Impact of Digital Industry 4.0 Innovations on Interorganizational Value Chains: A Systematic Literature Review

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Abstract

Purpose – Organizations invest in novel digital innovations to improve their business processes. These innovations, including Industry 4.0 technologies, enable full organizational integration with business process management (BPM), thereby requiring interorganizational relationship (IOR) capabilities. Many organizations lack knowledge about areas of interorganizational capability for integrating digital innovations into their value chains. They therefore have difficulty understanding that, as a socio-technical concept, digitalization surpasses the intra-organizational level and requires tools to develop mandatory IOR capabilities. Our systematic literature review (SLR) explores these capabilities within the discipline of BPM.

Design/methodology/approach – This SLR follows the standard methodology for structuring a broad research field. We assessed capabilities relevant to manufacturing organizations from 58 academic articles published between 2011 and 2021.

Findings – Building on existing firm-centric capability frameworks, we developed individual capabilities into a novel framework of digital interorganizational value chain (DIOVC). Our conceptual model provides a basis for researchers and practitioners to consider capabilities and the theoretical spectrum of interorganizational value chains.

Research limitations/implications – Future studies should validate these DIOVC capabilities as input for an updated model of BPM maturity aimed at improving business process performance through digital innovations.

Practical Implications – This study provides organizations with IOR knowledge, supports decision-makers in governing digital innovations, and develops interorganizational capabilities to improve their value chain performance.

Originality – Our DIOVC capability framework is robust, with constructs and dimensions grounded in literature, demonstrating theoretical and practical relevance.

Keywords – business process management, digital innovation; interorganizational; value chain; capability framework

Paper type – Literature review

1 Introduction

Organizations reach the highest possible levels of performance in their business processes by investing in novel digital Industry 4.0 (I4.0) innovations (Büchi *et al.*, 2020, Van Looy *et al.*, 2012). Introduced at the Hannover Messe in 2011, I4.0 is considered the fourth industrial revolution (Buer *et al.*, 2018). Emerging technologies (e.g., cyber-physical systems, the Internet of Things, blockchain) enable the full technological integration of all organizational functions that help enhance business processes (Varela *et al.*, 2019). Digitalization has been defined as the initial activity of further development stages for I4.0 transformation (Schuh *et al.*, 2017). Digitalization alone involves digital innovations using novel technologies and systems that help organizations manage their processes (Büchi *et al.*, 2020). Previous studies on digital innovation have primarily adopted a firm-centric perspective, focusing on how a single organization could benefit from engaging in cross-organizational relationships. Organizations often have difficulty understanding that, as a socio-technical concept, digital innovations affect the interorganizational perspective (Wagire *et al.*, 2021), extending beyond single organizations (Issa *et al.*, 2018). This perspective focuses on how business processes are managed using a wide variety of innovative I4.0 technologies and applied to

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"systematic smart implementations" within the interorganizational context (Wu *et al.*, 2016, 396). Because organizations lack knowledge and tools concerning the areas of interorganizational capability (Jolanta and Mantas, 2018) and the integration of I4.0 digital innovations (Frederico *et al.*, 2020), our main research question is: *What is the state of research regarding the use of digital innovations by Industry 4.0 within an interorganizational setup?*

The research question is descriptive within the scope of a systematic literature review (SLR) and intended to identify the conceptual boundaries and potential research gaps (Xiao and Watson, 2019). Previous SLRs covered the intraorganizational perspective (Büyüközkan and Göçer, 2018, Frederico *et al.*, 2020) and requested further research related to interorganizational business process performance requirements (Frederico *et al.*, 2020). Therefore, we aim to expose unexplored areas of business process management (BPM) research in combination with emerging I4.0 digital technologies using an interorganizational unit of analysis. We reviewed the body of knowledge by thoroughly familiarizing ourselves with the phenomenon of interest and by understanding the problems relevant to manufacturing organizations. We contribute to the academic knowledge from the perspective of interorganizational relationships (IOR) by synthesizing the capabilities that organizations need to overcome challenges relating to integration. We present an updated capability framework and an extended description of the most frequently represented capabilities. This article focuses on interorganizational value chains and their capabilities, as they should be seen from the perspective of both organizations and people (McCormack, 2007). They should also be considered from a technological perspective (Plomp and Batenburg, 2010), including in terms of the associated difficulties and challenges. To our knowledge, existing literature lacks a holistic capability framework that could help organizations accommodate socio-technical changes driven by digital innovations. Instead of replicating the efforts of previous studies, we intend to complement existing knowledge with a synthesis of relevant academic literature.

The remainder of this paper is organized as follows. After presenting the research background against which the SLR was conducted (Section 2), we describe the methodology (Section 3) and present the results (Section 4). In Section 5, we provide discussion, including the managerial implications and research limitations of our work. We present our conclusions in Section 6.

2 Theoretical background

This study addresses the intersection of four research streams: (1) digital innovations by I4.0, (2) collaboration within interorganizational value chains, (3) BPM, and (4) IOR. After describing the concepts of digital innovations involving emerging I4.0 technologies (Section 2.1) and interorganizational value chains (Section 2.2), we explain the trends in BPM and business process performance underlying our study (Section 2.3). We then define the key constructs relevant to our research question, comparing the capabilities of existing academic frameworks underlying this SLR (Section 2.4). Finally, we present updated capabilities in a combined framework (Section 2.5).

2.1 Digital innovation by Industry 4.0

Digital innovation is defined as "a product, process, or business model that is perceived as new requires some significant changes on the part of adopters, and is embodied in or enabled by IT" (Fichman *et al.*, 2014, p. 330). Digital innovations use new technologies (e.g., I4.0) aimed at resolving existing business problems and practices to achieve new business models, products, services, and/or processes (Fichman *et al.*, 2014). Digitalization alone involves novel technologies and systems that can assist firms in managing their business processes (Büchi *et al.*, 2020). Digital technologies—including cyber-physical-systems (CPS), the Internet of Things (IoT), and Blockchain—enable the full technological integration of all functions of manufacturing firms that increase productivity in their intra-organizational and interorganizational business processes (Varela *et al.*, 2019). "Industry 4.0 can be described as the increasing digitalization and automation of the manufacturing environment as well as the creation of digital value chains to enable the communication between products and their environment and business partners" (Oesterreich and Teuteberg, 2016, p. 122). This definition thus involves interorganizational value chains as the unit of analysis for helping organizations achieve a higher level of operational performance. Digital innovations affect strategic and operational levels (Ahmad and Van Looy, 2020), and their integration should be considered from the technological perspective of organizations and information systems (Jolanta and Mantas, 2018). This could generate new forms of cooperation between companies and update relationships with other organizations.

