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Consolidating digital servitization research: A systematic review, integrative framework, and future research directions

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ABSTRACT

Manufacturing firms are increasingly transforming toward digital servitization, characterized by convergence and simultaneous gains from digitalization and servitization. Due to the marked academic and practical relevance of digital servitization, we are witnessing a significant upsurge in studies published on this emerging topic. Thus, the present study undertakes a comprehensive bibliometric analysis to synthesize the prior knowledge on digital servitization and, more importantly, to highlight areas for future research. The findings from the analysis are organized so that important authors and organizations are highlighted through analyses of citation chains and co-authorship networks. The bibliographic coupling analysis of HistCite and VOSviewer reveals the emergence of four dominant thematic areas in the digital servitization literature. These four thematic areas are aligning digitalization and servitization transformations, value co-creation perspectives on digital servitization, conceptualizing the platform strategy for digital servitization, and business model innovation in digital servitization. Finally, based on the analysis of how the literature on digital servitization has evolved over the last two decades and the deeper analysis of thematic analysis, we raise important research questions and provide numerous areas for future research.

1. Introduction

Digital servitization continues to play an increasingly significant role in manufacturing firms because it brings many benefits to the customer, the (solution) provider, the environment, and society at large(Paschou et al., 2020). For customers, digital servitization can minimize downtime and transfer risks to the manufacturer/provider (Grubic, 2014; Grubic and Peppard, 2016), secure the transmission of data (Nybacka et al., 2010), and increase differentiation, flexibility, and customization (Wan et al., 2017). For the provider, it can reduce service delivery costs (Allmendinger and Lombreglia, 2005), generate new revenue streams (Kamp et al., 2017), and strengthen competitiveness and open up new business opportunities (Kohtamäki et al., 2019). The benefits related to the environment, such as the reduction in energy consumption (Opazo-Basáez et al., 2018) and environmental impact (Bressanelli et al., 2018) are also enhanced through digital servitization. In addition, the continuous development of digital servitization has resulted in delivering value to society. For instance, it can build sustainable businesses and production capacity (Hernández Pardo et al., 2012; Opazo-Basáez et al., 2018), and exercise an impact on social sustainability (Hernández Pardo et al., 2012; Lindström et al., 2018).

In the early years of digital servitization research, scholars defined digital servitization broadly – for example, *the provision of IT-enabled (i.e., digital) services relying on digital components embedded in physical products* (Holmström & Partanen, 2014; Vendrell-Herrero et al., 2017) – taking digital technology as an integral part of the total offering. These articles focused on the contribution of specific digital tools to servitization, such as ICT (Kowalkowski et al., 2013), remote monitoring (Grubic and Peppard, 2016), Internet of things (Hasselblatt et al., 2018), big data (Altmann & Linder, 2019) and 3D printing (Chaney et al., 2021). As digital servitization research has evolved, scholars have pointed to the link between digitization and digitalization as an enabler of servitization, defining digital servitization as *the use of digital technology to sustain the shift from a product-centric to a service-centric logic* (Coreynen et al., 2017). More recently, scholars have proposed a transformational definition of digital servitization, which refers to *the*

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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, such as the Internet of things (IoT), big data, artificial intelligence (AI), and cloud computing (Kohtamäki et al., 2019; Parida et al., 2019). Thus, the current scholarly discussion on digital servitization is still in the process of evolution and lacks a commonly agreed definition.

Nevertheless, the practical importance of digital servitization for manufacturing firms to secure future competitiveness (Paschou et al., 2020), combined with increased academic interest (Frank et al., 2019), has led to the rapid growth of digital servitization research in recent years. Consequently, this growth, usually associated with emerging research fields, calls for a systematic review of the extant knowledge. Some attempts to review the digital servitization literature have been made. One such attempt by Kohtamäki et al. (2019) used four theories of the firm (industrial organization, the resource-based view, organizational identity, and the transaction cost approach) to understand the digital servitization business models of firms in the context of ecosystems (Kohtamäki et al., 2019). Based on a rigorous literature review, they provide suggestions for future research on digital servitization business models in ecosystems (Kohtamäki et al., 2019). Another study has offered a digital servitization framework to promote understanding of how AI services impact value perceptions, consumer engagement, and firm performance measures (Manser Payne et al., 2021). Owing to such efforts, the research on digital servitization has achieved a significant level of differentiation from other domains in the academic establishment. Notwithstanding the commendable attempts to consolidate the research on digital servitization, gaps in the extant literature remain, which limits the prospect of attaining a comprehensive understanding of this topic. For instance, many definitions and views on digital servitization are currently accepted by the academic community. In addition, the abovementioned concepts (servitization, digitization, digitalization, digital servitization, and smart servitization) are closely associated (Ciasullo et al., 2021; Lerch and Gotsch, 2015), and this calls for better clarification of the origin and positioning of digital servitization. Moreover, it is essential to identify the key contributors and describe how they will shape the future research agenda on digital servitization. Therefore, current knowledge as reflected in the digital servitization literature is fragmented, and this provides the stimulus for a comprehensive bibliometric analysis of the past achievements and future promises of digital servitization research.

Against this background, the present study aims to review the digital servitization literature in order to scrutinize current themes and earmark areas for future research. More specifically, this study aims to address four research questions (RQs). RQ1: Who are the prominent contributors to the literature on digital servitization? RQ2: What is the origin of digital servitization? RQ3: Which prominent thematic areas emerge from the literature on digital servitization? RQ4: What are the potential future research areas that can advance the literature on digital servitization? We provide an answer to these RQs by analyzing the literature on digital servitization using a set of bibliometric techniques (Khanra et al., 2021; Caviggioli & Ughetto, 2019; Fahimnia et al., 2015; Xu et al., 2018). Such techniques are well positioned to help standardize current research knowledge from a multidisciplinary viewpoint by reviewing a vast number of documents (Caviggioli & Ughetto, 2019). Moreover, bibliometric techniques are focused on statistical foundations, leaving limited space for subjective biases that may influence traditional literature reviews (Xu et al., 2018).

The remainder of this article is structured as follows. Section 2 describes the bibliometric methodology of this paper, which introduces a three-stepped process to conduct a bibliometric literature review. This is followed by the descriptive and bibliometric findings in Section 3. Then, the origin, definition, and conceptualization of digital servitization is presented in Section 4. Section 5 presents the content analysis of thematic areas, which is followed in Section 6 by a framework for manufacturing firms to put digital servitization transformation into effect. Section 7 discusses the implications of the study. Finally, Section 8 draws the conclusions of the study and discusses its limitations.

2. Bibliometric methodology

At present, there are various types of literature review techniques at the disposal of researchers, such as a systematic literature review (Palmaccio et al., 2021), content analysis (Huang et al., 2021), meta-analysis (Mou & Benyoucef, 2021), and bibliometric citation analysis (Maditati et al., 2018). The current study employs a combination of bibliometric citation analysis and content analysis techniques to analysis the digital servitization literature (Maditati et al., 2018). Bibliometrics is a method that includes the statistical analysis of published articles and citations to measure their impact (Maditati et al., 2018). Content analysis is "a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use" (Krippendorff, 2004). Inspired by previous research in the field of systematic literature reviews (Favoretto et al., 2022; Kolagar et al., 2022; Maditati et al., 2018; Paschou et al., 2020), and by making changes, integrating some steps, and localizing them according to our research conditions, we defined a three-stepped process to conduct a bibliometric literature review (Fig. 2). Each step will be explained in detail.

2.1. Step 1: Identifying publications

The first step begins by setting certain practical screening criteria to ensure that only quality publications are included in the review. This study retrieved relevant digital servitization articles from WoS Core Collection, which is comprised of top-quality journals in SSCI, A&HCI, CPCI-SSH, ESCI, CPCI-S and SCI-EXTENDED, using three main terms: servitization, digitalization, and digital servitization. The set of keywords for each term was chosen based on other relevant reviews (Favoretto et al., 2022; Paschou et al., 2020) covering the domains investigated in this study (Table 1). The inclusion criteria selected were articles and reviews written in the English language and published in peer-reviewed journals. This search included articles and reviews that were published up to March 2022. In order to select articles in "business,

Table 1
Keywords used in the search strings for titles, keywords, and abstracts.

Terms	Keywords	Reference
Digitalization	digitali*ation OR digiti*ation OR "emerging technologies" OR "ICT" OR "big data" OR "cloud computing" OR "Internet of Things" OR "IoT" OR "remote control" OR "remote monitoring" OR "digital manufacturing" OR "digital technology*" OR "digital transformation" OR "Industry 4.0" OR "predictive analytic*" OR "advanced manufacturing" OR "additive manufacturing" OR "augmented reality" OR "virtual reality" OR simulation OR "cyber-security" OR "cyber-physical system*" OR "RFID" OR "automation and industrial robots" OR "3D printing" OR "smart data" OR "smartization" OR "smart manufacturing" OR "smart factory" OR "artificial intelligence" OR "AI" OR "digital twin" OR "network" OR "platform" OR "wearables"	(Favoretto et al., 2022; Paschou et al., 2020)
Servitization	serviti*ation OR "product-service system*" OR "PSS" OR "IPSS" OR "integrated solution*" OR "smart service*" OR "service transformation" OR "service infusion" OR "advanced service*" OR "service transition"	(Favoretto et al., 2022; Paschou et al., 2020)
Digital servitization	"digital serviti*ation" OR "digital PSS" OR "smart product-service system*" OR "smart PSS" OR "smart serviti*ation"	(Favoretto et al., 2022; Paschou et al., 2020)

management and economics", we added "business, management and economics" to the search in the "categories" section.

2.2. Step 2: Sample screening

As Fig. 2 shows, the search string included the intersection (AND: #7 in Fig. 1) between the first two keyword sets (digitalization and servitization) and the third keyword set (OR: #8 in Fig. 1) related to digital servitization (Favoretto et al., 2022). After that, the screening process started by reading the articles' titles, keywords, and abstracts. The eligibility criteria were applied in all searches to ensure the relevance of the final sample. For inclusion, the articles had to: (i) deal with concepts related to servitization and digitalization as main topics; (ii) address aspects related to the convergence of servitization and digitalization; and (iii) deal with the context of manufacturing firms. Articles that did not meet these criteria were excluded. Two authors of the research team were involved in this screening process. When a consensus was not reached, a third author was involved. In the following stage, the articles were read in full (emphasizing the introduction and result sections), since decisions can be tricky when an abstract is not clear (in terms of what the paper was about). Only articles that met the inclusion criteria and were able to contribute to the research objectives were selected. In addition, we searched the top 160 papers in "Cited References" of HistCite and retrieved 10 papers, which related to our research topic. Finally, to overcome the potential limitations of the search string, a backward snowball process based on Wohlin (2014) was performed, which resulted in the selection of 6 additional articles (Allmendinger and Lombreglia, 2005; Eloranta et al., 2021). Based on this process, 106 focal articles comprise the final sample.

2.3. Step 3: The combination of bibliometric citation analysis and content analysis

We employed a bibliometric analysis using HistCite and VOSviwer, which have been widely used by other studies in the management domain – for example, Maditati et al. (2018), Khanra et al. (2021). Specifically, HistCite was used for the descriptive, such as the year of publication (Fig. 3), leading scholars (Table 2), and the citation mapping analysis (Fig. 8). The bibliographic coupling analysis of authors (Fig. 4), documents (Fig. 5), and keyword co-occurrence (Fig. 6) (Khanra et al., 2021; Fahimnia et al., 2015; van Eck & Waltman, 2014) by VOSviewer were introduced in this paper, and four research streams were identified. Then, we identified the sub-streams of each cluster as well as their main views (Fig. 9) by using content analysis methods. Finally, we proposed a DS transformation framework incorporating all the analysis.

Search History — Web of Science Core Collection

Set	Results	Save History / Create Alert · Open Saved History	Edit Sets	Combine Sets (AND / OR) Combine	Delete Sets Select All · Delete
# 8	350	#7 OR #6 *Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC Timespan=1900-2021*	Edit	☐	☐
# 7	338	#4 AND #2 *Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC Timespan=1900-2021*	Edit	☐	☐
# 6	55	TOPIC: ("digital servitiˆation" OR "digital PSS" OR "smart product-service systemˆ" OR "smart PSS" OR "smart servitiˆation") *AND* DOCUMENT TYPES: (Article OR Review) *AND* LANGUAGE: (English) **Refined by: WEB OF SCIENCE CATEGORIES:** (BUSINESS OR MANAGEMENT OR ECONOMICS) *Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC Timespan=1900-2021*		☐	☐
# 5	137	TOPIC: ("digital servitiˆation" OR "digital PSS" OR "smart product-service systemˆ" OR "smart PSS" OR "smart servitiˆation") *AND* DOCUMENT TYPES: (Article OR Review) *AND* LANGUAGE: (English) *Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC Timespan=1900-2021*	Edit	☐	☐
# 4	1,093	TOPIC: (servitiˆation OR "product-service systemˆ" OR "PSS" OR "IPSS" OR "integrated solutionˆ" OR "smart serviceˆ" OR "service transformation" OR "service infusion" OR "advanced serviceˆ" OR "service transition") *AND* DOCUMENT TYPES: (Article OR Review) *AND* LANGUAGE: (English) **Refined by: WEB OF SCIENCE CATEGORIES:** (ECONOMICS OR MANAGEMENT OR BUSINESS) *Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC Timespan=1900-2021*		☐	☐
# 3	33,767	TOPIC: (servitiˆation OR "product-service systemˆ" OR "PSS" OR "IPSS" OR "integrated solutionˆ" OR "smart serviceˆ" OR "service transformation" OR "service infusion" OR "advanced serviceˆ" OR "service transition") *AND* DOCUMENT TYPES: (Article OR Review) *AND* LANGUAGE: (English) *Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC Timespan=1900-2021*	Edit	☐	☐
# 2	83,385	TOPIC: (digitaliˆation OR digitiˆation OR "emerging technologies" OR "ICT" OR "big data" OR "cloud computing" OR "Internet of Things" OR "IoT" OR "remote control" OR "remote monitoring" OR "digital manufacturing" OR "digital technologyˆ" OR "digital transformation" OR "Industry 4.0" OR "predictive analyticˆ" OR "advanced manufacturing" OR "additive manufacturing" OR "augmented reality" OR "virtual reality" OR simulation OR "cyber-security" OR "cyber-physical systemˆ" OR "RFID" OR "automation and industrial robots" OR "3D printing" OR "smart data" OR "smartization" OR "smart manufacturing" OR "smart factory" OR "artificial intelligence" OR "AI" OR "digital twin" OR "network" OR "platform" OR "wearables") *AND* DOCUMENT TYPES: (Article OR Review) *AND* LANGUAGE: (English) **Refined by: WEB OF SCIENCE CATEGORIES:** (BUSINESS OR MANAGEMENT OR ECONOMICS) *Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC Timespan=1900-2021*		☐	☐
# 1	3,694,862	TOPIC: (digitaliˆation OR digitiˆation OR "emerging technologies" OR "ICT" OR "big data" OR "cloud computing" OR "Internet of Things" OR "IoT" OR "remote control" OR "remote monitoring" OR "digital manufacturing" OR "digital technologyˆ" OR "digital transformation" OR "Industry 4.0" OR "predictive analyticˆ" OR "advanced manufacturing" OR "additive manufacturing" OR "augmented reality" OR "virtual reality" OR simulation OR "cyber-security" OR "cyber-physical systemˆ" OR "RFID" OR "automation and industrial robots" OR "3D printing" OR "smart data" OR "smartization" OR "smart manufacturing" OR "smart factory" OR "artificial intelligence" OR "AI" OR "digital twin" OR "network" OR "platform" OR "wearables") *AND* DOCUMENT TYPES: (Article OR Review) *AND* LANGUAGE: (English) *Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC Timespan=1900-2021*	Edit	☐	☐

Fig. 1. The initial literature sample retrieved from the WoS.

