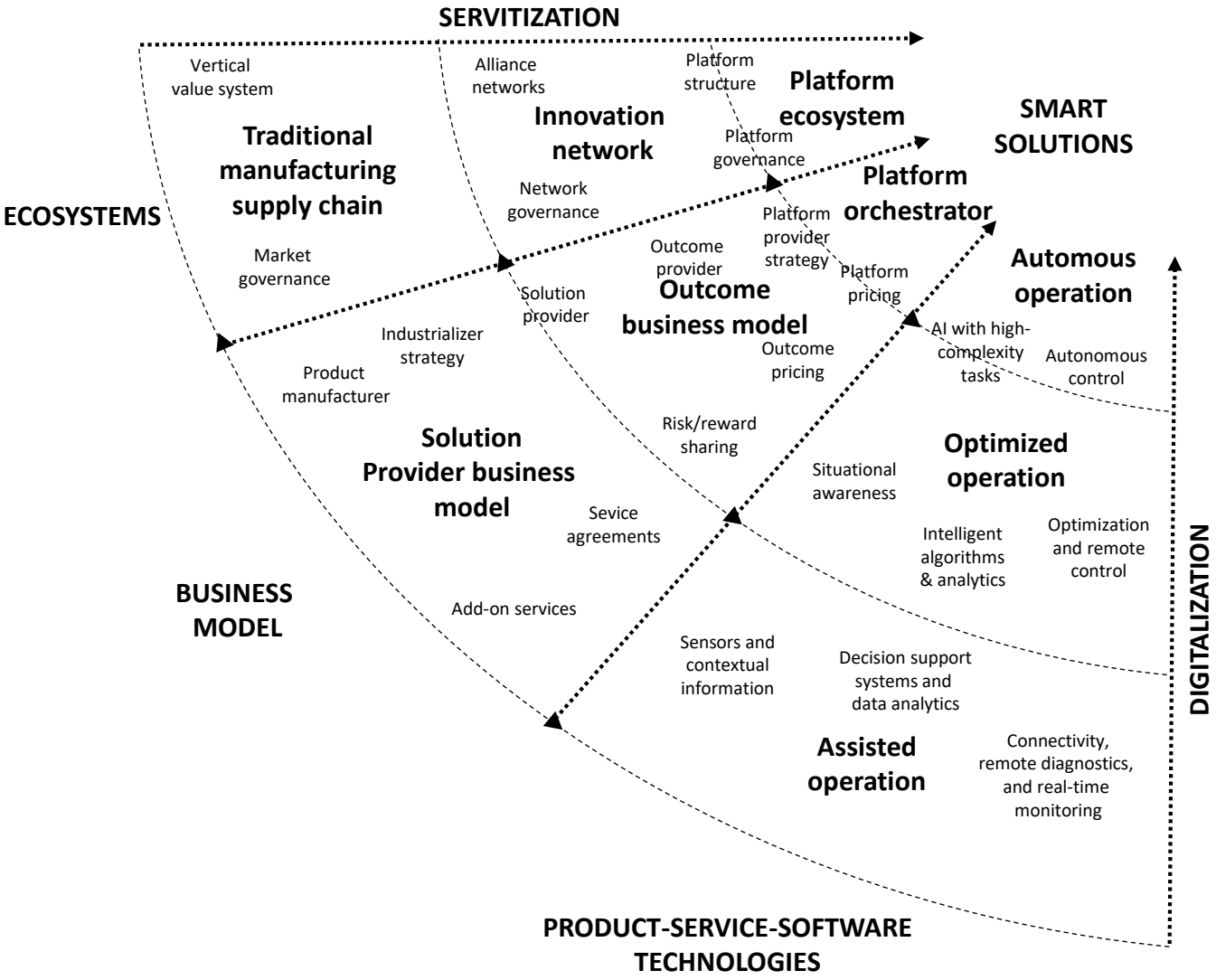

Figure 3. Configurations emerge in the interplay between technologies, business models, and ecosystems during digital servitization toward smart solutions.

5.2. Managing the digital servitization journey

Managing the digital servitization journey is an issue of central importance and the interplay between the three dimensions above calls for new managerial practices and routines. What do we know about managing the digital servitization path toward autonomous solutions, as described in Figure 3? We take examples from recent studies published in top journals, which provide insights

into managerial practices employed during the digital servitization journey. The question is an overly complex one, and, therefore, the managerial practices should be written in a configurational manner. They should emphasize the context in which company practices are configured, given that digital servitization is equifinal.