2.2 Interorganizational value chains

Sturgeon (2001) defines value chains as "productive (i.e., value-added) activities that lead to and support the end use of a set of related products or services, including lead firm(s)" (Sturgeon, 2001, p. 12). Whereas value chains comprise all actors, including the lead organizations, supply chains entail only productive activities of suppliers, with limited activities of the lead organizations. Interorganizational value chains thus comprise interconnected organizations, the synchronization of activities and information across value chains, and the creation of value within this system (Cropper *et al.*, 2008). We use the term "value chain" to denote the catalyst for manufacturing organizations to communicate about products within their environments and with their business partners beyond their supply chain. In such environments, value chains are determined as networks of interdependent organizations (Klötzer and Pflaum, 2017) that require key features for the implementation of I4.0 through horizontal integration, through either value networks or the end-to-end digital integration of engineering across the entire interorganizational business process (Oesterreich and Teuteberg, 2016). Following (Cropper *et al.*, 2008), we use the term "interorganizational entities" (IOEs) to refer to organizations with various forms of IOR (e.g., alliances, partnerships, networks).

2.3 BPM and business process performance

Organizations are systems of business processes and structures. A business process is defined as "a collection of inter-related events, activities, and decision points that involve a number and objects which collectively lead to an outcome that is at least one customer" (Dumas *et al.*, 2013, 6). Business processes are the central elements of organizations and their BPM, defined as "a body of methods, techniques, and tools to identify, discover, analyze, redesign, execute, and monitor business processes in order to optimize their performance" (Dumas *et al.*, 2013, p. 6). Because BPM includes organizational capabilities beyond the execution of defined tasks along an individual process lifecycle, an interorganizational approach is needed when specifying relevant capability areas required for successful BPM. Structured through capability frameworks, BPM is solidly linked to capability development (Van Looy *et al.*, 2012), which is relevant to the successful implementation of process orientation within organizations (Kerpedzhiev *et al.*, 2021). We argue that an institutionalized capability framework enables effective and efficient business processes, which in turn drive organizational success (De Bruin *et al.*, 2005). Organizations implement their business processes and measure performance at the proper time (Balfaqih *et al.*, 2016). Performance entails business process capabilities and concerns the future in terms of "the efficiency and effectiveness of action" (Neely *et al.*, 1996, p. 424). Effectiveness in business processes is understood primarily as "doing the right things" (Müller-Stewens and Lechner, 2003) by allocating mandatory resources to business processes to meet objectives and to generate maximum value by reducing operating costs (Viswanadham, 2018, Negi, 2021). Efficiency in business processes is understood as "do[ing] the things right" (Müller-Stewens and Lechner, 2003) by maximizing business process output with minimal effort (Negi, 2021). Organizations measure business process performance using process-performance indicators (del-Río-Ortega *et al.*, 2018), including (1) time, (2) cost, (3) quality, (4) flexibility (Dumas *et al.*, 2018), and (5) asset-management efficiency (Stephens, 2001).

2.4 Dimensions and capabilities in related chain frameworks

The issue of BPM capabilities constitutes a central theme in contemporary studies (Kerpedzhiev *et al.*, 2021). As defined by Van Looy et al. (2011), organizational capability is the ability “to achieve the targeted results by following a particular process or process area” (Van Looy, De Backer, & Poels, 2011, p. 130). Because digital innovations require new capability areas, existing frameworks must be updated (Kerpedzhiev *et al.*, 2021). Current academic literature includes specific capability frameworks, focusing on the digitalization of supply or value chains (Büyüközkan and Göçer, 2018, Plomp and Batenburg, 2010, Frederico *et al.*, 2020). One of the most comprehensive academic frameworks of digital supply chain (DSC) capabilities was developed by Büyüközkan and Göçer (2018), offering a non-validated DSC framework as a roadmap for future research (Büyüközkan and Göçer, 2018). It contains three dimensions: (1) digitalization, (2) technology implementation, and (3) supply chain management (SCM), which are cited 504 times in Google Scholar and 225 times on the Web of Science (Table I).

Dimensions	Description
Digitalization	Organizations define digitalization policies along the supply chain and continuously develop their digitalization capabilities
Technology Implementation	Approach that enables organizations to use digital technologies and implement them into the activities of their supply chain processes
Supply Chain Management	Modeling the supply chain process to meet strategic objectives involves making decisions to create an effective supply chain management process, which is the primary goal of DSC transformation.

Table I: DSC framework dimensions (Büyüközkan & Göçer, 2018)

We selected the DSC framework as the foundation for our study because it is not limited to recent digital innovations or technology levers. Instead, it aligns digital initiatives with supply chain objectives, adopting digital innovations to realize the untapped potential of existing resources and capabilities by successfully implementing technology to redesign the current supply chain into the targeted one. Moreover, the digital dimension covers new technologies, systems, and relationships that help organizations achieve the highest possible value chain performance. We provide detailed descriptions of the capability areas in the following section.

2.4.1 Framework for the development of digital supply chain

The DSC framework maps key digital evaluation objectives (Büyüközkan and Göçer, 2018) .We decompose it to identify features, components, technology enablers, challenges, and success factors associated with developing a DSC. The framework comprises three main areas (Figure 1): (1) digitalization, (2) technology implementation, and (3) supply chain management (SCM), each with capabilities and sub-capabilities (Appendix A).

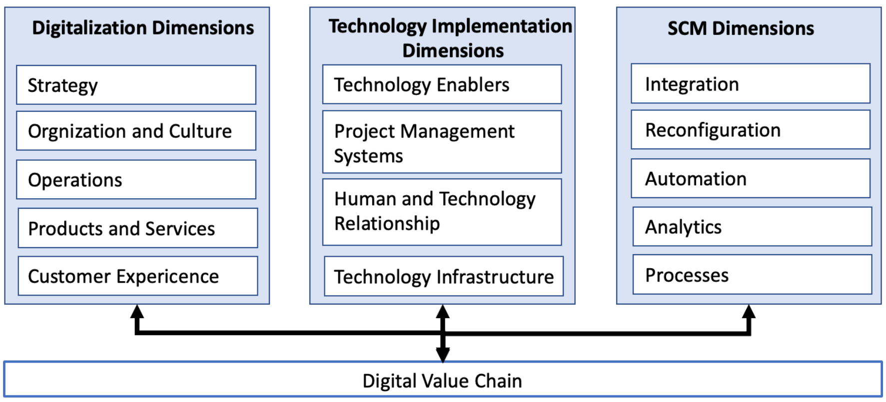

Figure 1: DSC capability framework (Büyüközkan & Göçer, 2018)

Digitalization includes five capabilities: digitalization strategy, digital organization and culture, digital operations, digital products and services, and the digital customer experience. Technology integration includes four capabilities: technology enablers, project management systems, human and technology relationships, and technology infrastructure. The third dimension (SCM) includes the integration, reconfiguration, automation, analytics, and processes of capabilities. A DSC is a good process for supply chain management aimed primarily at transforming the digital supply chain. As revealed by our analysis, however, the firm-centric DSC framework is subject to limitations in terms of BPM and interorganizational relationship, both of which call for extensions (Appendix B). First, the DSC framework refers to the Supply-Chain Operations Reference Model (McCormack, 2007, Stephens, 2001) as a basis for improving these processes and the ways in which organizations operate, without specifying the capabilities that organizations need to operate. Managing business processes nevertheless involves continuous activities aimed at managing and improving them by enhancing insight into their analysis, redesign, and execution. We therefore extend the DSC capability "process" to include sub-capabilities describing what organizations must assess and improve to achieve excellence in their business processes , as specified in the business process maturity framework (Van Looy *et al.*, 2012) (Section 2.3.2).