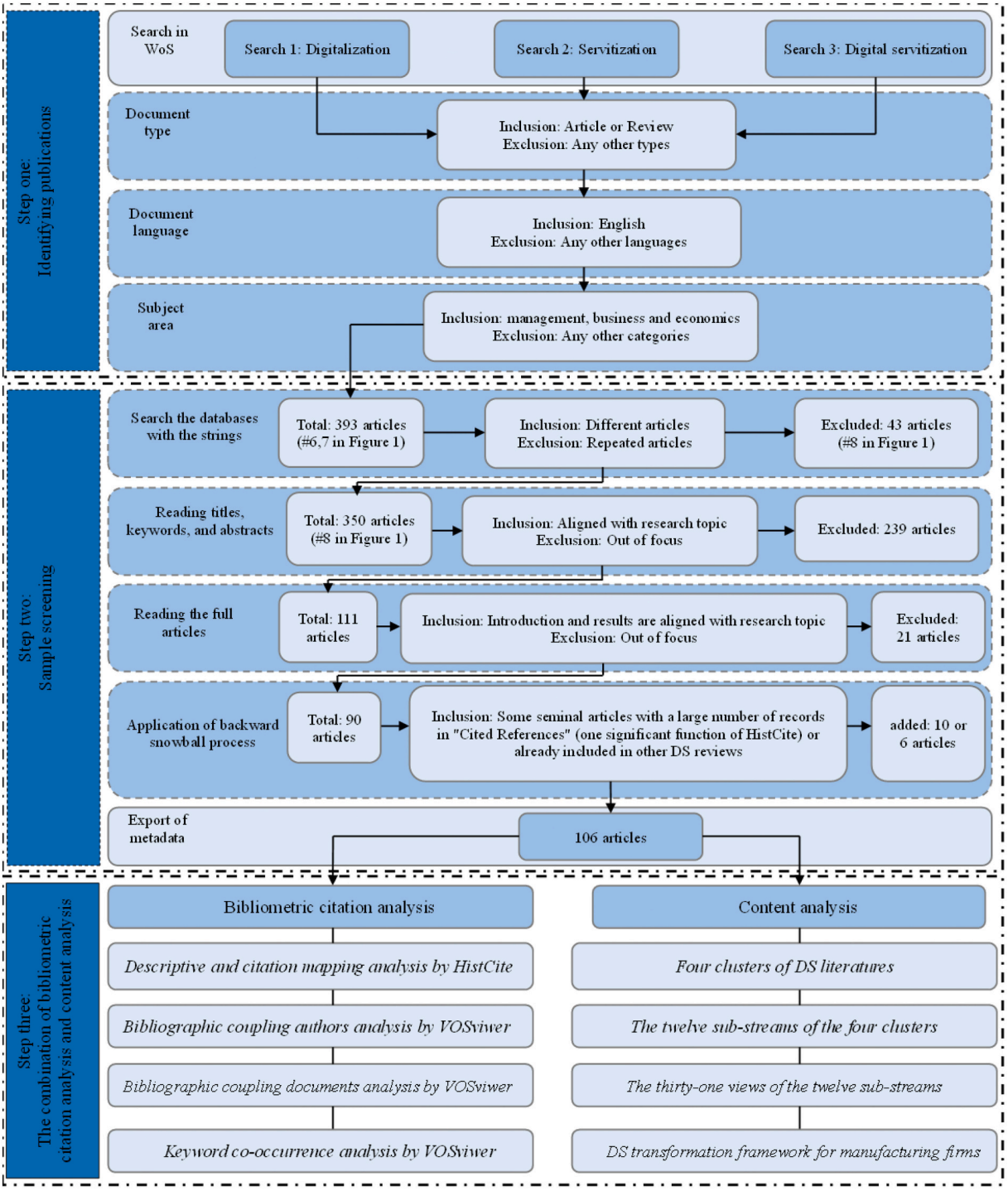

Fig. 2. Three-stepped process to conduct a bibliometric literature review.

3. Descriptive and bibliometric findings

In order to develop a complete conceptual overview, a descriptive and bibliometric analysis of 106 research articles has been carried out in this section, which offers a comprehensive synthesis of the included literature.

3.1. Descriptive findings

We can see from Fig. 3 that the 106 papers were published from 2005 to March 2022. In the very first five years, less than one paper was published per year. However, 85 of the papers were published in the last 5 years, accounting for more than 80 %, indicating that digital servitization is a novel field that increasingly attracts scholars' attention. As is shown in Table 2, we recognize ten authors – namely, Parida V., David S., Kohtamäki M., Gebauer H., Kowalkowski C., Wincent J., Saccani N., Baines T., Matthyssens P., and Sklyar A, who are among the top contributors in the area. Table 3 shows that the University of Vaasa (Finland), the University of Luleå (Sweden), the University of Linköping (Sweden), Hanken School of Economics (Finland), and the University of St.Gallen (Switzerland) are the most important organizations driving the research on digital servitization.

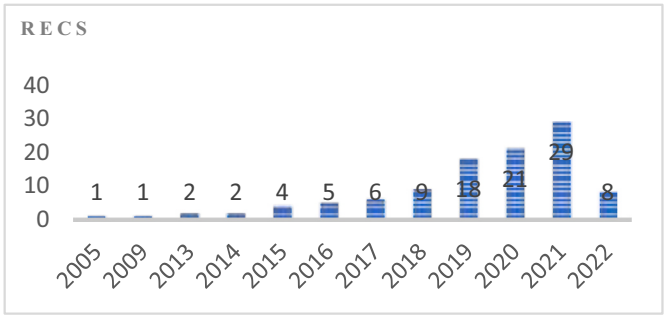

Fig. 3. Distribution of documents by year (2005-March 2022).

Table 4 suggests that Coreynen et al. (2017), Cenamor et al. (2017), Kohtamäki et al. (2019), Opresnik and Taisch (2015), Sklyar et al. (2019a), Ardolino et al. (2018), Baines and Lightfoot (2014), Lerch and Gotsch (2015), Rymaszewska et al. (2017), Eloranta and Turunen (2016) are the most influential papers in the digital servitization literature. Based on Tables 4 and 5, we recognize that eight journals – Industrial Marketing Management, Journal of Business Research, International Journal 0f Operations & Production Management, Journal of Business & Industrial Marketing, International Journal of Production Economics, Technological Forecasting and Social Change, Journal of Manufacturing Technology Management, Research-Technology Management – are among the top contributors in this area. In addition, according to the ranking of journal impact factor (2021), we selected the top 10 out of 38 journals (Table 6). There were 31 articles published in these 10 journals, accounting for 29.25 % of all articles (106). It can be

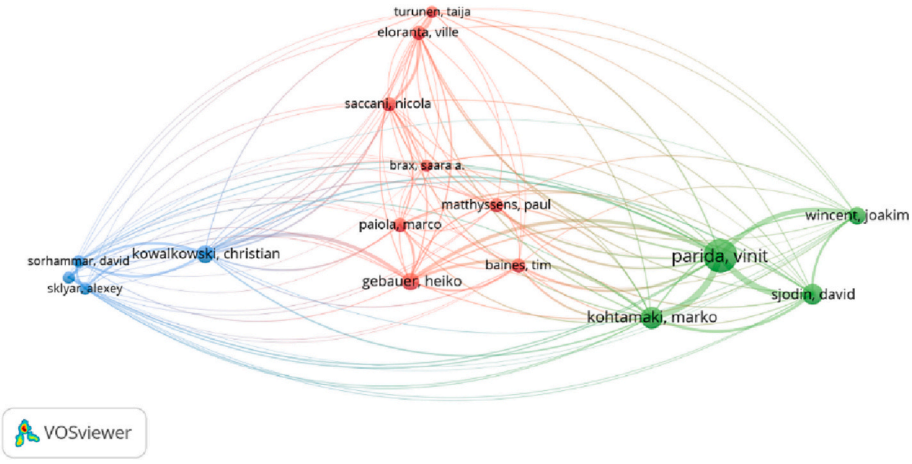

Fig. 4. Bibliographic data map of bibliographic coupling analysis based on authors.

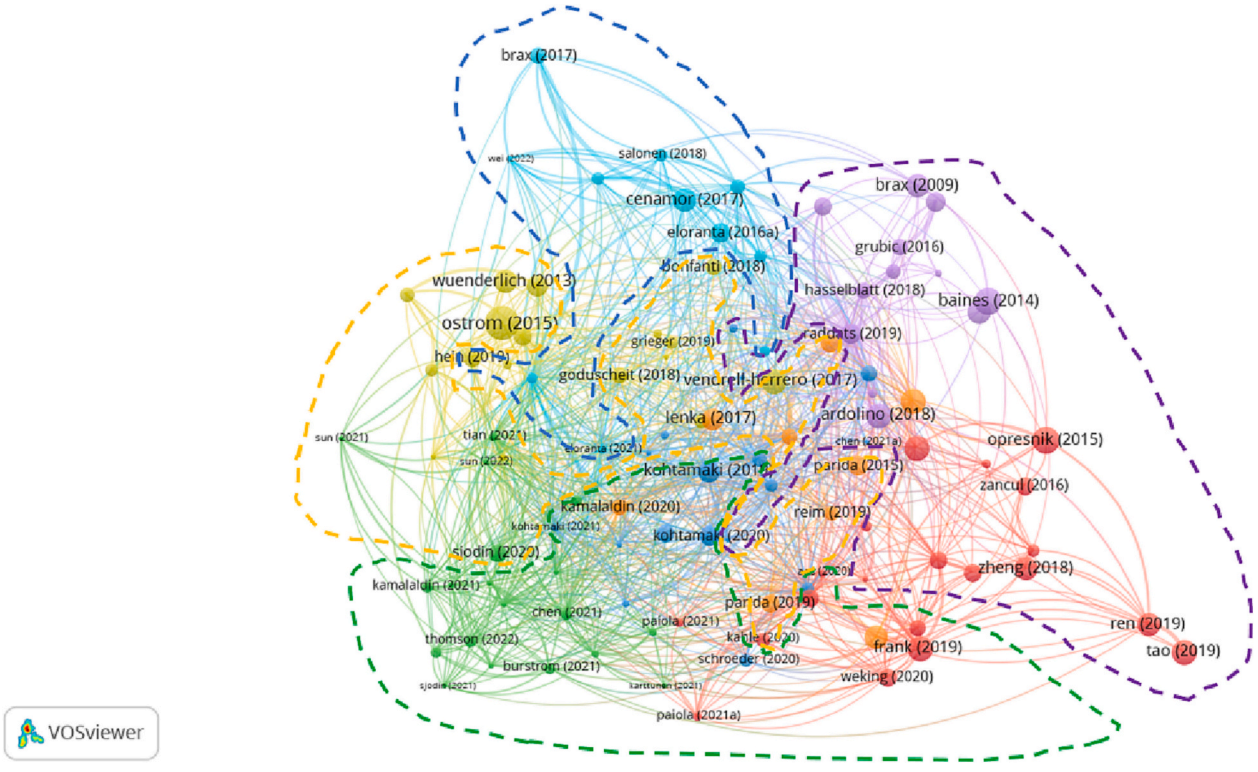

Fig. 5. Bibliographic Map of bibliographic coupling analysis based on documents.

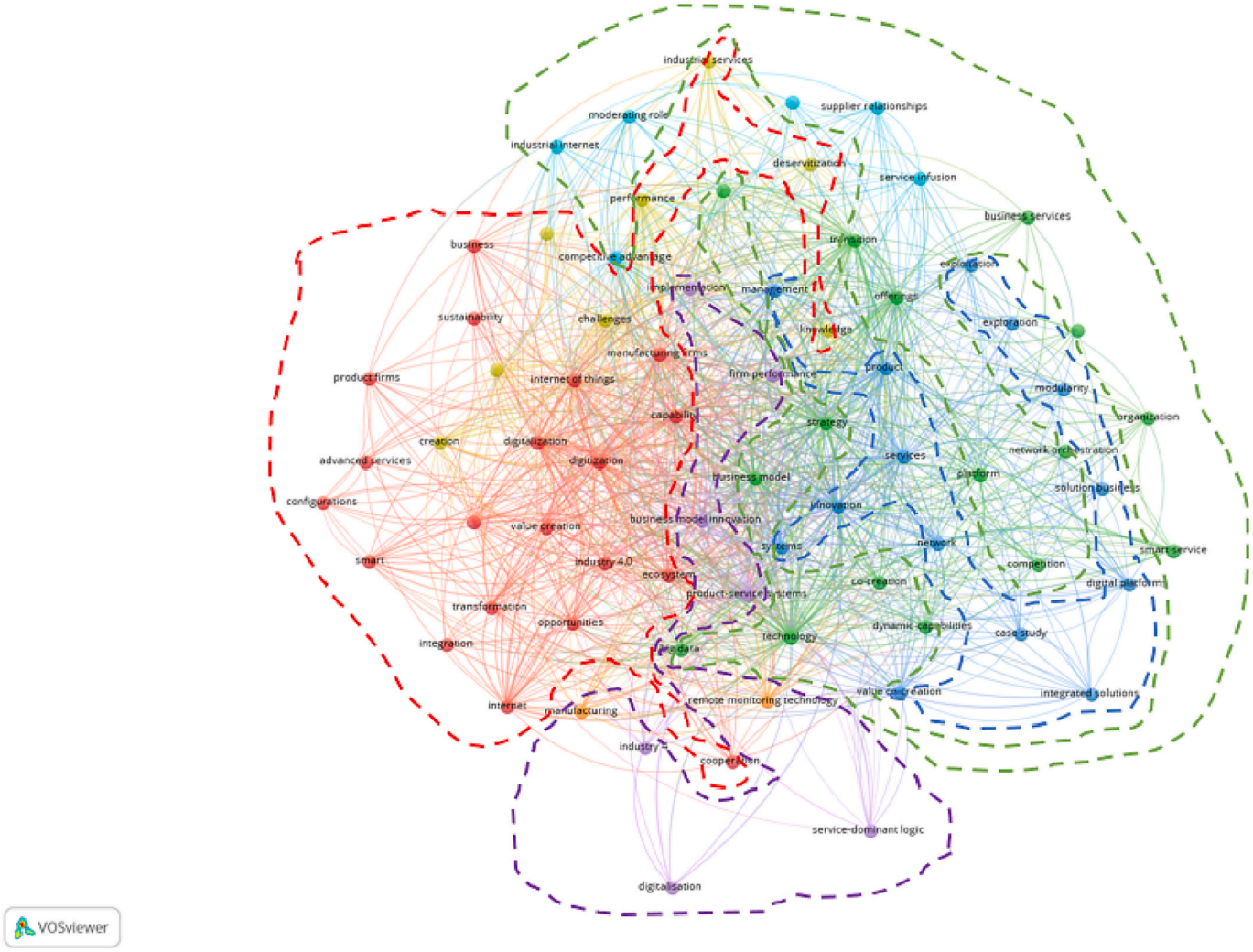

Fig. 6. Bibliographic data map of co-occurrence analysis based on keywords.