Table 6. Exemplary studies on managing the digital servitization journey.

Study	Managerial practices	Findings
Chen et al. (2021)	Managing the discontinuous and continuous innovation practices for a) value creation, b) efficiency, and c) accountability in digital servitization ecosystems.	Novel digital services emerge through a discontinuous and continuous interplay between new business models and digital technologies.
Eloranta, Ardolino, and Saccani (2021)	Complexity in platforms can be managed through 1) complexity reduction and 2) absorption of complexity.	According to the study, the platform approach may enable the development of new capabilities to manage and leverage complexity.
Jovanovic, Sjödin, and Parida (2021)	1) Autonomous service development, 2) Use of artificial intelligence, 3) Expansion of the ecosystem.	The study identifies platform archetypes that are characterized by specific innovation mechanisms.
Hsuan, Jovanovic, and Clemente (2021)	The study provides a digital servitization cube to map and categorize strategies.	Digital servitization strategies depend on the product, service, and software structures generating potential for modules but expecting adjustment.
Huikkola, Kohtamäki, Rabetino, Makkonen, and Holtkamp (2022a)	Managerial routines to integrate product-service-software innovation.	The study identifies innovation routines, pinpoints innovation processes and practices, and highlights the alignment of routines, processes, and practices between product, service, and software innovation.
Kamalaldin et al. (2020)	1) Complementary digitalization capabilities, 2) Relation-specific digital assets, 3) Digitally-enabled knowledge-sharing routines, and 4) Partnership governance	The study identifies four relational components that enable the company to profit from digital servitization relationships with customers.
Kohtamäki, Rabetino, Einola, Parida, and Patel, (2021)	Intentional narratives to shape the change in digital servitization: 1) Intentional narrative evolving from system supply to integrated lifecycle solutions 2) Intentional narrative evolving from remote diagnostics toward truly digital solutions 3) Intentional narrative evolving separate product and service capabilities to end-end operations 4) Intentional narrative evolving from technology emphasis to customer value thinking, and on to shaping the ecosystem.	The study maps the lengthy 20-year process of digital servitization covering service technologies, micro-activities and processes, strategies, and offerings, the ecosystem, and the intentional narratives used in managing the change.
Huikkola, Kohtamäki, Rabetino, Makkonen, & Holtkamp (2022b)	Managerial heuristics to guide smart solution development: 1) process, 2) boundary, 3) preference, 4) schedule, and 5) stop heuristics in digital servitization.	The central contribution of the study was to develop the idea of managerial heuristics, e.g., decision rules for smart solution development in digital servitization.
Thomson et al. (2022)	Suggests three mechanisms to align business model design, technology development, and ecosystem configuration in autonomous solutions: 1) adapting technology to ecosystem maturity, 2) aligning partner revenue flows, and 3) identifying technological value generators.	The study creates a maturity model for autonomous solutions. The study contributes by building the maturity model using three dimensions: technology, ecosystem, and business model.
Sjödin, Parida, Palmié, et al. (2021)	Suggest three practices for succeeding with AI-driven business model innovation in digital servitization: agile co-creation, data-driven delivery operations, and scalable ecosystem integration.	The study creates a co-evolutionary framework for scaling AI capabilities through business model innovation, underscoring the mechanisms and feedback loops between practices and capabilities.
Tsvetkova et al. (2021)	Identifies managerial practices of ecosystem formation in autonomous solutions as an institutionalized ecosystem: 1) institutional work:	Contributes by using institutional theory frame to understand PSSS in the case of autonomous solutions.

	removing barriers, 2) adaptation: avoiding barriers.	
Kohtamäki, Parida, et al. (2019)	With an emphasis on ecosystem orchestration, the study identifies how firm boundary theories can facilitate the digital servitization journey. Guidelines emerge from the four firm boundary theories: 1) resource-based view, 2) power-dependency approach, 3) organizational identity, and 4) transaction cost approach.	The study identifies how digital servitization shapes firm boundaries during the transition journey and how understanding the four firm boundary theories can enable profitable growth from digital servitization.

6. Research directions

Based on the review of digital servitization literature and the papers published in this special issue we propose numerous areas for future research that may guide the development of the research stream on digital servitization toward smart solutions.