Furthermore, the DCS capability framework reflects only a firm-centric perspective, focusing solely on the context of cross-company interactions, even though an interorganizational perspective is required. We overcame this second limitation by extending the DSC framework to include IOR capabilities (Cropper *et al.*, 2008) (Section 2.3.3).

2.4.2 Business process maturity framework

One of the most comprehensive BPM capability frameworks is the business process maturity framework (Van Looy *et al.*, 2012). The validated framework employs intraorganizational business processes from a firm-centric perspective and covers classified capability areas based on mapped 69 business process maturity models. It characterizes a direct relationship between the capability areas in business process performance, and it is managed by a model of business process maturity. As the capability areas take a comprehensive perspective on BPM and define how capabilities should be developed to reach desired objectives, therefore, we used Von Looy (2012) framework to replace the DSC process sub-capabilities. This validated business process maturity framework distinguishes six main capability areas: process modeling, deployment, optimization, management, culture, and structure (Van Looy *et al.*, 2012). Its concept of maturity acknowledges that processes have a lifecycle in which various processes are defined, managed, measured, controlled (Lockamy and McCormack, 2004), created, adjusted/updated, or retired (De Haes *et al.*, 2013). The criteria and dimensions of maturity models thus require a multidimensional perspective. The inclusion of process-related capabilities enables the DCS framework to distinguish the sub-dimensions of the process dimension in greater detail. Because digitalization requires extensive collaboration among organizations to generate the total business value of novel DIs (Plomp and Batenburg, 2010), we extend the existing DSC framework to include the capabilities of the interorganizational relationship (IOR) framework (Section 2.4.3).

2.4.3 Interorganizational relationship framework

Digital innovations enable the management of the upstream and downstream relationships with IOE and the creation of a digital value chain. Given that collaboration along value chains surpass the intraorganizational perspective, it requires the interorganizational perspective of IOEs (Cropper *et al.*, 2008). Because our research question is formulated from an interorganizational perspective, the IOR is our unit of analysis, along with its relevant capabilities. The DSC framework and business process maturity framework are based on a firm-centric (intra-organizational) perspective; therefore, we extended the IOR capabilities to the DSC framework. An IOR determines "enduring transactions, flows, and linkages that occur among or between an organization and one or more organizations in its environment" (Oliver, 1990, p. 241), comprising three dimensions: (1) governance, (2) structure, and (3) content (Cropper *et al.*, 2008). First, governance capabilities determine the content flows and coordinate their relationships with informal and formal rules of exchange between partners (Wang and Wei, 2007). Informal attributes—including relational norms (e.g., trust, commitment, coordination)—establish joint actions (e.g., joint problem-solving) and maintain their relationships through reciprocity and equity, based on shared goals (Joshi and Campbell, 2003). Second, the capabilities of the structure involve IOEs that are motivated to invest tangible and intangible resources (e.g., financial, human, technological), as well as in tacit or explicit knowledge. They also include the structural attributes, with diverse types of relationships among organizations. Third, the content capabilities mainly concern information or material flows between IOEs (Cropper *et al.*, 2008).

2.5 Combined framework of digital interorganizational value chain capabilities

Capability frameworks are the fundamental elements for maturity models that define how capabilities should be developed to pursue anticipated or desired objectives (Kerpedzhiev *et al.*, 2021). In light of the knowledge derived from the literature on capability frameworks focusing on the digitalization of supply or value chains, we highlight the need for a framework for develop DIOVC capabilities that accommodates the interorganizational perspective. Neither of the existing business process capability frameworks on the future of BPM accounts for the challenges and opportunities brought about by digitalization to the IOR in value chains. Our extended dimension and capabilities include the sub-capabilities (Appendix B) of process capability: business process modeling, deployment, optimization, management, culture, and structure (Van Looy *et al.*, 2012). Our confirmative research identifies ideal-typical capability configurations related to digital innovations that enable new business processes according to their impact on firm-centric and cross-company needs, with their intra-organizational and interorganizational collaboration, and their new forms of technology implementation.
We adopted a two-step approach to develop a combined DIOVC capability framework. First, we considered the basic dimensions of the DSC framework.

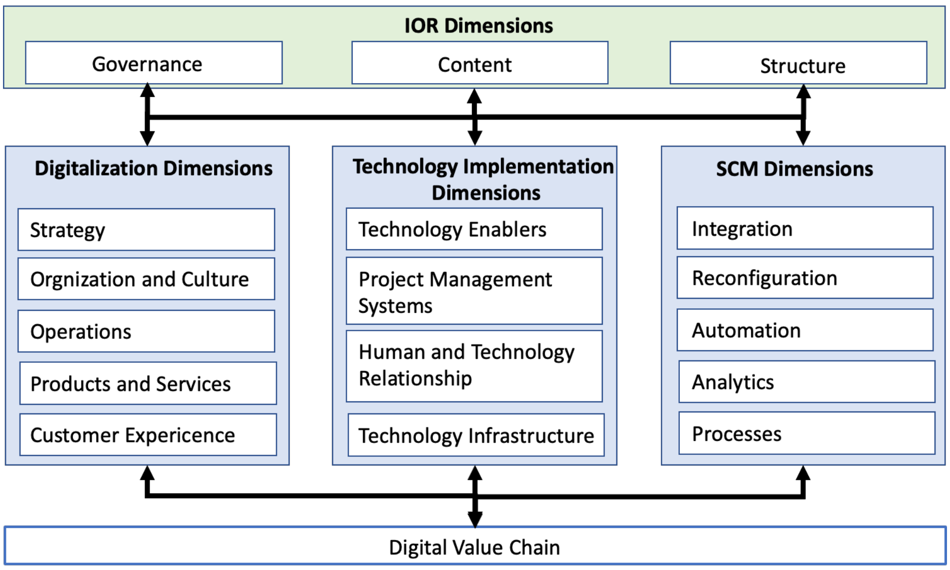

Figure 2: DIOVC capability framework

Next, we updated and extended existing capabilities based on the theoretical background, resulting in a new combined framework that more accurately considers the IOR elements of IOEs investing in digital technologies (Figure 2). The proposed DIOVC capability framework combines well-established capabilities within supply chain management processes, digitalization, and technology implementation with new requirements arising from the IOR context. The four dimensions comprise

17 capabilities, the 14 updated digital value chain capabilities, and the three extended IOR capabilities (i.e., governance, content, and structure) that affect the dimensions of digitalization, technology implementation, and SCM. Enhanced capabilities relate primarily to the existing 17 capabilities, requiring substantial further development in the field of BPM to improve the performance of interorganizational value chains through digitalization. As shown in Figure 2, we extend the IOR perspective to include other IOEs when new I4.0 digital technologies must be integrated into value chains to achieve compatibility in business processes (McCormack, 2007).