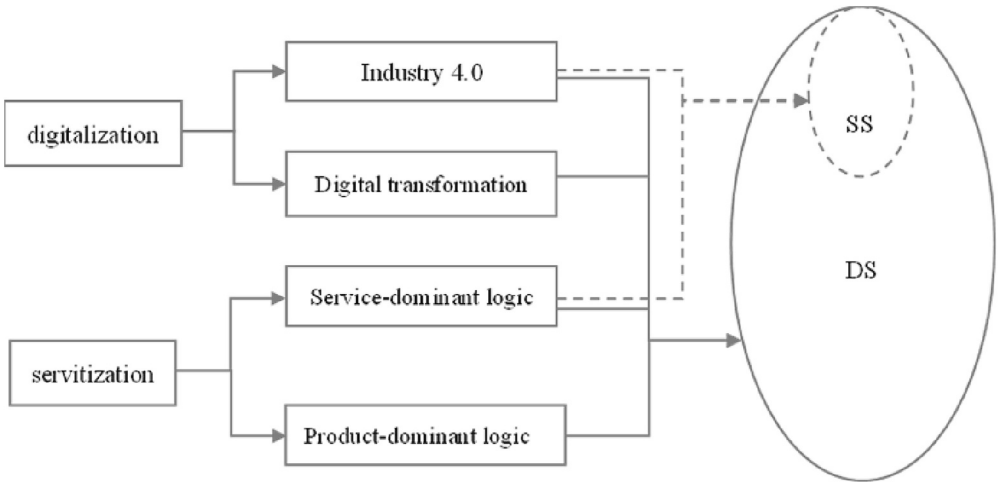

Fig. 7. The relationships between digital-servitization-related concepts.
Note. SS: smart servitization; DS: digital servitization.

seen from this that the digital-servitization-related literature is valued more highly by top journals. By analyzing these articles (see Table 7), we find that digital servitization from the perspective of the ecosystem has secured greater recognition by peer scholars, which provides a reference for future research directions.

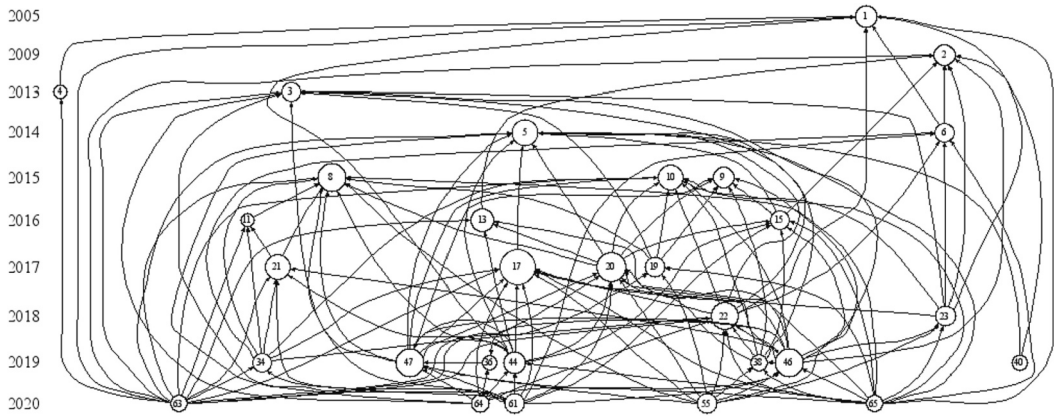

Fig. 8. HistCite citation mapping on digital servitization (Top 30).

3.2. Bibliometric findings

3.2.1. Bibliographic coupling analysis of authors using VOSviewer

Employing the bibliographic coupling analysis of VOSviewer, we used the authors as the unit of analysis, the fractional counting as the method, 3 as the minimum number of documents of an author, and 71 as the minimum number of author citations. Sixteen authors, shown in Fig. 4, met the thresholds. Three groups were formed from the bibliographic coupling analysis (Fig. 4). The red group is dominated by Matthyssens, P., followed by Gebauer, H., Baines, T., Payola, M., Brax, S.A., Saccani, N., Eloranta, V., and Turunen, T. The articles by Matthyssens, P., Gebauer, H., Payola, M., and Baines, T. are principally concerned with aligning digitalization and servitization transformations. On the other hand, Brax, S.A., Saccani, N., Eloranta, V., and Turunen, T. concentrate on conceptualizing a platform strategy for digital servitization. The authors in the green group are Parida, V., Kohtamäki, M., Sjödin, D., and Wincent, J. Their articles are focused on business model innovation in digital servitization. The blue group, comprising Kowalkowski, C., Sklyar, A., Sorhammar, D., and Tronvoll, B., adopt the value co-creation perspective on digital servitization. Therefore, we concluded that, in terms of the development of research on digital servitization, research teams dominated by Matthyssens, P., Parida, V., and Kowalkowski, C. have emerged. All focus on the topic of digital servitization but with differing emphases.

3.2.2. Bibliographic coupling analysis of documents using VOSviewer

We selected bibliographic coupling as the analysis type, documents as the unit of analysis, and fractional counting as the method in VOSviewer. The threshold for the number of citations is set to 0, and all 106 publications achieved this value. Because one article – Allmendinger and Lombreglia (2005) – had no references, the largest set of connected items is 105 out of the 106 items in the network. Seven clusters corresponding to different themes were generated (Fig. 5). However, following the content analysis of the articles in the seven clusters, four topics can be distinguished and, consequently, four clusters created (conceptualizing the platform strategy for digital servitization, aligning digitalization and servitization transformations, the value co-creation perspective on digital servitization, and the business model innovation in digital servitization).

3.2.3. Co-occurrence analysis of keywords using VOSviewer

Here, we created a map of the most frequent keywords for all 106 publications in order to identify the underlying structure of the concepts related to digital servitization. For this purpose, a co-occurrence analysis was conducted using all keywords as the unit of analysis. Firstly, we created a thesaurus file to clean the data by merging different variants of keywords to make more precise clusters. For example, we replaced "strategies" by "strategy" and "networks" by "network". A fractional counting method was used that considered a minimum of three occurrences. Then, we deleted some common terms in the topics, such as "impact", "view", and "perspective". Given that the research topic concerns digital servitization, keywords such as "digital servitization" and "servitization" were unlikely to support the classification process and would simply take up space in keyword co-occurrence. Therefore, we removed these keywords in favor of other keywords closer to the topic. Finally, we chose the 67 most frequent keywords in the 106 articles. The results are displayed in Fig. 6.

4. Emergence of the digital servitization literature

4.1. Origin, definition, and conceptualization of digital servitization

There are so many interrelated concepts connected to digital servitization, such as digitization, digitalization, digital technology, smartization, servitization, and smart servitization, which add to the complexity surrounding origin and definition. Thus, to better understand the definition of digital servitization and to achieve a deeper appreciation of its origins, it is necessary to explore the relationship among the related concepts.

Digital technology, which is the origin of all changes in digital servitization (Paschou et al., 2020), including "internet", "data science (DS)", "artificial intelligence (AI)", "cloud computing (CC)", "Internet of things (IoTs)", "blockchain", "various information systems", "3D printing", "virtual reality (VR)", "augmented reality (AR)", "sensors", "modern communication technology", and so on (Paschou et al., 2020; Rachinger et al., 2018). The different combinations of these technologies lead on to the concepts of "industry 4.0" (Frank et al., 2019). Since each technology has its own limitations, it needs to cooperate with each other to solve specific problems (Paschou et al., 2020). Each technology serves as a link between past and future, forming a generality of technology integration. This phenomenon is difficult to describe until digitalization (Svahn et al., 2017) appears. Digitalization refers to the combination and recombination of digital technologies to create and harvest value in new ways (Svahn et al., 2017). It is different from digitization, which means converting analog information into a digital format (Ng & Wakenshaw, 2017) because the role that they play in digital servitization is different – digitization is the basis of digital servitization whereas its innovativeness requires digitalization (Tronvoll et al., 2020). Digital transformation is a process where digital technologies create disruptions and trigger strategic responses from organizations that are seeking to alter their value creation paths whilst managing the structural changes and organizational barriers that affect the positive and negative outcomes of this process (Vial, 2019). The difference between digitalization and digital transformation may be the degree of change – digitalization tends to change incrementally, while digital transformation is more disruptive. There are some scholars (Tian et al., 2021b) who contend

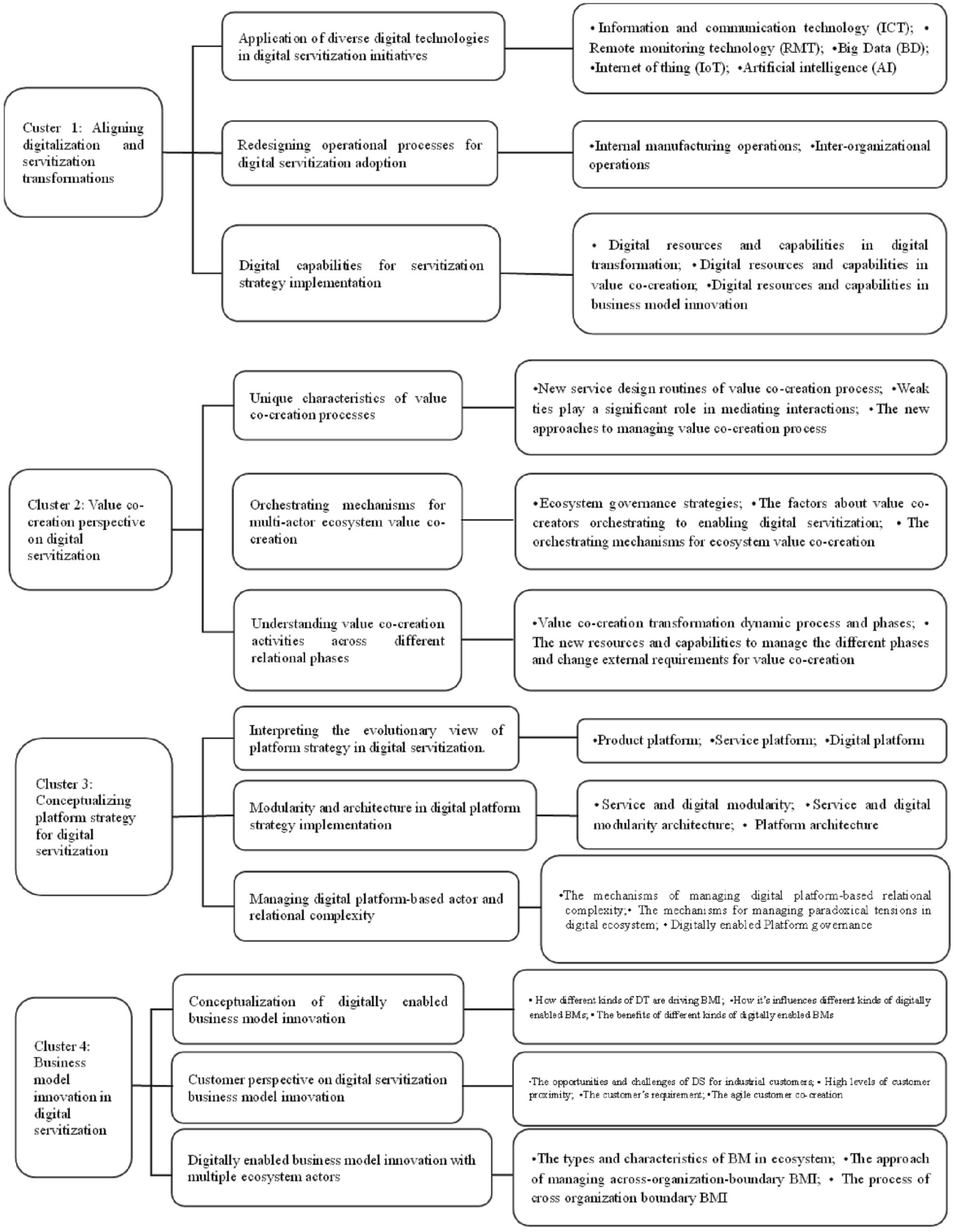

Fig. 9. The main views of each sub-stream in the four clusters of DS literature.

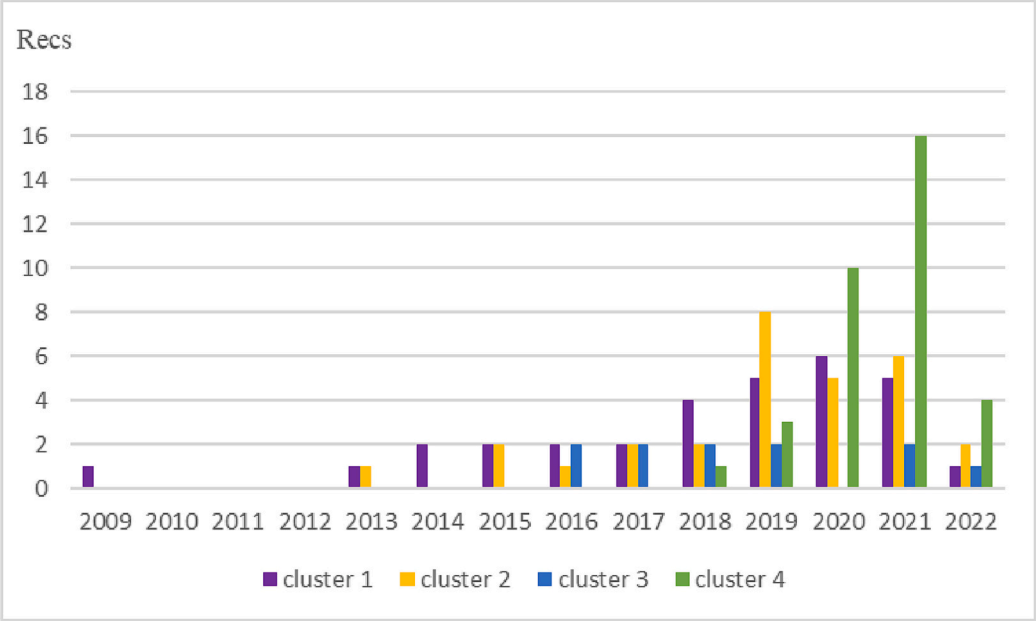

Fig. 10. Distribution of each cluster documents by year.

that the next stage of digitalization is smartization, which refers to the use of AI technology, one of the digital technologies (Baines et al., 2017), to provide new value-creating and revenue-generating opportunities. However, some scholars argue that it is unnecessary to emphasize the exception of smartization because AI technology is also a form of digital technology (Baines et al., 2017).