Theoretical suggestions for future research

The servitization literature has been evolving into the digital servitization literature, with specific insights on business models and transition processes. However, the literature has advanced the landscapes of digital servitization business models and transition processes by emphasizing the servitization aspect while offering somewhat less on the digital part. This study and related works in this special issue intend to map digital servitization toward smart solutions (Makkonen et al., 2022; Paiola et al., 2022). Future empirical work can provide more detailed insights on how digital servitization unfolds for solution providers. Firms may follow different paths to digital servitization, depending upon the different contexts, industries, and ecosystems (Kohtamäki, Rabetino, et al., 2021; Tsvetkova et al., 2021). Future studies should provide more specific evidence on the evolvement of different paths to digital servitization and the overarching view of the transformational process (Favoretto et al., 2022; Frandsen et al., 2022; Kohtamäki, Rabetino, et al., 2021; Tronvoll et al., 2020).

Research direction 1. The digital servitization path toward smart solutions should be empirically mapped in different contexts, industries, ecosystems, and cases.

Firms approach digital servitization through the design, development, and implementation of diverse business model innovations (Paiola et al., 2022). As shown in Table 4, firms may follow either a product provider, industrializer, solution provider, an outcome provider, or a platform orchestrator business model approach. There may be other types of business models, and different ways of coining the models, but these provide a reasonably good typology for a servitizing product manufacturing company. Business model descriptions intend to answer to the questions of to whom, what, how and why some value is delivered. These generic questions are important, and provide a starting point for considering business model configurations as a source of business model innovation, also in digital servitization. As Favoretto et al. (2022) argue, there is more room for describing the various business model innovations in digital servitization. In particular, additional evidence is needed on the various business models utilized when companies move toward autonomous solutions – for example, the various viable configurations of digital servitization business models.

Research direction 2. Further theory development is needed regarding novel business models enabled by digital servitization.

Moreover, research on business model innovation emerging from various consumer sectors (e.g., Uber, Airbnb, and Alibaba) should be complemented by studies scrutinizing the business model innovations in manufacturing sectors, as the B2B context differs from B2C. Consequently, broader exploration is needed concerning the potential of various platform business model innovations in manufacturing ecosystems, and how to facilitate learning and innovation within platform-based ecosystems. Thus, theory development is needed on business model innovation (Ozalp et al., 2018), such as digital platform business models in servitized product manufacturing companies and related ecosystems (Jacobides et al., 2018; Kohtamäki, Parida, et al., 2019).

Research direction 3. Further conceptual development of platform business models is needed, especially in the B2B contexs.

Alignment between product-service-software offerings has emerged as a topic in the digital servitization literature. As a result of manufacturing companies moving toward digital servitization business models, companies face the challenge of aligning product, service, and software systems and their development processes. The digital servitization literature has offered little discussion on the alignment of these development processes, although there are a few exceptions (Hsuan et al., 2021; Huikkola, Kohtamäki, Rabetino, et al., 2022a). Further empirical research is needed on models of advanced digital offerings to depict and analyze the digital offerings in use and the transition toward novel conceptualizations of product-service-software offerings (Kohtamäki, Parida, et al., 2019; Raddats et al., 2022). In particular, more knowledge would be needed regarding what type of companies are in a better situation to configure product-service-software modules into attractive offerings and how these companies can leverage and profit from data and smart solutions (Vendrell-Herrero et al., 2021).

Research direction 4. Future research is needed on product-service-software offerings, particularly regarding configurability/modularity and profit opportunities.

Previous empirical studies have highlighted the challenges that manufacturing companies have faced when trying to appropriate value from product, service, and software systems (Hasselblatt et al., 2018). Being path-dependent (Sydow et al., 2009), manufacturing companies find it difficult to turn their business models toward digital servitization (Kohtamäki, Parida, et al., 2019). Treating digital offerings as add-ons is not without problems, to say the least, and therefore value appropriation from digitalization likely requires a radical shift in the business

model to truly emphasize and exploit the potential value created by data (Kohtamäki, Parida, et al., 2020). That way, it can be leveraged for higher profits. Companies should fully commit when moving to digital servitization (Immelt, 2017; Kohtamäki, Parida, et al., 2020). However, little is known about various forms of value capture in digital servitization, particularly the design of alternative revenue models and risk assessment tools. Future studies are needed to analyze digital servitization business models and the routines and practices utilized to create and capture value from product, service, and software bundles. Digital servitization literature is still relatively silent on the affordances of various product, service, and software bundles.

Research direction 5. Product, service, and software systems may hold specific affordances that require future studies to understand how the digital servitization business model should be adopted to create and capture value.