3 Research methodology

Following the SLR methodology and applying mapping as a suitable method for structuring a broad research field, we focused on the content, methods, and trends in the existing literature (Kitchenham and Charters, 2007). We adopted a two-stage approach to conduct the SLR and gradually analyzed the research objectives (Webster and Watson, 2002). Building on the findings of the updated DIOVC framework (Section 2.5), which form the foundation for the proposed IOE perspective and help manufacturing organizations to manage the implementation of I4.0 digital innovation in their interorganizational value chains. First, we reformulated the main research question into three sub-questions (Frederico *et al.*, 2020) to cumulate the development of our DIOVC framework by exploring the existing body of knowledge, confirming the capabilities, and defining future research avenues:

- RQ1: Which evolution of digital innovation affects interorganizational business processes?
- RQ2: Which interorganizational capabilities of the DIOVC capability framework can be assessed and improved to increase a value chain's performance?
- RQ3: What are avenues for future research on I4.0 digital innovations related to interorganizational value chains and their maturities?

Second, we applied an end-to-end SLR approach in four iterative process phases (Figure 3), using software (Bandara *et al.*, 2015): extracting relevant information from the literature (Phase 1); organizing and preparing information for analysis (Phase 2); coding and analyzing data (Phase 3), and recording findings (Phase 4).

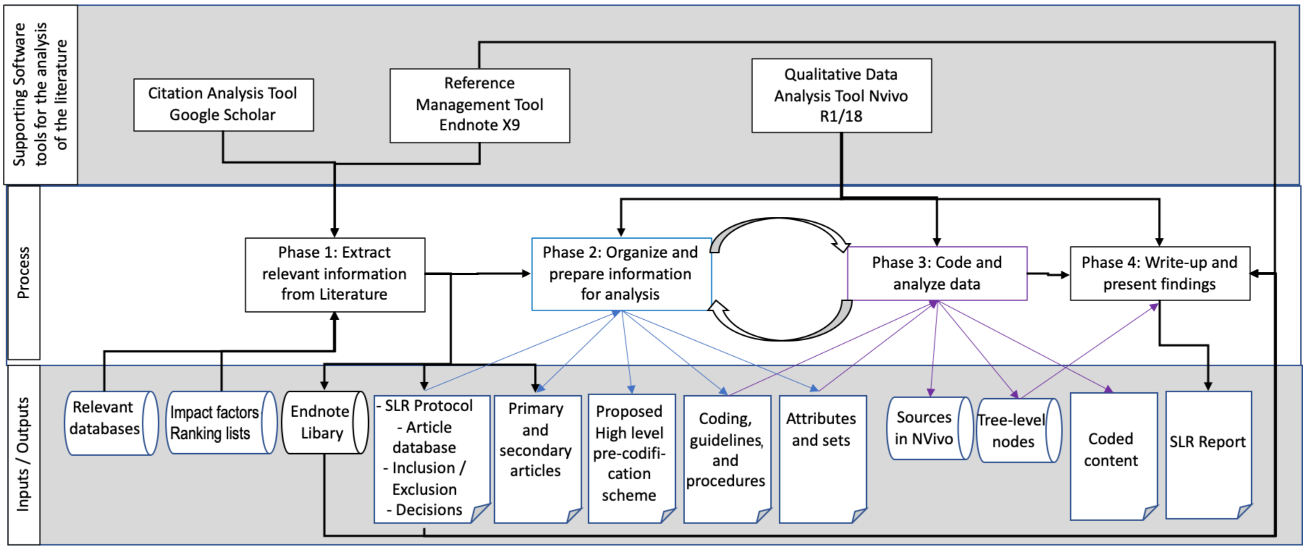

Figure 3: Applied end-to-end SLR approach (Bandara et al., 2015)

To answer RQ1, we classified the data to describe the chronological and geographical distribution, research structures, and theoretical underpinnings of the sampled papers (Section 4.1). To answer RQ2, we coded each of the deductively selected capabilities (Figure 2), for which we created respective nodes in NVivo and Excel. In the coding process in this stage, we identified relevant text passages and captured them in one or more respective nodes. We completed the second round of coding inductively, coding content within nodes to determine what the captured data revealed for each theme (Section 4.2). To answer RQ3, we summarized the data from the sampled papers in a concept matrix to locate the gaps in the literature and generate new themes (Section 4.3).

3.1 SLR planning

We tracked the planning for the SLR according to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) statement (Moher *et al.*, 2009). We started by identifying the problem and organized the information for analysis to minimize the chances of bias in the results (Kitchenham and Charters, 2007). The SLR protocol (Table II) shows the rationale applied to the sources of the articles (academic databases), search terms (keywords), search strategy (search methods), inclusion/exclusion criteria, and quality criteria. To enhance reliability , we submitted the protocol to peer review before conducting the search (Okoli and Schabram, 2010).

Sources	(1) SCOPUS, (2) Web of Science, (3) EBSCO Host, (4) Science Direct, (5) JSTOR, (6) SpringerLink
Search terms	A combination of "digital innovation," "Industry 4.0," "interorganizational," and "value chain" derived from term definitions and aligned to the search strings of the individual databases
Search strategy	All search requests created with pre-defined keywords for each database
Inclusion criteria	(1) published online after 2010; (2) containing a combination of search terms in the title, abstract, and keywords; (3) published in journals or conference papers; (4) no sector limitation; and (5) full text written in English
Exclusion criteria	(1) full text not written in English; (2) full text not assessed in databases; or (3) unrelated to the research questions
Quality criteria	The primary source of information from a selection of the six databases Only peer-reviewed articles and conference proceedings

Table II: SLR protocol

After screening the articles, we added the sampled studies to the SLR database and analyzed them for content to answer the research questions. When entering the coding phase, we adopted a hybrid approach involving several high-level coding schemes from existing frameworks, but allowed them to evolve new themes and codes obtained from the literature (Fielt *et al.*, 2014). In the first coding round, we chose the deductive coding approach using *a priori* codes to define similarities or differences relative to existing frameworks (Figure 2). We used the pre-defined coding schemes to analyze the topic of interest and explain the results. The second round of coding was performed inductively, using the coded content to determine whether the data captured the identified capabilities and defined various capabilities from the literature.