Servitization, which is the addition of services to product offerings to provide additional customer value (Tian et al., 2021a; Vandermerwe and Rada, 1988), offers a number of benefits to manufacturers, including financial (Neely, 2008), strategic (Baines and Lightfoot, 2014) and marketing (Gebauer et al., 2017) benefits. Servitization is a complex field, especially since it has involved technologies (Rabetino et al., 2018), such as the Internet of things [IoT], blockchain, big data, cloud computing platforms and robotics. Are digitalization and servitization the same or at least similar constructs? Whilst it is possible to move toward services without digitizing the offer, and it is possible to digitize an offer without offering it as a service, the interaction between digitalization and servitization is considered very strong (Lerch and Gotsch, 2015). Therefore, the phenomenon of "digital servitization" (Chen et al., 2021; Ciasullo et al., 2021; Coreynen et al., 2017; Vendrell-Herrero et al., 2017) makes its appearance. There are two perspectives on its definition. In a broad sense, it refers to the provision of IT-enabled (i.e., digital) services relying on digital components embedded in physical products (Holmström & Partanen, 2014; Schroeder & Kotlarsky, 2015). In a narrow sense, it refers to the use of digital technology to sustain the shift from a product-centric to a service-centric logic (Coreynen et al., 2017). Recently, some scholars have proposed the concept of smart servitization, which refers to a further shift toward more connected, intelligent, and autonomous product-service systems (Frank et al., 2019; Tian et al., 2021b). However, in terms of the difference between digitalization and smartization, the divergence in origin between digital servitization and smart servitization may be the respective technologies behind them. Since AI technology is one of the digital technologies (Baines et al., 2017), it can provide evidence for the limited number of publications in smart servitization. Therefore, we can conclude that smart servitization – the future research direction of digital servitization – is embodied in digital servitization. Table 8 lists some of the main publications of digital-servitization-related conceptions. (See Table 9.)

As talked above, we have concluded that the origin of digital servitization is the interaction between digital technology and servitization. The relationships between digitalization and servitization are shown in Fig. 7. Paschou et al. (2020) provide evidence for this idea. In their paper, they found that research on digital servitization dates from 2005, published in the Harvard Business Review, in a paper entitled "Four Strategies for the Age of Smart Services" (Allmendinger and Lombreglia, 2005). This article emphasizes the necessity for enterprises to use technologies to provide smart services, which means building intelligence (awareness and connectivity) into the products themselves (Allmendinger and Lombreglia, 2005). Therefore, there are both connections and differences between digital technology, digitization, digitalization, smartization, and servitization, which are related to the origin of digital servitization – and the origin of digital servitization is the interaction between digital technology and servitization. We can also conclude that smart servitization, the future research direction of digital servitization, is embodied in digital servitization.

4.2. *A broad outline of the evolution of the digital servitization literature*

Citation mapping of articles by HistCite can show the relationships between different documents in one field, allowing the important articles in this field to be quickly identified (Maditati et al., 2018). Concerning the value of LCS, HistCite graph maker generated 30 nodes, which were the top 30 articles on digital servitization, and 137 links, which represent the number of relationships in the 30 articles. Each number in the circle node represents one paper – the larger the circle node, the larger the number of citations. The 30 articles provide a broad outline of the evolution of the digital servitization literature. For 2017, when DS was first established as a new concept (Favoretto et al., 2022), we divided the 30 articles into two distinct periods – namely, before and after 2017.

On the papers published in 2017, scholars have paid attention to the question of how digitalization can enable servitization, and they have been widely cited. For instance, Coreynen et al. (2017) is the first-most-cited paper (with TLCS of 30 and TGCS of 135, represented as node 17 in Fig. 8), which examined how digital technologies can enable servitization pathways of industrial, commercial, and value servitization. The authors pointed out that each of the servitization pathways should be marked by different sets of resources and capabilities. This article may be representative of the topic of how digitalization can enable servitization. Lenka et al. (2017) (note 19 in Fig. 8) point to digitalization

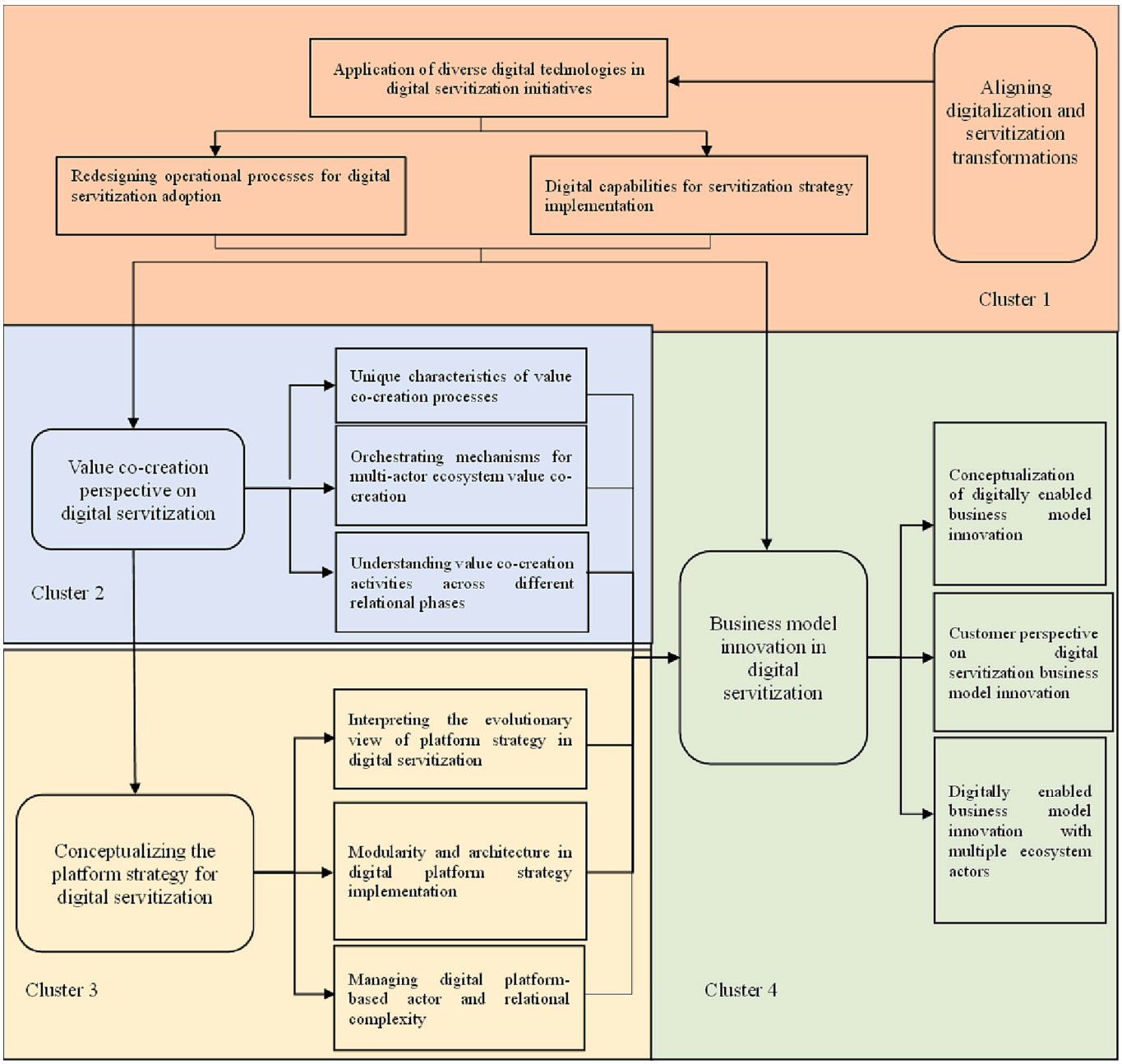

Fig. 11. An integrative digital servitization transformation framework for manufacturing firms.

Table 2
Most influential authors from 106 digital servitization publications.

#	Author	RECS	TLCS	TGCS
1	Parida V	24	167	879
3	David S	13	112	475
2	Kohtamäki M	11	87	396
4	Gebauer H	6	78	382
5	Kowalkowski C	6	84	398
6	Wincent J	6	58	339
9	Saccani N	5	42	452
7	Baines T	4	67	375
8	Matthyssens P	4	54	219
10	Sklyar A	3	51	187

Table 3
Most influential institutions among 106 digital servitization publications.

#	Institution	Recs	TLCS	TGCS
1	Univ Vaasa	25	187	1151
2	Luleå Univ Technol	24	163	881
3	Linköping Univ	11	131	771
4	Hanken Sch Econ	9	85	497
5	Univ St Gallen	9	74	315

capabilities as enablers of value co-creation and thus servitization. Cenamor et al. (2017) (note 20 in Fig. 8) explore how a platform approach facilitates the implementation of advanced service offerings in manufacturing firms. Rymaszewska et al. (2017) (note 21 in Fig. 8) seek to address how servitization can utilize the third wave of Internet development, such as the Internet of things (IoT). These articles are based on previous studies, suggesting pathways for how digital technologies can enable servitization, the mechanisms of digitalization capability on servitization (value co-creation), a platform approach facilitating the implementation of advanced service offerings, and the

Table 4
Most influential papers of 106 digital servitization publications.

#	The information of articles	LCS
1	Coreynen, W., Matthyssens, P., Van Bockhaven, W. Boosting servitization through digitization: Pathways and dynamic resource configurations for manufacturers. Industrial Marketing Management, 2017.	46
2	Cenamor, J., Sjödin, D.R., Parida, V. Adopting a platform approach in servitization: Leveraging the value of digitalization. International Journal of Production Economics, 2017 Oct., 192: 54–65	33
3	Kohtamäki, M., Parida, V., Oghazi, P., Gebauer, H., Baines, T. Digital servitization business models in ecosystems: A theory of the firm. Journal of Business Research, 2019.	31
4	Opresnik, D., Taisch, M. The value of Big Data in servitization[J]. International Journal of Production Economics, 2015.	29
5	Sklyar, A., Kowalkowski, C., Tronvoll, B., Sorhammar, D. Organizing for digital servitization: A service ecosystem perspective. Journal of Business Research, 2019.	29
6	Ardolino, M., Rapaccini, M., Saccani, N., Gaiardelli, P., Crespi, G., et al. The role of digital technologies for the service transformation of industrial companies. International Journal of Production Research, 2018; 56 (6): 2116–2132	28
7	Baines, T., Lightfoot, H.W. Servitization of the manufacturing firm Exploring the operations practices and technologies that deliver advanced services. International Journal of Operations & Production Management, 2014.	27
8	Lerch, C., Gotsch, M. Digitalized Product-Service Systems in Manufacturing Firms. A Case Study Analysis. Research-Technology Management, 2015.	24
9	Rymaszewska, A., Helo, P., Gunasekaran, A. IoT powered servitization of manufacturing - an exploratory case study. International Journal of Production Economics, 2017 Oct., 192: 92–105	24
10	Eloranta, V., Turunen, T. Platforms in service-driven manufacturing: Leveraging complexity by connecting, sharing, and integrating. Industrial Marketing Management, 2016.	20

Table 5
Top 7 journals of 106 digital servitization publications.

#	Journal	RECS	TLCS	TGCS	Impact Factor (2021)
1	*Industrial Marketing Management*	19	162	938	8.890
2	*Journal of Business Research*	14	116	506	10.969
3	*International Journal of Operations & Production Management*	9	68	494	9.360
4	*Journal of Business & Industrial Marketing*	9	33	160	3.319
5	*International Journal of Production Economics*	4	86	635	11.251
6	*Technological Forecasting and Social Change*	4	14	272	10.884
7	*Journal of Manufacturing Technology Management*	3	21	103	8.144
8	*Research-Technology Management*	3	41	238	2.855

Table 6
Top 10 of 36 journals.

#	Journal	RECS	TLCS	TGCS	Impact Factor (2021)
1	*Harvard Business Review*	1	19	204	12.129
2	*California Management Review*	1	0	0	11.678
3	*IEEE Transactions on Systems, Man, and Cybernetics: Systems*	1	3	195	11.471
4	*Technovation*	1	0	8	11.373
5	*International Journal of Production Economics*	4	86	635	11.251
6	*Journal of Cleaner Production*	2	4	283	11.072
7	*Journal of Business Research*	14	116	506	10.969
8	*Technological Forecasting and Social Change*	4	14	272	10.884
9	*Journal of Research in Interactive Marketing*	1	1	15	10.176
10	*Journal of Service Research*	2	11	855	10.052

Table 7
Most influential papers of 31 digital servitization publications in top 10 journals.

#	The information of articles	LCS
1	Cenamor J, Sjödin DR, Parida V. Adopting a platform approach in servitization: Leveraging the value of digitalization. INTERNATIONAL JOURNAL OF PRODUCTION ECONOMICS. 2017 OCT; 192: 54–65.	33
2	Kohtamäki M, Parida V, Oghazi P, Gebauer H, Baines T. Digital servitization business models in ecosystems: A theory of the firm. JOURNAL OF BUSINESS RESEARCH. 2019 NOV; 104: 380–392.	31
3	Opresnik D, Taisch M. The value of Big Data in servitization. INTERNATIONAL JOURNAL OF PRODUCTION ECONOMICS. 2015 JUL; 165: 174–184.	29
4	Sklyar A, Kowalkowski C, Tronvoll B, Sorhammar D. Organizing for digital servitization: A service ecosystem perspective. JOURNAL OF BUSINESS RESEARCH. 2019 NOV; 104: 450–460.	29
5	Rymaszewska A, Helo P, Gunasekaran A. IoT powered servitization of manufacturing - an exploratory case study. INTERNATIONAL JOURNAL OF PRODUCTION ECONOMICS. 2017 OCT; 192: 92–105.	24
6	Allmendinger G, Lombreglia R. Four strategies for the age of smart services. HARVARD BUSINESS REVIEW. 2005 OCT; 83 (10): 131 – +	19
7	Sjödin D, Parida V, Kohtamäki M, Wincent J. An agile co-creation process for digital servitization: A micro-service innovation approach. JOURNAL OF BUSINESS RESEARCH. 2020 MAY; 112: 478–491.	15
8	Sjödin DR, Parida V, Kohtamäki M. Capability configurations for advanced service offerings in manufacturing firms: Using fuzzy set qualitative comparative analysis. JOURNAL OF BUSINESS RESEARCH. 2016 NOV; 69 (11): 5330–5335.	14
9	Frank AG, Mendes GHS, Ayala NF, Ghezzi A. Servitization and Industry 4.0 convergence in the digital transformation of product firms: A business model innovation perspective. TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE. 2019 APR; 141: 341–351.	14
10	Sjödin D, Parida V, Kohtamäki M. Relational governance strategies for advanced service provision: Multiple paths to superior financial performance in servitization. JOURNAL OF BUSINESS RESEARCH. 2019 AUG; 101: 906–915.	12

impact of Industry-4.0-related technologies on servitization, leading on to subsequent research on digital-technology-based business model innovation.

The papers published before 2017 focus mainly on the application of digital technologies in servitization. From Fig. 8, we see that the research on digital servitization originates from 2005 (note 1 in Fig. 8), is published in the Harvard Business Review, and is titled "Four Strategies for the Age of Smart Services" (Allmendinger and Lombreglia, 2005). They emphasize the necessity for enterprises to use technologies to provide smart services, which means building intelligence (awareness and connectivity) into the products themselves (Allmendinger and Lombreglia, 2005). Following on from that, many scholars have investigated the value of digital technologies in servitization, such as information and communications technology (ICT) (Kowalkowski et al., 2013: note 3 in Fig. 8), remote monitoring technology (RMT) (Grubic, 2014: note 6 in Fig. 8), Big Data (Opresnik and Taisch, 2015: note 8 in Fig. 8), and the Internet of things (IoT) (Zancul et al., 2016: note 11 in Fig. 8). There are other scholars who have talked about the change of relationship between company and customer in terms of applying digital technologies, such as the complex nature of establishing integrated solutions (Brax & Jonsson, 2009: note 2 in Fig. 8), user attitudes and behaviors related to smart interactive services (Wunderlich et al., 2013: note 4 in Fig. 8), digitalized product–service systems (Lerch and Gotsch, 2015: note 10 in Fig. 8), as well as the management of advanced services, such as platform (Baines and Lightfoot, 2014: note 5 in Fig. 8; Eloranta & Turunen, 2016: note 13 in Fig. 8), global service innovation capabilities (Parida et al., 2015: note 9 in Fig. 8), and capability configurations for advanced services (Sjödin et al., 2016: note 15 in Fig. 8).