Theoretico-methodological suggestions for future research

A business model should find an optimal fit between strategy and structure, between business environment and strategy, and between business environment and structure. The interplay between the macro and micro dimensions of business can be approached from either perspective. Institutional theory approaches the interplay from a macro perspective with the macro environment affecting the micro behaviors, whereas practice theory approaches the interplay from the micro-perspective with the micro shaping the macro (Seidl & Whittington, 2014). When advancing the digital servitization literature, both angles deserve attention. For example, what are the challenges and resistances, and how do firms, business units, and individuals cope (Lenka, Parida, Sjödin, & Wincent, 2018). Specific attention should be put on the macro-level institutional structures influencing on the digital servitization (Tsvetkova et al., 2021).

Research direction 6. A macro-level understanding is needed of the institutional challenges faced by manufacturers when moving toward smart solutions.

We need theories and models to understand the behavioral micro-issues of digital servitization toward smart solutions. The micro-approaches for analyzing the transition may involve studies and approaches from behavioral economics – for example, micro-foundations movement or practice theoretical implications (Kohtamäki, Parida, et al., 2019). Current studies on digital servitization provide very little evidence using micro-foundations or practice theoretical approaches to micro-level issues in digital servitization processes. The digital servitization literature would benefit from in-depth engagement with the behavioral micro-foundations approach (Felin et al., 2015; Lenka et al., 2018) or practice theoretical approaches (Kohtamäki et al., 2018, 2022; Kohtamäki, Rabetino, et al., 2021).

Research direction 7. Micro-level conceptual tools are needed to study servitization business model innovations

In the transition toward smart solutions (e.g., autonomous solutions), companies have to deeply integrate themselves into the surrounding institutional environment (Huikkola, Kohtamäki, Rabetino, et al., 2022a; Tsvetkova et al., 2021), creating the interplay between the firm-level micro and the institutional macro environment. Therefore, the micro-macro interplay becomes a central issue for digital servitization. We need empirical studies and theorizing on the interplay between the micro and the macro to generate knowledge, which is currently lacking. Consequently, there is a call for studies to analyze the interplay between the micro and the macro – the relationship between the digital servitization strategy and the ecosystem, how ecosystems are created from micro to macro (Kohtamäki, Rabetino, et al., 2021; Kouamé & Langley, 2018).

Research direction 8. The micro-macro interplay in digital servitization toward smart solutions.

Research on digital servitization and servitization has a strong background in realist and social constructionist empirical research (Rabetino et al., 2018). Digital servitization, as servitization research, uses both the case method and the multiple case method quite often (Rabetino, Kohtamäki, Brax, et al., 2021). Hence, it may be slightly surprising that only rarely do studies utilize processual methods (Rabetino, Kohtamäki, Kowalkowski, et al., 2021). This is a significant drawback, considering the processual nature of digital servitization as a transition process, and the particular value of the processual method in these types of contexts (Langley et al., 2013). Therefore, future digital servitization research should tap into process research to unfold the activities and processes related to digital servitization (Kohtamäki, Rabetino, et al., 2021; Makkonen et al., 2022). At its core, digital servitization is a transformation process for providers and customers (Kamalaldin et al., 2020), and it may require a radically different innovation process, ensuring agility and customer co-creation while stimulating internal capability development (Sjödin et al., 2020). From a methodological standpoint, future digital servitization studies would benefit from processual methods (Kohtamäki, Rabetino, et al., 2021).

Research direction 9. Process research is needed to understand the evolvement of digital servitization in manufacturing companies. Future studies should explore the opportunities to use ethnographic research and observational data.

Alongside some other previous reviews, we highlight the potential of the configurational approach in producing accurate descriptions of complex empirical realities. The configurational approach allows complex combinations of characteristics and the existence of multiple viable configurations and, therefore, provides a significant potential for the analysis of antecedents

affecting digital servitization and outcomes of digital servitization (Fiss, 2007; Forkmann, Henneberg, et al., 2017; Forkmann, Ramos, et al., 2017; Kohtamäki, Henneberg, et al., 2019). Hence, we wish to encourage scholars to fully utilize the potential of the configurational approach and related methods, such as FSQCA (Rabetino, Kohtamäki, Kowalkowski, et al., 2021).

Research direction 10. The configurational approach can provide interesting opportunities to understand complex combinations of characteristics, as in the case of digital servitization.