3.2 Search sources and criteria

We selected six renowned academic databases in the field of management information systems and business administration (Table III), because they are known for providing high-quality, peer-reviewed publications in a structured way and with user-friendly export functionality to the SLR database.

Database	EBSCO host	WoS	SCOPUS	Science Direct	JSTOR	Springer Link
Access Date	07.15.21	06.20.21	06.20.21	06.20.21	07.21.21	07.21.21
Papers Found	29	10	365	6	0	111

Table III: Database results

The next step involved determining search terms or keywords to be searched and retrieving relevant studies from the six databases. Our final search terms were ("digital innovation*"OR digital* OR "I*4.0") AND (chain* OR "business process*") AND ("inter*organi?ation*" OR "cross*organi?ation*"). The search strings were adjusted to the individual databases.

3.3 Extraction of relevant literature

Our search criteria yielded 521 papers. After removing the duplicates, we had 511 articles (Figure 4). For each paper included, we recorded two types of information in our research database. The first type consisted of primary data about the papers: (1) title, (2) keywords, (3) electronic database details, and (4) source-based categories and related information. The second type consisted of specific data related to our research questions. The final SLR analysis included only papers that met the pre-defined and explicit inclusion and exclusion criteria (Liao *et al.*, 2017), as specified in Table II. We included all relevant articles and conference papers that (1) were published online after 2010 (with 2011 being the official announcement of I4.0) up to 2021; (2) contained a combination of search terms in the title, abstract, and keywords; (3) were published in journals and conference papers; (4) had no sector limitation; (5) had their full text written in English; and fulfilled conditions that were (6) partially and (7) closely related. We further screened the resulting 511 papers by reading each title, keywords, and abstract. After two assessments of the defined exclusion criteria, we excluded 428 papers.

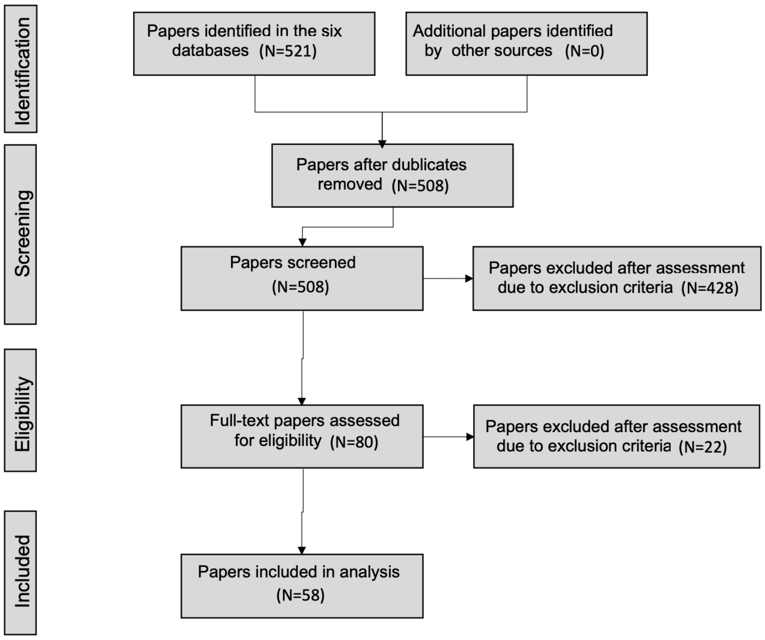

Figure 4: PRISMA flow

The eligibility stage of this SLR thus yielded 80 papers. Finally, we reviewed all articles, focusing on content (i.e., introduction, discussion, and conclusions). We analyzed the articles against the research questions and excluded papers that did not answer them. We updated the SLR database accordingly (including 58 papers) and assigned each one a unique ID number for traceability (Appendix D). We added the coded papers to an initial concept matrix (Webster and Watson, 2002) and labeled them in alphabetical order (R1–R58). The final coding results were translated into this SLR concept matrix (Appendix C).

4 Results

In this section, we present the results according to the three research questions.

4.1 RQ1: Evolution of digital innovation that affects interorganizational business processes

4.1.1 Chronological distribution of the sampled articles

The chronological distribution of the sampled papers is presented in Figure 5, differentiating between journal papers and conference papers. As illustrated by this graph, a relatively higher number of papers (mainly journal articles) were published since 2019. These papers refer to digitalization or I4.0

in various forms, focusing on various forms of business processes or supply chains and exploring various relationship types. The keywords of articles published between 2019 and 2022 indicate that the combination of technology-related and socio-related research has increased since 2019.

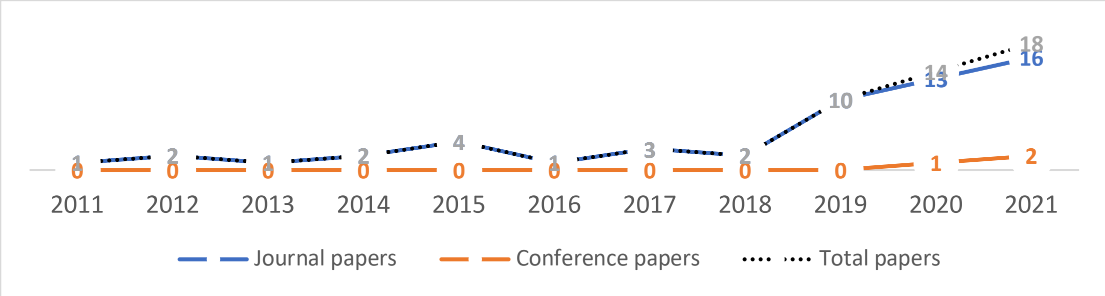

Figure 5: Chronological distribution of sampled papers (N=58)

This is due to novel technologies (Digitalization, I4.0, Blockchain, AI Platform, Networks), in combination with socio-related keywords (digital supply chain, relationship, collaboration, trust). The sampled publications (N=58) were found in 43 journals, with 25 papers identified in the 10 most frequently cited sources (Figure 6). Two journals accounted for 10 of the 58 articles: *International Journal of Production Economics* (7 papers; 12%) and *Industrial Marketing Management* (3 papers; 5%). Each of the other journals accounted for only one or two articles.