Table 8
The main publications of related conceptions of digital servitization.

Items	Literature review
Digitization	Rachinger et al., 2018; Ng and Wakenshaw, 2017
Digitalization	Svahn et al., 2017; Hinings et al., 2018; Lindman and Saarikko, 2019; Lusch and Nambisan, 2015
Digital technology	Rachinger et al., 2018; Ferreira et al., 2017
Smartization	Baines et al., 2017; Schiavone et al., 2019
Servitization	Tian et al., 2021a; Raddats et al., 2019; Vandermerwe and Rada, 1988
Digital servitization	Chen et al., 2021; Kohtamäki et al., 2019; Coreynen et al., 2017; Vendrell-Herrero et al., 2017
Smart servitization	Kamp et al., 2017; Tian et al., 2021b

Thus, they have contributed to the emergence of the DS concept in the servitization literature.

After 2017, with the application of the technologies of Industry 4.0, such as the Internet of things (IoT), cloud computing (CC), and predictive analytics (PA) in servitization, many studies have started to focus directly on DS as the main unit of analysis (e.g., Kohtamäki et al., 2019; Sklyar et al., 2019a) rather than focusing on the use of digital technologies to enable services in product companies. In 2018, using the data–information–knowledge–wisdom (DIKW) model, Ardolino et al. (2018) (note 22 in Fig. 8) discussed how the Internet of things (IoT), cloud computing (CC), and predictive analytics (PA) transform low-level entities, such as data, into information and knowledge to support the service transformation of manufacturers. Hasselblatt et al. (2018) (note 23 in Fig. 8) augment the literature by developing a conceptual model of five core capabilities (digital business model development; building scalable solution platforms; IoT value selling; IoT value delivery; business intelligence and measurement) that industrial companies need to develop in order to build, sell, and deliver Internet-of things-enabled solutions successfully. Most of the articles that followed investigated DS from a business model perspective. For instance, Frank et al. (2019) (note 34 in Fig. 8) presents a conceptual framework that connects servitization and industry 4.0 concepts from a business model innovation (BMI) perspective. Kohtamäki et al. (2019) (node 46 in Fig. 8) is the third-most-cited paper, which explores how the servitization literature acknowledges digitalization, what business-model configuration types are discussed in the servitization literature, how the digital component shapes servitization business models, and how digital servitization is defined and constructed in the servitization literature. Paiola and Gebauer (2020) (note 61 in Fig. 8) focus mainly on what are the challenges that this digital servitization poses to the business models of traditional manufacturers. Other articles address a variety of research topics, such as the transformation process of DS with a service ecosystem perspective (Sklyar et al., 2019a: note 36 in Fig. 8; Sklyar et al., 2019a: note 47 in Fig. 8), the relationship governance in digital servitization (Sjödin et al., 2019: note 38 in Fig. 8; Kamalaldin et al., 2020: note 65 in Fig. 8), modular solution offerings (Rajala et al., 2019: note 40 in Fig. 8), an agile co-creation process for digital servitization (Sjödin et al., 2020: note 55 in Fig. 8), the strategic organizational shifts that underpin digital servitization (Tronvoll et al., 2020: note 64 in Fig. 8). Some articles also talked about the literature review of DS and servitization, such as Paschou et al. (2020) (note 63 in Fig. 8) and Raddats et al. (2019) (note 44 in Fig. 8).

5. Content analysis of thematic areas

Thematic areas connecting articles in each cluster were identified from a content analysis of the articles in Fig. 5 and Fig. 6. Content analyses of the most prestigious articles in each theme yielded sub-themes within their respective areas. Representative articles are listed in Table 10 and the main views of each sub-theme are listed in Fig. 9.

Table 9
The most commonly used definitions of digital servitization.

Definitions	Literature
•A transition from pure products and add-on services to smart solutions/ product–service systems, which possess the capabilities of connectivity, monitoring, control, optimization and autonomy.	Porter and Heppelmann, 2014; Lenka et al., 2017; Kohtamäki et al., 2020; Chen et al., 2021
• The utilization of digital tools for transformational processes whereby a company shifts from a product-centric to a service-centric business model and logic.	Tronvoll et al., 2020; Ardolino et al., 2018; Coreynen et al., 2017; Sklyar, Kowalkowski, Sorhammar, & Tronvoll, 2019b; Sklyar et al., 2019a; Kowalkowski, Gebauer, Kamp, & Parry, 2017; Classen & Friedli, 2021
• The provision of IT-enabled (i.e., digital) services relying on digital components embedded in physical products".	Vendrell-Herrero et al., 2017; Porter & Heppelmann, 2014; Holmström & Partanen, 2014; Schroeder & Kotlarsky, 2015
• The transition toward smart product-service-software systems that enable value creation and capture through monitoring, control, optimization, and autonomous function.	Kohtamäki, Parida et al. (2019, p. 4); Solem et al., 2022; Lerch and Gotsch, 2015; Simonsson and Agarwal, 2021; Hsuan et al., 2021
• Servitization as a part of Industry 4.0, which not only emphasizes the value that digital technologies can provide in terms of service value delivery to the customer but also the value of internal manufacturing processes.	Frank et al., 2019
• Smart servitization refers to a traditional product provider's transition to offering a bundle of smart connected products with smart services, which is a further shift toward more connected, intelligent, and autonomous product–service systems.	Kamp et al., 2017; Tian et al., 2021b
•Digital servitization focuses on how digital technology enables the supply of services in innovative ways.	Cenamor et al., 2017; Coreynen et al., 2017; Sklyar et al., 2019a; Vendrell-Herrero et al., 2017; Paiola and Gebauer, 2020
• A reference to business models that enhance traditional non-digital goods and services with the implementation of ICT or other digital technologies.	Vendrell-Herrero et al., 2017
•The adoption of digital technologies achieves more environmentally friendly production processes, communication channels, and products and services, enhancing economic value.	Opazo-Basáez et al., 2018
•The transformation in processes, capabilities, and offerings within industrial firms and their associated ecosystems to progressively create, deliver, and capture increased service value arising from a broad range of enabling digital technologies, such as the Internet of things (IoT), big data, artificial intelligence (AI), and cloud computing.	Sjödin et al., 2020; Kamalaldin et al., 2020; Parida et al., 2019; Rindfleisch, O'Hern, Sachdev, 2017; Hasselblatt et al., 2018; Paiola and Gebauer, 2020; Eloranta et al., 2021;
•In the article of Vendrell-Herrero et al. (2017), they point out proposition 1, which said digital servitization increases the relative dependence of upstream firms on downstream companies. From this point, we concluded that the application of digital technology, such as Big Data and cloud computing, in enterprise transformation to accelerate the process of enterprise servitization and shift enterprises from product-centered to service-centered processes to enhance the value of traditional non-digital products and services. In addition, in the article of Sun and zhang (2022), they clearly pointed that the application of digital	Vendrell-Herrero et al., 2017; Sun and Zhang, 2022

(continued on next page)

Table 9 (*continued*)

Definitions	Literature
technology, such as Big Data and cloud computing, in enterprise transformation to accelerate the process of enterprise servitization and shift enterprises from product-centered to service-centered processes to enhance the value of traditional non-digital products and services.	

5.1. Cluster 1: Aligning digitalization and servitization transformations

The adoption of digital technologies for servitization by manufacturers represents a distinctive cluster within the digital servitization literature. Specifically, these firms apply diverse digital technologies to redesign operational processes and develop new digitally oriented resources and capabilities for digital servitization transformation. Below, we provide a description of the key studies that form part of the cluster.

5.1.1. Application of diverse digital technologies in digital servitization initiatives

Numerous early studies related to servitization merely discuss digital transformation in general terms. For instance, an early study by Kowalkowski et al. (2013) investigated how information and communication technology (ICT) can enable service differentiation and, thus, act as a catalyst for service business orientation. They identify two distinct types of service-oriented differentiation: services in support of the product (SSP) and services in support of the client's actions (SSC). The study finds that SSCs have the largest positive impact on firms' service business orientation (Kowalkowski et al., 2013). Another study by Grubic and Peppard (2016) describes how four manufacturers utilized remote monitoring technology (RMT); they identify ten factors that enabled and constrained the realization of expected outcomes. The enabling factors identified include: skills, experience, and knowledge; support from customers and other complementary data sources, processes, and structures; operations centers; historical data; and presence of in-house knowledge and capabilities (Grubic and Peppard, 2016). Opresnik and Taisch (2015) scrutinize how manufacturers exploit the opportunity arising from combining big data and servitization. This article introduces the critical role of five "Vs" in big data – value, in addition to the other four "Vs" - volume, variety, velocity, and verification (Opresnik and Taisch, 2015). As regards servitization, the article adds a third layer needed to create added value – information or digital in addition to the two existing layers: product and service (Opresnik and Taisch, 2015).

Increasingly, recent studies – for example, Qvist-Sørensen (2020) – point to the need for companies to acquire new skills, such as data and analytics as represented by the Internet of things (IIoT) and artificial intelligence (AI), which will play an ever greater role in company interaction with existing and new customers. For industrial companies, servitization is linked to both higher risk and higher earnings potential (Qvist-Sørensen, 2020). Blockchain is another influential digital technology that has some unique technological features, such as a decentralized structure, distributed notes and storage mechanisms, a consensus algorithm, smart contracting, and asymmetric encryption to ensure network security, transparency, and visibility (Dutta et al., 2020). Some scholars have argued that blockchain is a crucial technology for the supply chain (Kurpjuweit et al., 2021)– for example, supply chain transparency (Zelbst et al., 2020), and supply chain operations (Dutta et al., 2020). Other scholars have noted that the application of blockchain technology inherently necessitates an (open) platform ecosystem. For instance, TradeLens is a leading global shipping platform ecosystem that is underpinned by blockchain technology (Jovanovic et al., 2021). However, its application to digital servitization transformation has received less consideration. In addition, AI is in the early

Table 10
Clusters of digital servitization literature.

Clusters	Sub-streams	Representative literature
Cluster 1: Aligning digitalization and servitization transformations	• Application of diverse digital technologies in digital servitization initiatives.	Kowalkowski et al., 2013; Grubic and Peppard, 2016; Opresnik and Taisch, 2015; Qvist-Sørensen, 2020
	• Redesigning operational processes for digital servitization adoption.	Brax and Jonsson, 2009; Baines and Lightfoot, 2014; Lerch and Gotsch, 2015; Zancul et al., 2016; Huikkola and Kohtamäki, 2020; Gaiardelli et al., 2021
	• Digital capabilities for servitization strategy implementation.	Hasselblatt et al., 2018; Martin-Pena et al., 2019; De la Calle et al., 2020; Jovanovic and Morschett, 2021; Simonsson and Agarwal, 2021; Coreynen et al., 2017
Cluster 2: Value co-creation perspective on digital servitization	• Unique characteristics of value co-creation processes.	Solem et al., 2022; Sklyar et al., 2019a; Sjödin et al., 2020; Birch-Jensen et al., 2020; Kropp and Totzek, 2020
	• Orchestrating mechanisms for multi-actor ecosystem value co-creation.	Sjödin et al., 2019; Wunderlich et al., 2013; Parida et al., 2019; Sklyar et al., 2019a;
	• Understanding value co-creation activities across different relational phases.	Kamalaldin et al., 2020; Sun and Zhang, 2022; Tian et al., 2021b; Payne et al., 2021;
Cluster 3: Conceptualizing the platform strategy for digital servitization	• Interpreting the evolutionary view of platform strategy in digital servitization.	Rajala et al., 2019; Wei et al., 2019; Beverungen et al., 2021;
	• Modularity and architecture in digital platform strategy implementation.	Brax et al., 2017; Salonen et al., 2018; Turunen et al., 2018; Cenamor et al., 2017; Hsuan et al., 2021
	• Managing digital platform-based actor and relational complexity.	Eloranta and Turunen, 2016; Eloranta et al., 2016; Eloranta et al., 2021; Hein et al., 2019; Wei et al., 2022
Cluster 4: Business model innovation in digital servitization	• Conceptualization of digitally enabled business model innovation.	Aas et al., 2020; Schroeder et al., 2020; Naik et al., 2020; Boldosova, 2020; Paiola and Gebauer, 2020; Paiola et al., 2021a
	• Customer perspective on digital servitization business model innovation.	Sjödin et al., 2021; Rapaccini et al., 2020; Coreynen et al., 2020; Kamalaldin et al., 2021
	• Digitally enabled business model innovation with multiple ecosystem actors.	Frank et al., 2019; Weking et al., 2019; Kohtamäki et al., 2019; Sjödin et al., 2022; Paiola et al., 2021b; Hoch and Brad, 2021; Kolagar et al., 2022; Burström et al., 2021; Thomson et al., 2022; Kohtamäki et al., 2021; Chen et al., 2021; Struyf et al., 2021

stages of disrupting the service ecosystem (Sjödin et al., 2021)a. Much is yet to be learned about how customers can define value in AI services, which factors will impact AI usage, and how the customer experience of service delivery may change in an AI context. Future research should identify any unique value-creating AI activities across customer-facing or back-office operations.

5.1.2. Redesigning operational processes for digital servitization

"Operational processes" are the routines or activities that firms engage in to accomplish some business purpose or objective (Porter, 1991; Ray et al., 2004). They can be divided into internal and inter-organizational operational processes (Coreynen et al., 2017; Ribeiro et al., 2022). There are three core internal- operational processes – namely, "product–service development processes", "sales processes", and "service delivery processes" (Favoretto et al., 2022). Based on these core operational processes, some scholars consider redesigning them to gain acceptance in a digital servitization context. For instance, Brax and Jonsson (2009) assert that, to facilitate this collaborative process, building an integrated-solutions business means that the interdependence of the solution components – both within the provider company and the offering, and between the provider and the client – must be carefully managed. Baines and Lightfoot (2014) find six distinct technologies and practices that illustrate how operations are configured to successfully deliver advanced services – namely, facilities and their location, micro-vertical integration and supplier relationships, information and communication technologies (ICTs), performance measurement and value demonstration, people deployment and their skills, and business processes and customer relationships. Lerch and Gotsch (2015) contend that firms who can master the evolution to services will integrate tangible products, intangible services, and digital architectures to deliver novel digitalized PSS that provide strongly customer-oriented and highly customized solutions.