7. Discussion and conclusions

Theoretical conclusions

This paper has aimed to contribute to the literature by theorizing on the digital servitization journey toward smart solutions. We have analyzed the interplay between business model configurations, product-service-software in which we seek to provide not only one path to success but a model (refer to Figure 3) that enables readers to develop various configurations between business models, technological components, and business ecosystems. Many configurations may lead to optimal outcomes, as the equifinality proposition suggests. The configurational perspective enables researchers and managers to appreciate the complexity of the empirical business world.

As our analysis suggested, the empirical literature on digital servitization is increasing rapidly. The current study has analyzed 261 papers on how digital servitization studies can support the digital servitization journey toward smart solutions. The digital servitization literature has been expanding quickly but, so far, relatively few studies have been conducted on the most advanced forms of product-service-software systems (Hsuan et al., 2021; Huikkola, Kohtamäki, Rabetino,

et al., 2022a), such as autonomous solutions (Makkonen et al., 2022; Tsvetkova et al., 2021). We approached the management of the digital servitization toward smart solutions from the perspectives of product-service-software technologies, business models, and ecosystems, with the emphasis on their interplay (Favoretto et al., 2022; Thomson et al., 2022), configurations and management practices (Kohtamäki, Rabetino, et al., 2021). Obviously, each of the three streams of 1) product-service-software technologies and related capabilities (Marcon et al., 2022; Vendrell-Herrero et al., 2021), 2) business models (Kohtamäki, Parida, et al., 2019; Paiola et al., 2022; Raddats et al., 2022), and 3) ecosystems (Frandsen et al., 2022) provides empirical studies and theory development opportunities. Substantial opportunities exist in the potential configurations as a form of micro-macro interplay between the product-service-software technologies, business models, and ecosystems. Their interplay generates important and challenging questions for future studies to examine so that the body of knowledge on digital servitization toward autonomous solutions continues to develop. Opportunities exist in different empirical contexts, such as various industries, ecosystems, and cases, using several approaches and lenses within digital servitization research and various theoretico-methodological approaches, such as processual, configurational, and practice–theoretical methodologies. Surely, the special issue through the studies included provides a fertile ground for future scientific discussions and debates on digital servitization toward smart solutions.

Papers in the special issue on "Moving toward autonomous solutions: The role of Product-Service-Software Systems"

Thus, the current IMM special issue on "Moving toward autonomous solutions: The role of Product-Service-Software Systems", is one of the early attempts to integrate research on autonomous solutions under the concepts of digital servitization toward smart solutions. The

special issue articles cover related topics well creating theoretical grounds and providing important empirical evidence on digital servitization toward smart solutions, using autonomous solutions as a case in point (e.g., Makkonen et al., 2022; Tsvetkova et al., 2021). The studies in this special issue cover issues related to the ecosystems, business models, and product-service-software technologies and their interplay. **Frandsen, Raja, and Neufang (2022)** use a longitudinal case study to understand the dynamic evolution of an ecosystem over time in digital servitization. They show the interplay between actors, technologies and ecosystems, and highlight ecosystem as a constantly molding amoeba-like mechanism. **Tsvetkova et al., (2021)** provide a case in point on the role of institutional barriers when creating, delivering and capturing value of autonomous ships. **Favoretto, Mendes, Oliveira, Cauchick-Miguel, and Coreynen (2022)** contribute by developing a conceptual framework for digital servitization covering various levels such as strategic, organizational and networks. **Vendrell-Herrero, Bustinza, and Vaillant (2021)** study provides evidence on the adoption of various services in manufacturing firms, the role of hybridization and internationalization on the adoption of capabilities, and the role of capability configurations in achieving firm performance, with emphasis on advanced services. **Makkonen, Nordberg-Davies, Saarni, and Huikkola (2022)** use a longitudinal case study to describe a model to understand the interplay between value propositions, resource reconfigurations and institutional arrangements. **Raddats, Naik, and Ziaee Bigdeli (2022)** Study the role of digital service innovations and provide a framework for digital service innovations. **Marcon et al., (2022)** focus on capabilities required by different types of digital solutions in digital servitization. **Paiola, Agostini, Grandinetti, and Nosella (2022)** study the process of business model innovation when a manufacturer establishes a novel IOT-based model in parallel with the existing one. Finally, **Rad et al. (2022)** contribute by generating a review of 11 core technologies improving the performance of a supply chain. Overall, the papers in the special

issue provide variety of perspectives on how digitalization transforms the ecosystems, business models, and product-service technologies, creating a fertile ground for future scientific discussions and debates on digital servitization toward smart solutions.

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