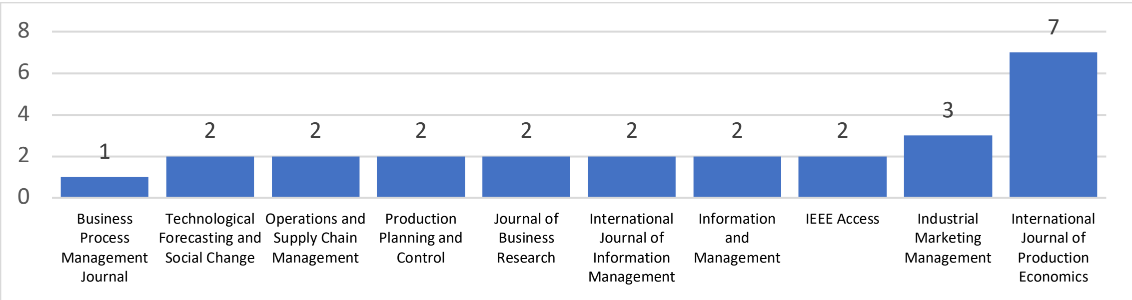

Figure 6: The 10 most frequently cited journals (N=25)

4.1.2 Research structures

We classified the 58 papers into two main dimensions: socio-related (38 papers) and technology-related (20 papers) (Figure 7). Papers containing multiple types of insight were categorized according to their most prominent contribution to the dimensions. Most of the papers (66%) focused on the social dimension of the socio-technical structure.

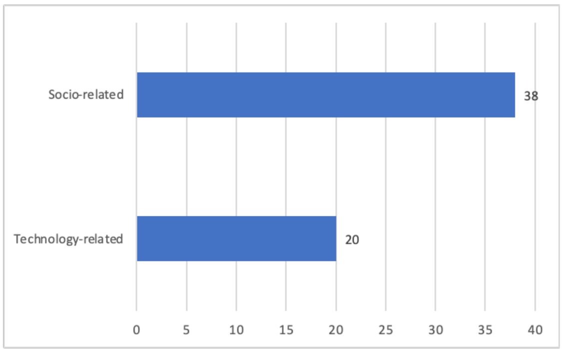

Figure 7: Focus of articles (N=58)

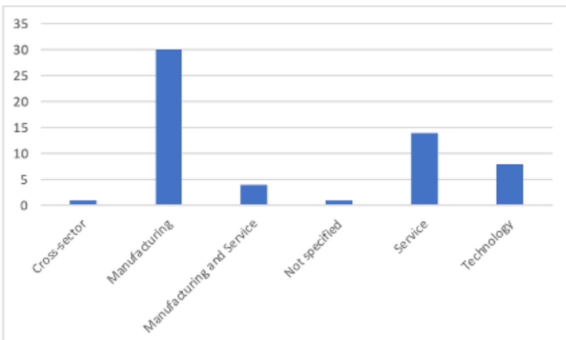

Figure 8: Articles classified into sectors (N=58)

This research topic represented an interdisciplinary field, referring to various disciplines, including management, design science, business process, organizational, and information systems (IS). Furthermore, the sampled papers were mainly linked to three sectors: manufacturing (30 papers), services (14 papers), and technology (8 papers) (Figure 8). Papers containing multiple types of insights were categorized according to their most prominent contribution. Based on the search criteria, most papers considered digital innovations in the interorganizational manufacturing sector along with the supply chain process. This categorization would later help to define our intended scope and agenda for future research.

4.1.3 Geographical distribution of the sampled papers

The geographical distribution of the sampled papers is presented in Figure 9. Although studies were observed across the globe, Europe was the dominant continent in our sample (34 papers). This was because of the primary focus of the European research community and the original declaration of Industry 4.0 in Europe. Asia had the second highest paper count (15 papers), followed by North America (5 papers). Fewer papers were found for Australia (3 papers), Africa (1 paper), and South America (1 paper).

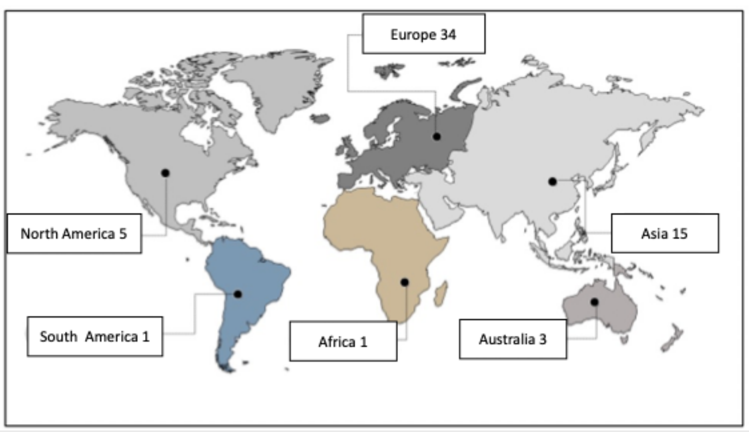

Figure 9: Geographical distribution of papers (N=58)

The analysis subsequently focused on the three countries with the most papers. The country count considered the institutional location of the first author. European researchers in Germany released seven papers, followed by Sweden and Italy (4 papers each). Outside of Europe, Chinese researchers released seven papers, followed by the US (4 papers). The titles of the selected articles underlined a high interest in research related to digital innovations and supply chains in China.

4.1.4 Theoretical underpinnings

In addition to enhancing our comprehension and explanation of digital innovation and its elements, the theories applied in the papers provided the theoretical lens needed to explore the emerging impact on interorganizational value chains.

Researching business process topics associated with I4.0 was challenging, due to differences in research perspectives and foundation spectrums (Barringer and Harrison, 2000). This necessitated theory selection to provide guidance and structure to this SLR. We analyzed the sampled papers and identified 11 theories across 12 papers (Table IV). The most frequently cited are the resource-based and knowledge-based views (2 citations each). Each of the other nine theories is cited only once: transaction cost economics, social exchange, organizational information processing, relationship marketing, supply chain practice, resource dependence, S-D logic, networks, and social capital. The papers also apply different epistemological considerations and research designs. The theories identified are middle-range and minor theories related to management, organization, marketing, and social science, and they are applicable to sector-specific or process-independent research.