As digital technology develops, Industry 4.0 calls for end-to-end digital integration of supply chains and a new boundary-spanning logic of process design (Ribeiro et al., 2022). Mendling et al. (2020) argue that, over time, process design must balance: i) new feature innovation with immediate feedback; ii) predefined structure with freedom for adaptation; iii) enforcement of process compliance with identification of positive deviance; and iv) local optimization with global options for reuse. The collaborative nature of Industry 4.0 highlights the need to manage inter-organizational operational processes, which refer to the interrelated activities that are shared and executed by two or more entities to achieve value for partners (Ribeiro et al., 2022; Bala & Venkatesh, 2007). For example, Zancul et al. (2016) propose a method that focuses on the business-process implications of the Internet of things (IoT) when adopting an IoT-enabled product–service system (PSS) that considers business model and product enhancements. Huikkola and Kohtamäki et al. (2020) propose a new agile solution development model for technology and manufacturing companies, which offers a new way to consider ideas related to new product, service, process, and business model development. Gaiardelli et al. (2021) argue that economic transformation has forced companies to redefine their value propositions and increase traditional product offerings with supplementary services – the so-called product–service system (PSS). Since the adoption of Industry 4.0 technologies is a very common feature, they identified the main trajectories that would shape a future scenario in which PSS and Industry 4.0 would merge. Scholars have been encouraging convergence between business process management and digital innovation research (Mendling et al., 2020). However, we note that research is scant on the convergence between digital technologies and business processes. This shortcoming points to the need for further study, especially in an ecosystem context.

5.1.3. Digital capabilities for servitization strategy implementation

The changes in operational processing ought to be supported by different sets of resources and capabilities (Coreynen et al., 2017). In particular, firms need to develop digital resources and capabilities to enable the transformation to digital servitization. For instance, Hasselblatt et al. (2018) argue that manufacturing firms benefit from five strategic Internet of things (IoT) capabilities that allow them to develop, build, sell, and deliver IoT services. – namely, digital business model development, scalable solution platform building, value selling, value delivery, and business intelligence and measurement (Hasselblatt et al., 2018). Martin-Pena et al. (2019), using quantitative research methods, find that digitalization positively mediates the relationship between servitization and firm performance. This study contends that digitalization facilitates service quality through better resource allocation, and digitalization capabilities support the interaction of resources, processes, and outcomes between manufacturing firms and customers to co-create value (Martín-Peña et al., 2020). De la Calle et al. (2020) studied the relationship between digital capabilities and servitization in Spanish industries, and they found that advanced manufacturing technologies (AMT) have no significant or positive impact on servitizing, except when combined with digital capabilities for the purpose of internet-based marketing. Jovanovic and Morschett (2021) explore the impact of digitalization and administrative heritage on the decision concerning how best to configure industrial service offerings across borders (Jovanovic and Morschett, 2021). Here, they investigate the impact of different service characteristics and the servitization strategy on this decision. Simonsson and Agarwal (2021) employed a survey and an empirical assessment of several large industrial organizations interested in servitization and digitalization (Simonsson and Agarwal, 2021). They find that digital capabilities can deliver perceived value by using digital business models that provide stakeholders with swift access to data. This section has dealt with the literature covering the digital resources and capabilities that enable digital servitization transformation from a broad perspective. In the following clusters, we view the literature that exhibits a sharper focus on these resources and capabilities.

In summary, cluster 1 has investigated the application of diverse digital technologies in digital servitization initiatives, redesigning operational processes for digital servitization acceptance, and digital resources and capabilities for digital servitization implementation. Although existing studies have made significant contributions to the field, they have also highlighted numerous research gaps, such as how blockchain technology can best be combined with other complementary digital technologies, how digital technologies can be used to promote new operational processes to engage with the value network and the ecosystem, and so on.

5.2. Cluster2: Value co-creation perspective on digital servitization

With the development and application of digital technologies, research on value co-creation has gradually changed from a single dimension of supplier–customer interaction (Kohtamäki and Rajala., 2016) to a multi-dimensional interaction between enterprises and customers, enterprises and suppliers, and so on (Marcos Cuevas et al., 2016). Applying diverse digital technologies for the purpose of digital servitization transformation forces manufacturing firms to redesign their operational processes and develop new digitalization-oriented resources and capabilities (Coreynen et al., 2017). Furthermore, the consumption behaviors of customers are changed (Verhoef et al., 2019) to more personalized customization and smart requirements. These changes accelerate the reach and pace of value co-creation development (Beverungen et al., 2020), profoundly transforming businesses and societies globally (Vendrell-Herrero et al., 2017). This has created a significant research cluster in the digital servitization literature – value co-creation in digital servitization (Cluster 2) – which is related to the process characteristics, transformation phases of value co-creation, and the orchestrating mechanisms underlying ecosystem value co-creation. Following the lead of Sjödin et al. (2020), we conceptualize value co-creation from the perspective of digital servitization transformation. It is defined as the agile co-creation process with the characteristics of

flexibility, pace, and customer focus.

5.2.1. Unique characteristics of value co-creation processes

To attain successful innovation in line with the digital servitization principles of smart PSS, Solem et al. (2022) state that the participants involved need to reconfigure the institutional logic and establish new service design routines (Solem et al., 2022). This is to be accomplished through service design activities, such as user insights through creative customer data acquisition, smart PSS collaboration through co-creation across departments, smart PSS ideation through creative forms of collaboration, and effective smart PSS delivery and commercialization through creative concept design. Furthermore, Sklyar et al. (2019a) find that the interaction between actors typically relied on non-continuous (e.g., analogue) communication in the pre-digitalized ecosystem and, as a result, strong ties predominated in resource integration patterns. In contrast, digitalized ecosystem technology enabled weak ties to play a significant role in mediating interactions (Sklyar et al., 2019a). Birch-Jensen et al. (2020) explored how firms make use of customer feedback to support quality improvement in digitally connected services (DCS). Their findings show that customer-initiated feedback increased when the firm developed its service offering into DCS. They derived three key components in customer feedback for quality improvement in DCS: channeling, processing, and knowledge conversion (Birch-Jensen et al., 2020). Kropp and Totzek (2020) examined how institutional pressures (mimetic, normative, and coercive) – which provide shared expectations of and norms for legitimate behavior – and system characteristics influence business-to-business (B2B) customer acceptance of smart product–service systems (PSSs) (Kropp and Totzek, 2020). Sjödin et al. (2020) explain that value co-creation in digital servitization is best managed through an agile micro-service innovation approach. Such an approach requires incremental micro-service investments, sprint-based micro-service development, and micro-service learning by doing to ensure customized and scalable digital service offerings (Sjödin et al., 2020). Thus, the characteristics of value co-creation require different thinking – agile, experimental, and small development steps undertaken in close cooperation with leading customers (Sjödin et al., 2020). Value co-creation is difficult to observe empirically. Studies must pay greater attention to the micro-foundations that underpin the value co-creation phenomenon (Storbacka et al., 2016). Therefore, formalizing value co-creation processes will benefit the process of understanding. However, there remains a lack of clarity on the steps and activities required for such processes to develop new digital solutions.

5.2.2. Orchestrating mechanisms for multi-actor ecosystem value co-creation

Many ecosystem actors and stakeholders (Parida et al., 2015) are involved in value co-creation activities for digital servitization. These include customers, providers, retailers, and competitors, who consciously need to determine what ecosystem governance strategies to apply. Sjödin et al. (2019) identify three alternative governance strategies that enable advanced service providers to benefit from service provision: i) innovation governance strategy (high service innovation, low attractiveness of alternatives, and low use of explicit contracts); ii) relational governance strategy (high service innovation, high perceived switching costs, and low use of explicit contracts); and iii) market-based governance strategy (high service innovation, low perceived switching costs, high attractiveness of alternatives, and high use of explicit contracts). Some scholars have discussed the factors that value co-creators must orchestrate in order to enable digital servitization. For instance, Wunderlich et al. (2013) employ a grounded theory approach, drawing on depth interviews to develop a framework of barriers to and facilitators of users' attitudinal and behavioral responses to smart interactive services. Their findings reveal that control, trustworthiness, and collaboration beliefs emerge jointly as important and interrelated influencers linked to the service counterpart, which can help better orchestrate the relationship between stakeholders. Parida et al. (2019) argues that the complexity and interdependencies in the circular economy mean that no single company can succeed alone and, thus, ecosystem-wide orchestration is necessary (Parida et al., 2019). The authors extend the work of prior studies by detailing how ecosystem orchestrators implement these mechanisms (standardization, nurturing, and negotiation) to influence the transformation of both core and peripheral ecosystem partners. Digital servitization is entangled in the ecosystem and is enabled by centralization, embeddedness, and integration (Sklyar et al., 2019a). To achieve service-led, digital growth, a firm and its network must make three interconnected shifts: i) from planning to discovery, ii) from scarcity to abundance, and iii) from hierarchy to partnership (Tronvoll et al., 2020). Moreover, other scholars have explored platform-based governance – an important topic in digital servitization that we discuss in the next section. The ecosystem value co-creation process needs engagement and intensive collaboration between provider and customer (Story et al., 2017; Valtakoski, 2017) and, at the same time, it requires competition (Sjödin, 2018). Taken as a whole, it is a complex phenomenon that needs to be better understood.

5.2.3. Understanding value creation micro-activities across different relational phases

Digital servitization requires closer provider–customer relationships characterized by co-creation logic, long-term commitment, and greater investment in relationships (Kamalaldin et al., 2020). Kamalaldin et al. (2020) state that value co-creation goes through three relational transformational phases – namely, foundational, intermediate, and advanced – where one phase builds on the other. The relational view theory provides an overview of how the four relational components (complementary digitalization capabilities, relation-specific digital assets, digitally enabled knowledge-sharing routines, and partnership governance) evolve as the relationship progresses (Kamalaldin et al., 2020). Moreover, the extent of external actor involvement in value co-creation increases from customers to multiple dynamic and heterogeneous complementors. For instance, Sun and Zhang (2022) disentangle the dynamic process of shifting from traditional customer orientation to digital customer orientation in platform ecosystems. They show that digital incentives – incentive orchestration, incentive decentralization, and digital facilitation – can be instrumental in accelerating this process. In addition, new resources and capabilities are needed to manage the different phases and changing external requirements for value co-creation. These include dynamic capabilities (especially technology integration capability, resource integration capability, and network capability) (Sun and Zhang, 2022), orchestration capabilities (Tian et al., 2021b), and artificial intelligence (AI) capabilities (Manser Payne et al., 2021). SMEs suffer from the liability of smallness (Freeman et al., 1983), which creates additional resource constraints and liquidity problems (Fready et al., 2022). This is one reason why value co-creation is of greater significance for SMEs. Consequently, SMEs may face the risk of losing control over the solution during the value co-creation process with other leading companies. Greater attention should be paid to the characteristics of the value co-creation process, orchestrating mechanisms, and transformation phases between SMEs and leading companies, so that win-win approaches to co-create value between SMEs and leading companies can be found.

In sum, these sub-clusters are related to the characteristics of the value co-creation process in digital servitization, the orchestrating mechanisms in ecosystem value co-creation, and the value co-creation transformation phases. However, we are still unclear on the steps and activities in the value co-creation process needed to develop new digital solutions. Moreover, the ecosystem value co-creation process is complex, and a better understanding is highly desirable. We need to study the power dynamics of SMEs in trying to create value with ecosystem partners in addition to the risk of losing control over the solution.

5.3. Cluster 3: Conceptualizing the platform strategy for digital servitization

The development and application of digital technology in servitization has made the environment of value co-creation increasingly complex. The platform approach can make good use of the environmental complexity because it can arrange the business system (e.g., organization, product, technology) into long- and short-lived components (often referred as the "core" and the "periphery") (Baldwin & Woodard 2009; Thomas et al., 2014). In consequence, conceptualizing the platform strategy for digital servitization has aroused the interest of scholars. The key aspects of this topic are discussed below.

5.3.1. Interpreting the evolutionary view of platform strategy in digital servitization

Since platforms originated in the car industry in the twentieth century, the term "platform" has been connected with manufacturing (Steinberg, 2021). Thus, manufacturing companies have been encouraged to use modular production to quickly generate different products based on the product platform (Meyer, 1997; Robertson,1998). It is the base structure of this product platform that has the potential to enhance supply chain capabilities (Meyer et al., 1997; Tatikonda, 1999; Halman, 2003; Jiao et al., 2003; Watanabe, 2004). Following Honda's success in utilizing automotive platforms and expansion of the computer industry in the late twentieth century, scholars began to expand their research on platforms from automotive production to the management and business strategy area (Wheelwright & Clark, 1992; Cusumano & Selby, 1995; Cusumano, 2010).

Meanwhile, the implementation of servitization strategies has meant that manufacturing firms face an increasingly fierce competitive environment. Therefore, scholars have been imitating the product modular and investigating the design of the service modular, especially in the digital era. For instance, Rajala et al. (2019) have identified integrated solutions business as the first generation of servitized offerings and modular solution offerings as the second development phase in the servitization of original equipment manufacturers (Rajala et al., 2019). They examine how the servitized manufacturer, Kone, moved from an integrated solutions business to a modular solutions business and developed the requisite capabilities to design, produce, and implement modular solution offerings.

Wei et al. (2019) explores how customer solution providers leverage digital platform architectures and platform openness to exert control over complex organizational networks. Their findings show that the features of product modules (core or peripheral), service modules (relationship intensity and customization), and knowledge modules (explicit, tacit, and codified) exert differential influence on the levels of platform openness (Wei et al., 2019). Beverungen et al. (2020) have outlined three platform types – smart data platform, smart product platform, and matching platform – as strategic options for firms who wish to evolve from smart service providers to platform providers and generate a higher level of value co-creation (Beverungen et al., 2020). Jovanovic et al. (2021) identify three platform archetypes. Each platform archetype is characterized by a specific innovation mechanism that contributes to the platform service discovery and expands the platform value – namely, product platform, supply chain platform, and platform ecosystem. They argue that each platform archetype involves a gradual development of platform architecture, platform services, and platform governance, which mirror each other (Jovanovic et al., 2021). As can be seen, platform approaches play an increasingly significant role in enabling digital servitization transformation. However, given the different platforms levels, we would encourage future research to investigate architectural innovation in services, including the external determinants of architectural control and the changing dynamics of the platform approach.

5.3.2. Modularity and architecture in digital platform strategy implementation

Brax et al. (2017) elaborate on the roots of the emerging research stream on service modularity (Brax et al., 2017). They provide a concise overview of existing work on the subject and outline an agenda for future research on service modularity and architecture. A service module is "a system of components that offers a well-defined functionality via a precisely described interface and with which a modular service is composed, tailored, customized, and personalized" (Tuunanen et al., 2012). Service architecture is the way in which the service system functionalities are decomposed into individual functional elements that together deliver the overall services provided by the system (Simon, 1962). A platform ecosystem is an evolving meta-organizational form where the platform architecture provides a shared technological core to support the ecosystem's members in creating and capturing value (Hou & Shi, 2020; Kretschmer et al., 2020). A platform ecosystem is usually organized around a hub firm that owns or sponsors the platform (Rietveld & Schilling, 2020). A platform sponsor designs the platform architecture that describes how a relatively stable platform core, with specific design rules and a diverse set of complementary modules, allows stakeholders to orchestrate data collection, data storage, data flow, data aggregation, and data commercialization (Alaimo et al., 2020; Constantinides et al., 2018; Tiwana et al., 2010). Therefore, platform architecture includes a product module, a digital module, an information module, and so on.