Theory	Paper IDs	Resources	Rational	Organizational		Application	
				Intra-organization	Inter-organization	Sector-specific	Sector-independent
Resource-based view (Dyer, 1996)	(R1), (R8)	Differences in resource efficiency from relationship-specific assets	Resource performance differentiation controlled by an organization	X	X	-	X
Knowledge-based view (Grant, 1996)	(R20), (R21)	Knowledge sharing	Knowledge-based differentiation	-	X	-	X
Transaction cost economics (Dyer, 1996)	(R20)	Transaction governance	Most efficient types of organizational structures	X	X	-	X
Social exchange theory (Blau, 1968)	(R33)	Economic and social resources	Actor motivation and reward expectation	-	X	-	X
Organizational information processing theory (Thompson *et al.*, 2017)	(R5)	Information-processing capabilities and demand	Resolving uncertainty in organizational structures	-	X	-	X
Relationship marketing theory (Berry, 2002)	(R33)	Buyer/seller relationship	Relationship complexity	-	X	-	X
Supply chain practice view (Kosmol *et al.*, 2019)	(R26)	Imitable SCM practices	Firms' motivation for using SCM practices	-	X	limited to SCM	-
Resource dependence theory (Pfeffer and Salancik, 2003)	(R30)	Access to critical resources	Resolving uncertainty by coordinating relationships	-	X	-	X
S-D Logic (Vargo and Lusch, 2004)	(R25)	Resource density (integration and application)	Service as the common denominator of economic exchange and value creation	-	X	-	X
Network theory (Halldorsson *et al.*, 2007)	(R25)	Cooperative relationships on a personal level to access resources	Management of relationships	-	X	-	X
Social capital theory (SCT) (Müller *et al.*, 2020)	(R31)	Tangible and intangible resources	Social interaction and connection (resource & normative)	X	X	-	X

Table IV: Theories applied in papers (N=12)

The supply chain practice view is limited to the application of supply chain management. None of the sampled articles combines theories, focusing only on single-theory research designs. All theories are considered from the interorganizational perspective, with only three also addressing the intra-organizational perspective.

4.2 RQ2: Interorganizational capabilities to improve value chain performance

The sampled articles were then used to explore the IOR capabilities required to improve value chain performance. In the second SLR phase, we summarized the dimensions, capabilities, and sub-capabilities of our updated DIOVC capability framework (Appendix B). The results yielded a description of each capability area. As demonstrated in the concept matrix (Appendix C), the collected papers were mapped to four dimensions without identifying any new dimensions. Accordingly, we identified the capabilities that were highly represented and under-represented.

4.2.1 Mapping against framework dimensions and capabilities

Four dimensions and 17 capabilities are presented in Figure 10 (Section 3.1.1). We summarized our coding in a concept matrix (Appendix C), the results of which indicated that 12 capabilities (55%) are addressed in fewer than 10 papers. On average, 13 references are considered per capability. The IOR capabilities are apparently the most important to our updated framework. Furthermore, none of the selected articles considers all dimensions and capabilities of the framework. The most highly represented (top 10) capabilities have an average of 22.6 references, with a significant delta to the overall average. Processes revealed 61 coding results, with the process sub-area (Figure 11) identifying management as highly represented (30 references; 49%). We summarized the findings of all highly representative capabilities and extended the existing capabilities to include those extracted from the sampled papers. All highly represented DIOVC framework capabilities apparently affect the effectiveness of business processes and how IOEs implement IO business processes. In other words, they are key capabilities that determine the proper allocation of mandatory resources to the business process to meet objectives. The activities associated with these capabilities should be supported by processes that allocate the required resources to increase the performance of the value chain from a joint objective.

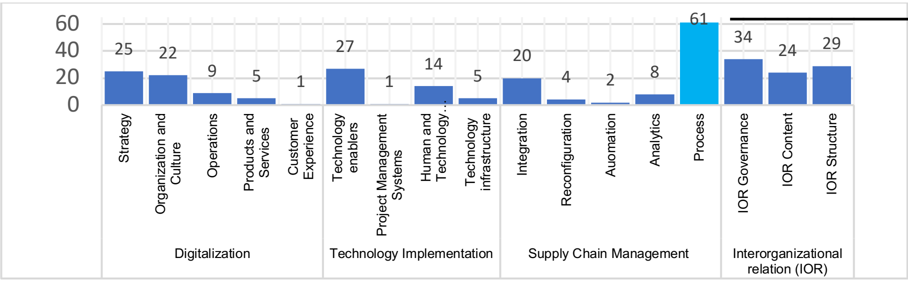

Figure 10: Capability count extracted from literature review

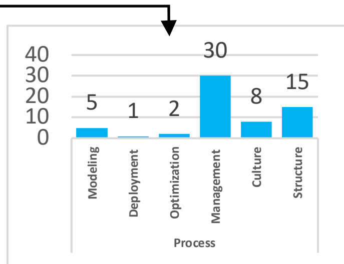

Figure 11: Process sub-capabilities

We also identified under-represented capabilities (Appendix C), including customer experience from the digitalization dimension (1 citation). Customer experience capability is linked to demand chains, along with product customization, which requires sharing real-time information across IOEs to improve the supply chain's ability to deliver faster and improved products or services (Chong and Zhou, 2014). Another under-represented capability is project management systems from the technology implementation dimension (1 citation). Project management systems across IOEs need further research to coordinate tasks and investments, as well as to manage the successful implementation of I4.0 digital innovations, not only at the level of the firm, but also across IOEs by coordinating technological changes. Automation (2 citations), process deployment (1 citation), process optimization (2 citations), and process modeling (5 citations) from the SCM dimensions are also under-represented. It is essential for organizations to develop capabilities in the process modeling, deployment, and optimization of SCM before reaching more mature levels of capability in the pursuit of BPM excellence. Without the first phases of business process modeling, organizations cannot design their business processes, define their process and resource structures, or specify their interorganizational interfaces. Moreover, they cannot specify the implementation and measurement of business practice, and business process optimization will be limited, based on the limited capabilities of business process evaluation and improvements.

4.3 RQ3: Avenues for future research

In line with the RQ3, we present an agenda for identifying knowledge gaps and propositions for future research. Based on RQ1 and RQ2, which form the foundation for the DIOVC capability framework, we identified several avenues for researchers interested in the fields of BPM, digital innovation, and IOR.

4.3.1 BPM research avenues

The research agenda topics and the 10 identified research avenues are summarized in Table V, along with potential research questions, as described below.

Research agenda topics	Research avenues (1–10)	Research questions
Theoretical background	1) Theories in interorganizational business processes	Which theories are relevant to developing models of interorganizational business process maturity for integrating digital innovations into BPMs?
Highly represented capabilities	2) IOR Governance	What are relevant risk-benefit sharing agreements related to digital innovations that improve IOR between organizations during the business process lifecycle?
	3) IOR Structure and Business process Modeling	What are unique tasks, common tasks, and their interfaces between IOR structure and business process modeling in interorganizational business processes?
	4) Digital Strategy	What strategic instruments do IOEs need to consider in different states of IOR maturity related to interorganizational value chains?
Under-represented capabilities	5) Interorganizational business process modeling	Which process and resource structures are mandatory for IOEs in designing their interorganizational business processes?
	6) Interorganizational business process deployment	Which control and measurement methods can organizations apply for joint decision-making in interorganizational business processes?
	7) Interorganizational business process optimization	How can technologies improve interorganizational business processes by aligning maturity levels among IOEs?
Interorganizational business process performance	8) IOE process performance indicators	Which performance measurement approaches and metrics are suitable for interorganizational value chains?
PMS	9) Interorganizational Project Management System (PMS)	What are the relevant PMS requirements for interorganizational BPM maturity models?
BPM maturity model	10) Interorganizational BPM maturity model	How should BPM maturity models be applied to access IOE capabilities and synchronized from the maturity-level perspective?