Salonen et al. (2018) find that a modular solution design acts as a key integration mechanism, allowing the provider to orchestrate actors in the supply network to simultaneously exploit resources related to the existing solution modules and to explore new ones (Salonen et al., 2018). Turunen et al. (2018) have analyzed the debate related to the strategic role of information in the industrial service business – that is to say, whether information is a resource that could and should be protected. The results of the study provide new insights into both the characteristics and boundary conditions of new entrants' approaches to strategically benefitting from information resources, and they indicate that the strategic relevance of information lies in novel data combinations (Turunen et al., 2018). Therefore, information or digital modular is becoming an increasingly essential factor in digital servitization. Cenamor et al. (2017) highlight the importance of information modules in replacing product and service modules as the core modules in successful servitization (Cenamor et al., 2017). The study by Hsuan et al. (2021) finds that DS trajectories are idiosyncratic and dependent on the design architectures of PSSw modules, and that decomposition and integration of PSSw modules facilitate DS transition through business model modularity (Hsuan et al., 2021). Jovanovic et al. (2021) explain that a key part of the digital transformation journey is investing in the technology of the platform core (Jovanovic et al., 2021). From their findings, we know that, in different phases, the focus points of platform sponsors are different. For instance, during the initial phase, it is the platform architecture, by progressively increasing the capacity for product data collection, that attracts the attention of platform sponsors and, consequently, facilitates the integration of digital modules (Jovanovic et al., 2021). Next, analytics utilization – referred to as external modules (Iansiti and Lakhani, 2020) – is the focus point of platform sponsors because advanced sensors provide increased data quality and data variety (Jovanovic et al., 2021). Finally, artificial intelligence enablement exploits the power of AI and platform openness in leveraging external data sources and revealing hidden insights (Jovanovic et al., 2021). Overall, a key milestone in platform architecture development was investing in the sensor network that generated data and allowed a higher degree of connectedness within the industrial assets. Thus, data aggregation and data analytics have unlocked opportunities for higher value creation through collaboration with external partners (Jovanovic et al., 2021). However, a relatively understudied aspect of platform architecture is concerned with exploiting the characteristics of modularity in a multi-provider context to allow rapid and effective configuration of

complex services provided by multiple suppliers.

5.3.3. Managing digital platform-based actor and relational complexity

Over the last decade, the increasing adoption of digital technologies in manufacturing firms has made servitization more complex (Eloranta et al., 2021). Thus, it is critical for manufacturing firms to establish digital platforms to manage their strategy (Favoretto et al., 2022). Some scholars have investigated the mechanisms of managing digital platform-based relational complexity. For instance, Eloranta, Orkoneva, Hakanen, and Turunen (2016) find that platforms are seen as extending the physical product's capacity to produce new usage scenarios, facilitate inter-firm information flows, enable collective benefits, and create awareness of new value potential. At the same time, Eloranta and Turunen (2016) report on how platforms are used to leverage network-related complexity and to orchestrate the networks. Three distinct logics – namely, connecting, sharing, and integrating – that drive the platform approaches are identified (Eloranta & Turunen, 2016). To complement the work of Eloranta and Turunen (2016), Eloranta et al. (2021) provide a structural characterization of how complexity-management mechanisms are deployed on digital platforms. They identify nine different complexity-management mechanisms, which are described and classified according to their complexity management action (absorption or reduction) and their domain (cognitive or relational) (Eloranta et al., 2021).

Given that the industrial digital platform, which can be divided into three phases – namely, product platform, supply chain platform, and platform ecosystem – has evolved, there are more and more diverse actors participating in the platform, whose value has expanded in consequence (Jovanovic et al., 2021). This demands that companies develop new solutions for paradoxical tensions between flexibility and efficiency, control and autonomy, and standardization and customization in service networks, such as micro-services to configure novel solutions (Sjödin et al., 2020). Hein et al. (2019) explain how platforms enable value co-creation in their ecosystem. They stress that the platform: i) encourages the supply side through the integration of complementary assets; ii) promotes the demand side by ensuring platform readiness; and iii) connects both processes by servitization through application enablement (Hein et al., 2019). Moreover, Wei et al. (2022) explore paradoxical tensions and their management in modular solution networks on digital platforms by using a case study approach. They find that solution providers cope with these paradoxes by employing two simultaneous mechanisms – namely, unification (focusing on forming similarities among them) and diversification (aiming at increased variety among modules and module providers) – which are made possible through digital platform features, such as algorithms, online communities, and platform access (Wei et al., 2022). Jovanovic et al. (2021) explore platform governance, which requires that tensions related to platform openness and control are addressed but also that simultaneous collaboration and competition with complementors is managed (Rietveld and Schilling, 2020) from a holistic perspective. They point out that platform sponsors gradually entice partners on the supply side, followed by platform adoption on the demand side (e.g., customers) (Jovanovic et al., 2021). The first phase of platform governance includes **value chain expansion**, which means training, testing, and promoting the platform among traditional intermediaries, such as delivery partners (Jovanovic et al., 2021). In the second step, platform governance seeks **value system expansion**, which involves simulating platform use among various partners and customers (Jovanovic et al., 2021). Finally, the **ecosystem expansion** is facilitated by opening up the platform interfaces, promoting interoperability between different platform services and creating an open marketplace for new partners to deploy their value-added services (Jovanovic et al., 2021). However, one point to extract from existing research concerns the involvement of start-ups and small firms in the platform and how to design the platform to maximize gains from their innovative solutions. In addition, larger firms who manage the platform try to be more control oriented, which undermines any strategy that would seek to provide a multi-sided platform. Therefore, we need to explore the circumstances in which democratic governance and centralized decision making can build greater engagement among platform users and resilience in service-network platforms.

All in all, the literature on conceptualizing the platform strategy for digital servitization pays most attention to interpreting the evolutionary view on platform strategy for digital servitization, the service, digital modularity, and platform architecture for digital platform strategy implementation, and the management of digital platform-based relational complexity. However, based on the current research, there are some gaps that need further examination, such as ecosystem modularity, the role of the platform in involving start-ups and SMEs, and the network relationships management mechanism for digital servitization.

5.4. Cluster 4: Business model innovation in digital servitization

Applying diverse digital technologies in manufacturing servitization has changed the methods used for value creation, value delivery, and value capture (Sjödin et al., 2020; Sklyar et al., 2019a; Tronvoll et al., 2020). These changes are redirecting the focus of research, which pays most attention to the conceptualization of digitally enabled business model innovation, customer perspectives on digital servitization business model innovation, and digitally enabled across-organizational-boundaries business model innovation. This new research topic is referred to as “business model innovation in digital servitization”. The key aspects of this cluster are discussed below.

5.4.1. Conceptualization of digitally enabled business model innovation

Emerging technologies have a clear role in enabling service-oriented business models (Rymaszewska et al., 2017). Increasingly, scholars are discussing the type and characteristics of digitally enabled business models in the digital servitization literature. For example, the new product–service system BM taxonomy with eight categories significantly extends earlier taxonomies in the digital era (Aas et al., 2020). These new business models vary with regard to the degree of the suppliers' ownership of delivered products, degree of smartness of the services provided, and degree of performance orientation of contracts (Aas et al., 2020). More recently, scholars have sought to explain how different digital technologies enable novel business model innovation. In this regard, Boldosova (2020) have investigated the role of storytelling and big data analytics in smart service sales (Boldosova, 2020). Karttunen et al. (2021) explore the capabilities of Internet-of-things-enabled product-service system business models (Karttunen et al., 2021). Korkeamäki et al. (2021) argue that the most advanced forms of servitization, such as outcome-based service offerings (OBS), are complex and highly customized (Korkeamäki et al., 2021). Scaling them is a challenge that requires significant investment in digital technologies to ensure solution modularity and profitability. Paiola and Gebauer (2020), in following a qualitative research method, have sought to describe the service-oriented impact of IoT technologies on firms' business models (Paiola and Gebauer, 2020). Nonetheless, extant manufacturing resources and capabilities – although critical – must be complemented with new ones in order to successfully leverage the possibilities offered by IoT technologies and develop advanced service-oriented business models (Sjödin et al., 2016; Sklyar et al., 2019a).

Scholars have also investigated the underlying mechanisms of digital-technology-enabled business models. Schroeder et al. (2020) set out to investigate how the IoT contributes to the advanced services that manufacturers offer their customers. According to these scholars, the difference between advanced services and basic and intermediate services is that advanced services focus on supporting customers to achieve their goals rather than supporting the product itself (Schroeder et al., 2020). For instance, the value propositions of “customers are offered a commitment to minimize the occurrence and extent of unplanned product downtime”, “customers are offered continuous access and availability of essential consumables”, “customers are offered support

with the appropriate usage of their product", "customers are offered a commitment to provide the administrative function associated with the use of the product", and "customers are offered specific and targeted advice to identify inefficiencies in their business processes related to the product". In order to explain the reasons behind the diversity and the processes that manufacturers go through to create these outcomes from IoT- enabled servitization, Naik et al. (2020) draw on affordance theory and its core principles of affordance perception (understanding an opportunity provided by technology) and affordance actualization (taking advantage of an opportunity provided by technology). They develop a framework that explains how the opportunities that IoT provides can be realized through manufacturers' servitization efforts. The analysis identifies three types of affordance and actualization process that help manufacturers successfully exploit the opportunities provided by the IoT (Naik et al., 2020).

Another sub-theme of research focuses on investigating the direct and indirect benefits from digitally enabled business models, such as efficiency improvements (Kohtamäki et al., 2020), probability, and sustainability. Kohtamäki et al. (2020) state that digital servitization can be viewed as the use of digital technologies to create and appropriate value from product-service offerings. Thus, digital servitization is understood as the interplay between digitalization and servitization. This can help manufacturing companies to reduce data processing costs by automatizing data collection, warehousing, and diagnostics (Wamba et al., 2017). Therefore, the application of digital technology has produced new business models, such as remote diagnostics, which can improve the efficiency of value creation, value capture, and value delivery. Paiola et al. (2021b) attempt to answer the research question of how digitally based business model innovation and networking in manufacturing servitization impact sustainability (Paiola et al., 2021a). Their study confirms that new digital services provided by manufacturers exert inherently valuable impacts on the sustainability of their customers. Furthermore, in current DS and BMI in manufacturing, relevant sustainability cannot be achieved without the simultaneous and aligned exploitation and evolution of DS and networking. Gains can accrue from using technology to shift the focus from manufactured products to customer processes and leveraging network relationships transformation (Paiola et al., 2021a). Bressanelli et al. (2018) earmark the role of digital technologies as an enabler of the CE in usage-focused business models, which relates to digital servitization (Bressanelli et al., 2018).

From the above discussion, we can see that the existing conceptualization of digitally enabled business model innovation is focused largely on how different kinds of digital technology are driving business model innovation, on how they influence different kinds of digitally enabled business model, and on what benefits result from the different kinds of model identified. The application of digital technology brings many opportunities as well as challenges. One of the challenges is the transformation of cognition. Many enterprises fail in their digital transformation efforts because there is no digital cognition. Consequently, more in-depth discussions on digital cognition should be conducted in future research.

5.4.2. Customer perspective on digital servitization business model innovation

Much of the discussion on digital servitization has been related to the providers' or suppliers' views on business model innovation. However, increasingly, researchers recognize that the successful adaption and implementation of digitally enabled business models largely depends on the industrial customers' ability to change their internal processes. Few scholars have begun to tackle this important perspective on digital servitization business models. For example, Sjodin et al. (2021) investigate the procurement process in industrial customer organizations with regard to digital servitization (Sjodin et al., 2021). They describe the key challenges in the traditional approach and identify novel procurement practices to capture value from digitalization. They define three overarching principles for procurement 4.0: a) nurture digital ecosystem generativity, b) orchestrate cross-functional integration, and c) leverage supplier capabilities through agile co-creation (Sjodin et al., 2021). The research by Rapaccini et al. (2020) demonstrates that high levels of customer proximity may provide one solution to the question of how firms can provide spare parts and components when supply chains are interrupted and buffer stocks are lacking, as in the case of the COVID-19 pandemic (Rapaccini et al., 2020). Kamalaldin et al. (2021) have investigated how equipment suppliers configure appropriate ecosystem strategies (mainly dominator, orchestrator, complementor, and protector) to achieve digitally enabled process innovation in various industrial customer contexts. They find that the customer's requirement is one significant factor (Kamalaldin et al., 2021). A recent study by Sjödin et al. (2021) has explored how manufacturing firms can develop AI capabilities and innovate their business models to scale AI in digital servitization. They find that agile customer co-creation is significant in business model innovation and impacts the role of AI capabilities in enterprises – namely data pipeline, algorithm development, and AI democratization (Sjödin et al., 2021).

From the above discussion, it is clear that, in the research on customer perspectives on digital servitization business model innovation, scant attention is given to digital innovation. However, the customer perspective on digital servitization business model innovation and digital innovation belong together – they represent two sides of the same coin. For better or worse, digital innovation involves re-engineering, re-inventing and, in some cases, obliterating whole domains of activity without any engineering at all. Yet, in spite of the current divide evidenced in the literature, it is clear that the customer perspective on digital servitization business model innovation and digital innovation are complementary fields of inquiry that have much to learn from each other. We should, therefore, encourage convergence between the customer perspective on digital servitization business model innovation and digital innovation research.

5.4.3. Digitally enabled business model innovation with multiple ecosystem actors

In an Industry 4.0 context, companies must not only change internal processes but also align those changes with other ecosystem actors (Frank et al., 2019; Porter & Heppelmann, 2014). In this sub-stream, scholars study the types and characteristics of business models in the ecosystem, such as customer-oriented business model innovation, process and customer-oriented business model innovation (Frank et al., 2019), process-focused and product-focused business models, and hybrid business models (Weking et al., 2020). Super-pattern integration innovates the BM around new processes, servitization around new products, and expertization around a hybrid of products and processes (Weking et al., 2020). Kohtamäki et al. (2019) maintain that digitalization transforms the business models of solution providers. It shapes their firm boundary decisions as they develop digital solutions across organizational boundaries within ecosystems, such as harbors, mines, and airports (Kohtamäki et al., 2019). Thus, digitalization not only affects the business models of individual firms but also requires that other firms' business models are aligned within the ecosystem. Hence, business models in digital servitization should be viewed from an ecosystem perspective.

Some scholars have discussed how to manage cross-organization boundary business model innovation. Sjödin et al. (2022) find that manufacturing can realize some digitally enabled across-organizational-boundaries value propositions (Sjödin et al., 2022). For instance, a global automation and control system provider, ABB, has established dedicated digital partnerships with technology providers (e.g., Microsoft, IBM, and Ericsson), SMEs, and startups (e.g., the Synnerleap program), while driving digitalization with customers and existing service partners. Paiola et al. (2021b) have revealed that the richness and centrality of corporate prior knowledge regarding technologies, customers, and suppliers can effectively orient a firm's choice of the most

accessible and suitable value-creation paths toward digital business model innovation (Paiola et al., 2021b). Hoch and Brad (2021) argue that business model innovation can be managed by an innovative approach to designing a digital ecosystem and multi-sided platform (Hoch and Brad, 2021). Burström et al. (2021) draw the conclusion that, in the short term, incumbents may use an ecosystem reconfiguration strategy, whereas long-term strategies demand ecosystem revitalization and resilience (Burström et al., 2021). Thomson et al. (2022) argue that manufacturers should adopt the three principles that encapsulate the interconnections between the framework dimensions to successfully innovate autonomous solutions: technology, ecosystem, and business model. First of all, when developing autonomous solutions, alignment is needed between the complexity of the solution and the ability of the receiving organizations to manage that complexity (Thomson et al., 2022). Second, aligning partner revenue flows helps to ensure win–win scenarios for the different ecosystem actors involved in the autonomous solution (Thomson et al., 2022). Finally, identifying technological value generators means that an important part of autonomous solution commercialization lies in earmarking the use cases where increased automation can solve customer pain points (Thomson et al., 2022).

Other scholars have focused on the process of cross-organization-boundaries business model innovation. For example, Kohtamäki et al. (2021) have developed an understanding of a holistic, continuous, emergent process of digital servitization by using social practices, such as managerial sayings and doings, to map the change process from the micro (firm) to the macro (ecosystem) level. Chen et al. (2021) focus on changes in the business model, such as the value proposition, the value delivery system, and the value capture mechanism for digital servitization. They argue that digital servitization business model innovation by manufacturers must pass through different stages, characterized by both discontinuous and continuous interplay between business models and digital technologies (Chen et al., 2021). At the beginning of each stage, new value propositions and value delivery systems are discontinuously created and then enabled with digital technology (Chen et al., 2021). As a result, new value-capture mechanisms are activated (Chen et al., 2021). Meanwhile, the elements of the existing business model are continuously improved (Chen et al., 2021). Struyf et al. (2021) investigate the process of cross-organization boundary business model innovation, stressing the importance of developing a higher-order capability so that the interconnectedness within and between levels and across different steps of DS is managed through an effective strategy (Struyf et al., 2021).

We can see from the existing literature on digitally enabled across-organizational-boundaries business model innovation that the principal focus is placed on the types and characteristics of new business models, the approach to managing business model innovation, and the process of business model innovation. There is little discussion on malleable organizational design and the digital business ecosystem in the digital economy era. This is not conducive to organizations quickly adapting to the rapidly changing environment, avoiding threats and seizing opportunities. Therefore, future research should pay greater attention to this topic.

On the whole，the research of business model innovation in digital servitization has aroused increasing interest over the past five years, but there are still many areas that require greater research responsiveness. Since rapid technological advances carry far-reaching implications for how firms compete and how they develop and implement their strategies, there is still a lot to uncover. We propose several directions for future research in Table 11.

6. Digital servitization transformation framework for manufacturing firms

Analysis of the digital servitization thematic areas not only provides a unique understanding of how the field has evolved but also shows how the themes represent interrelated aspects of a holistic digital

Table 11
Future scopes to advance research on digital servitization transformation.

Thematic area	Research gaps	Potential research questions for future research
Aligning digitalization and servitization transformations	Investigating AI and blockchain technologies for digital servitization in manufacturing firms.	• How can organizations utilize the potential of blockchain and AI technologies to offer advanced digital services? • What are the influencing variables that positively and negatively moderate the relationship between blockchain and AI technology on firm performance? • How do firms initiate, develop, and mature AI and blockchain technological capabilities for the digital servitization transformation of manufacturing industry?
	Understanding the operational processes enabling transformation toward digital servitization from the ecosystem perspective.	• What are the unique and defining characteristics of the new operational processes from the ecosystem perspective on digital servitization? • How should firms engage in strategic cooperation with digital ecosystem actors to enable the digital servitization strategy to be realized? • How do different (e.g., collaboration or competition) ecosystem cooperation strategies influence the operational processes of manufacturing firms?
	Exploring the role of digital resources and capabilities in digital servitization.	•What different digital resources (e.g., digital infrastructure, platform) should firms invest in and develop in order to ensure successful digital servitization transformation? •How should enterprises of different sizes (small versus large firms) allocate their resources and capabilities to successfully realize the digital servitization transformation? •What are the micro-foundations of digital capabilities that influence the organizational level transformation toward digital servitization?
Value co-creation perspective on digital servitization	Understanding the activities in the value co-creation process.	•What are the steps and activities in the value co-creation process when trying to develop new digital solutions between supplier and customer? •What are the roles and responsibilities of different actors in the value co-creation process in digital servitization?
	Investigating the complex ecosystem value co-creation environment of digital servitization,	•What mechanism can ecosystem leaders use to orchestrate the role and contributions from

(*continued on next page*)

Table 11 (*continued*)

Thematic area	Research gaps	Potential research questions for future research
	which requires both cooperation and competition.	ecosystem partners during the value co-creation process with customers? •How can the balance between competition and cooperation logics with involving ecosystem partners be maintained in joint co-create activities? • What are the decision criteria that inform manufacturing firms in taking an active or passive role in the multi-actor value co-creation process?
	Understanding the characteristics of value co-creation processes, orchestrating mechanisms, and transformation phases for digital servitization between SMEs and incumbent companies.	•What are the differences between SMEs and incumbent firms in the value co-creation process for digital servitization? •How can incumbent firms create an innovative ecosystem involving diverse start-ups and SMEs for digital solutions development and commercialization? •How can SMEs mitigate the risk of losing control over the digital solution during the value co-creation process involving incumbent firms or dominant ecosystem leaders?
Conceptualizing the platform strategy for digital servitization	Investigating the role of modularity in digital servitization transformation.	•How can digital servitization benefit from a modular approach that configures intangible service modules, tangible product modules, and software modules? • How can the modular architecture of platform ecosystems be designed to enable digital servitization transformation?
	Understanding the multi-sided industrial platform perspective with emphasis on start-ups and SMEs.	•How can a competitive digital platform that incentivizes start-ups and SMEs to engage with a large firm be best developed? •How should the roles be defined in a multi-sided platform strategy where the platform is designed to involve start-ups and SMEs? •What are the governance mechanisms that can build greater engagement among platform users and customers?
	Addressing relational complexities in the digital platform context.	•What are the factors that affect the complexity of digital platforms? •What is the mechanism in the factors that affect the complexity of digital platforms?
Business model innovation in digital servitization	The transformation of digital cognition in digital servitization.	•How much attention should managers be able or prepared to give to new digital business models depending on their digital mindset? •What types of cognitive orientation are most likely to make managers more aware of opportunities for digital transformation and able to act on them? •What do organizations need to do to overcome the cognitive hurdles managers face?
	The convergence of customer perspective on digital servitization business model innovation and digital innovation.	•How does digital innovation enable, constrain, shift, or otherwise upend the design, enactment, management, and analysis of the customer perspective on digital servitization business model innovation? •How can technology, techniques, and theory from managing the customer perspective on digital servitization business model innovation assist understanding of digital innovation processes and outcomes? •Can the efficiency and generative capacity of the customer perspective on digital servitization business model innovation be balanced, and by what means?
	The malleable organizational design and digital business ecosystems in the digital servitization.	•How do digital-technology-related factors and digitization-based mechanisms help address these tensions across multiple levels? •To what extent (and when) does the technology generativity emanating from new generations of digitization (e.g., IoT, blockchain) require incremental or wholesale changes to regulatory regimes? •What impact has digital technology on the fluidity of firms' boundaries and when does it create rigidities versus flexibility?

servitization transformation. Thus, the proposed framework (see Fig. 11) is relevant for manufacturing firms because it delineates critical activities associated with digital servitization. More specifically, the distribution of cluster 1, which aligns the digitalization and servitization transformations, documents the period from 2009 to December 2022 and includes 31 articles, as shown in Fig. 10. In 2013, the first article of cluster 2 (including 29 articles) in 105 digital servitization literature on the value co-creation perspective on digital servitization appears. From 2016 to 2022, there are 11 articles on conceptualizing the platform strategy for digital servitization (Cluster 3) that were published. The articles in cluster 4, which included 34 documents, were published in the five years from 2018 to 2022. Therefore, we can obviously see that the evolutionary path of the digital servitization literature. According to the distribution of each cluster documents by year (Fig. 10) and the content analysis of each cluster (Section 5), we discussed the logic of each cluster and how a specific cluster influences other cluster.

Since the development of digital technologies, their application in

servitization has brought increasing numbers of contributions from firms, which has led many manufacturing firms to apply diverse digital technologies to redesign operational processes and develop new digitalization-oriented resources and capabilities for digital servitization transformation. This is called, "aligning digitalization and servitization transformations" (Cluster 1). Furthermore, it has changed the consumption behaviors of customer to more personalized customization and smart needs. These changes have accelerated the reach and pace of value co-creation development (Beverungen et al., 2020), profoundly transforming businesses and societies around the globe (Vendrell-Herrero et al., 2017). This has formed a significant research cluster in the digital servitization literature – namely, value co-creation in digital servitization (Cluster 2) – which is related to the process characteristics, the transformation phases of value co-creation, and the orchestrating mechanisms of ecosystem value co-creation. With the development and application of digital technology in servitization, the environment of value co-creation becomes increasingly complex. The platform approach is a good way to take advantage of the benefits of environmental complexity because it can organize the business system (e.g., organization, product, technology) into long- and short-lived components (often referred as the "core" and the "periphery") (Baldwin & Woodard 2009, Thomas et al., 2014). Therefore, conceptualizing a platform strategy for digital servitization (Cluster 3) has aroused the interest of scholars, in aspects including "interpreting the evolutionary view of platform strategy in digital servitization", "modularity and architecture in digital platform strategy implementation", and "managing digital platform-based actor and relational complexity". From the above discussion, we can conclude that applying diverse digital technologies in manufacturing servitization has changed the methods of value creation, value delivery, and value capture (Sjödin et al., 2020; Sklyar et al., 2019a; Tronvoll et al., 2020). These changes are reflected in a research focus on "conceptualization of digitally enabled business model innovation", "customer perspective on digital servitization business model innovation", and "digitally enabled business model innovation with multiple ecosystem actors". This new research topic can be called, "business model innovation in digital servitization" (Cluster 4).

Based on the above description of the four dominant digital servitization clusters, we propose an integrative framework (see Fig. 11). The framework intends to link the clusters and respective sub-activities that manufacturing firms need to consider as they engage in digital servitization transformation. This integrative transformational suggests a process view, where manufacturing firms start with understanding the application of diverse digital technologies related to digital servitization initiatives (Cluster 1). It implies not only redesigning operational processes but also developing corresponding resources and capabilities to support the new customer value creation. The next step involves accelerated reach and pace of value co-creation development, profoundly transforming provider-customer relationships (Cluster 2). These activities are followed by new management approaches for orchestrating the complex environment and ecosystem relationships, such as implementation of platform strategy (Cluster 3). Finally, all previous activities need to be aligned with the innovation of digital technology-based value creation, value delivery, and value capture – that is to say, digital technology-based business model innovation (Cluster 4) – to ensure a competitive and sustainable digital servitization transformation.

7. Conclusion

7.1. Theoretical implications

The present study contributes to scholarly knowledge in three key theoretical ways. First, we provide a theoretical understanding of the origin and conceptualization of digital servitization (Fig. 7). In general, digitization forms the basis of digitalization. Whilst the origin of digitalization is in digital technology, the interaction between digitalization and servitization is conceptualized as "digital servitization". Therefore, we conclude that the origin of digital servitization is the interaction between digital technology and servitization. Moreover, we indicate how digital servitization is different from smart servitization. AI technology is a more advanced technology than other digital technologies and is also a form of digital technology; therefore, we can conclude that smart servitization – the future research direction of digital servitization – is embodied in digital servitization.

Second, we provide insights into how digital servitization research has evolved around different clusters with its unique specialization. Cluster 1 can be called, "aligning digitalization and servitization transformations", which focuses on capturing contributions that are derived from the application of digital technologies in servitization. They mainly talk about the application of diverse digital technologies to redesign operational processes and develop new digitalization-oriented resources and capabilities for digital servitization transformation. Cluster 2, the value co-creation perspective on digital servitization, mainly focuses on the characteristics of the value co-creation process in digital servitization, the orchestrating mechanisms in ecosystem value co-creation, and the value co-creation transformation phases. The cluster of conceptualizing a platform strategy for digital servitization (Cluster 3) is mainly concerned with interpreting the evolutionary view of platform strategy in digital servitization, modularity, and architecture for digital platform strategy implementation, and managing digital platform-based actor and relational complexity. Cluster 4 focuses on business model innovation in digital servitization, including conceptualization of digitally enabled business model innovation, customer perspective on digital servitization business model innovation, and digitally enabled across-organizational-boundaries business model innovation.

Third, we propose a framework for digital servitization that shows all the different dimensions of digital servitization transformation and provides a guide on the interlinks between the clusters. Specifically, the application of digital technology has changed the operational processes, and the resources and capabilities that enterprises need to create value. At the same time, it has changed the consumption behaviors of customers to more personalized customization and smart needs. These changes are blurring the boundaries of enterprises, changing them from value providers to value co-creators. With the development and application of digital technology in servitization, the environment of value co-creation becomes increasingly complex. Enterprises or ecosystems increasingly need new platform architecture-based modular management methods to deliver and capture value in complex environments. Therefore, this makes the innovation of digital technology-based value creation, value delivery and value capture – that is to say, digital technology-based business model innovation – increasingly important and dominant.

7.2. Practical implications

The findings from this study demonstrate that the literature on digital servitization is still in its infancy. Therefore, this literature review can help entrepreneurs to clarify the related concepts of digital servitization and provide some managerial insights into the transformation process of digital servitization. The key managerial insights emerging from this study are as follow. First, the strategy formulation of digital servitizing firms may require support from corresponding resources and the development of capabilities to exploit them. Therefore, managers in digital servitizing firms should embrace ambidexterity in manufacturing products and offering digital services. Second, selling high-value solutions to the customers of a digital servitizing firm requires advanced service design methods. Therefore, managers in digital servitizing firms may tune their business models so that they share the benefits obtained from digital servitization with select consumers who use their products optimally. Third, the success of digital servitization often depends on the value-creation and value-delivery processes in digital servitized offerings. Consequently, managers in digital servitizing firms should consider involving customers as co-creators of value. Finally, the digital platform

is becoming more and more important to manage the complexity of digital servitization. Thus, managers in digital servitization should pay greater attention to digital platform construction.

7.3. Research limitations

The findings from the study should be interpreted in light of certain limitations. First, HistCite can only process data from the Web of Science Core Collection and is unable to analyze data from Google Scholar, Scopus, and others, resulting in the absence of some crucial papers. Second, some new but important articles may not have been analyzed because the bibliometrics consider high citation as an indicator of influential articles. Third, the four clusters (i.e., aligning digitalization and servitization transformation, value co-creation perspective on digital servitization, conceptualizing the platform strategy for digital servitization, and business model innovation in digital servitization) that were based on the findings of bibliometric tools may not be completely clear-cut and a certain degree of overlapping and some exceptions may exist. Future research can use other types of bibliometric indicators or tools to obtain more information, such as using CiteSpace to provide evolutionary patterns. It is also worthwhile for scholars to adopt bibliometrics to investigate the various research streams of digital servitization presented in this paper.

7.4. An agenda for future research on digital servitization

Based on the analysis of literature, we have identified several research gaps and propose suggestions for future research. All of the research gaps and corresponding research questions are shown in Table 11.

CRediT authorship contribution statement

Lei Shen: Writing - Review & Editing, Investigation, Conceptualization, and Funding acquisition. **Wanqin Sun:** Writing - Review & Editing, Investigation, Conceptualization, and Methodology. **Vinit Parida:** Supervision, Conceptualization, and Editing.

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Data availability

The data that has been used is confidential.

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