Table V - Future research avenues

4.3.1.1 Theoretical background

From a theoretical perspective, the updated DIOVC capability framework suggests that further development is required in the BPM domain to drive value chain performance improvement through digital innovations. Based on the 11 theoretical reflections (Section 4.1.4), we observed that the theoretical literature on interorganizational relationship formation is fragmented, with several disciplines contributing to the field. This multifaceted nature of IOR formation often involves a mixture of motives, intentions, and objectives, and it calls for closer examination. Further interorganizational BPM research should explore which theories are relevant for developing interorganizational business process maturity models for the integration of digital innovation (Avenue 1).

4.3.1.2 Highly represented capabilities

Further research is required for the three highly represented capabilities of IOR Governance (Avenue 2), IOR structure (Avenue 3), and digital strategy (Avenue 4), each of which is especially beneficial to the intersection of intra-organizational and interorganizational capabilities.

We call for more research on IOR governance to determine the effect of digital innovations on risk-benefit sharing agreements across the various maturity stages that improve IOR between IOEs throughout the BPM lifecycle (Avenue 2).

The capabilities of IOR structure and business process modeling are essential in the first phases of BPM. Future research should therefore explore these capabilities in greater detail to identify individual tasks, typical tasks, and their interfaces (Avenue 3).

Digital strategy formulation related to emerging IO technologies, including I4.0, can significantly enhance organizations and interorganizational business process capabilities. Because much of those topics need further investigation, we call for more research on the critical success factors of different stages of IOR maturity that IOEs should consider in relation to interorganizational value chains (Avenue 4).

4.3.1.3 Under-represented capabilities

Further research is also required in relation to the three under-represented capabilities. Given our focus on interorganizational value chains, the modeling (Avenue 5), deployment (Avenue 6), and optimization (Avenue 7) of business processes indicate a need for methods and tools needed by organizations when implementing digital innovations into their interorganizational business processes.

This concerns how organizations model their business processes and how they are designed with their process and resource structures and managed with various innovative I4.0 technologies. We call for further research on the process and resource structures that organizations should consider when aligning interorganizational business process design phases (Avenue 5).

The deployment of business processes includes methods and IT systems regarding the intermediate phase of the business process lifecycle. It entails the implementation of business processes, along with the relevant measurement and control. Future research should therefore explore the control and measurement methods applied by organizations for collaborative decision-making in interorganizational business processes (Avenue 6).

Business process optimization determines methods and IT regarding the final phases of the business process lifestyle, including evaluation and improvement. It provides input for a new lifecycle to redesign existing business processes based on the identified improvements and collected information for simulations. This phase is essential for redesigning the business processes, as it determines how it should be performed in the future (Avenue 7). It remains unclear how interorganizational business processes can be improved, how I4.0 technology will contribute to improving value chain performance, and which maturity levels must be synchronized among all affected IOEs to avoid process incompatibility.

4.3.1.4 Interorganizational business process performance

Proven intraorganizational process performance indicators that are successful in one firm do not necessarily work in IOEs. Decision-makers should therefore jointly select performance measurement approaches, techniques, criteria, and metrics that suit their interorganizational business processes (Balfaqih *et al.*, 2016). Future research should enhance understanding of which joint IOE process performance indicators should be selected and how to measure them (Avenue 8).

4.3.1.5 Project management systems

Project management systems aim to ensure successful implementation at the firm level and across IOEs by coordinating technological changes. We call for more research on linking the IOE tasks and investments of actors within the value chain network at the IOR level. Interorganizational project management systems should synchronize organizational and technological activities to reach the same maturity level and avoid process incompatibility (Avenue 9).

4.3.1.6 BPM maturity model

Organizations must understand their maturity stages for I4.0, as the digitalization of business processes has evolved through continual significant changes in relationships, processes, technologies, and information systems (Wagire et al., 2020). Researchers conclude that BPM maturity models should be used to develop mandatory organizational capabilities and aligned goals (Lockamy and McCormack, 2004). Deeper investigations of how to apply BPM maturity models to access IOE capabilities and synchronized from the maturity-level perspective seems promising (Avenue 10).

4.3.2 Conceptual model

As a final step, we defined a conceptual model (Figure 12) for future research to provide empirical evaluation of our DIOVC capability framework. Literature and theories characterizing the direct relationships (i.e., straight line) correspond to this intention to improve business process performance.

Capability frameworks and their dimensions alone will not generate BP improvements (Kerpedzhiev *et al.*, 2021). Instead, we used them as a basis for defining our conceptual model, which is understood as a set of concepts describing the research topic without explaining it (Meredith, 1993). The model is derived from research by Van Looy et al. (2014) and by Rosemann et al. (2005) and extended to include our DIOVC capability framework.

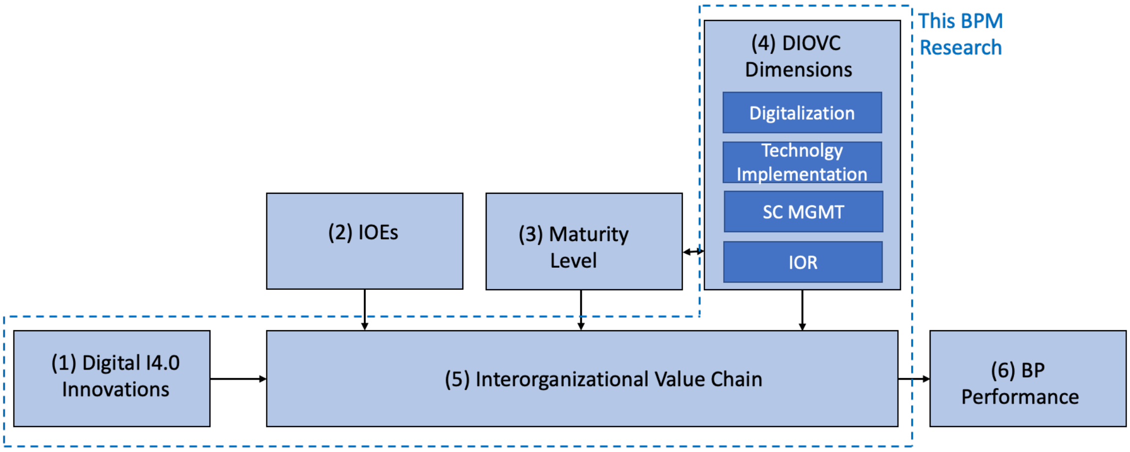

Figure 12: Conceptual model for future research

(1) Digital innovations drive opportunities for organizations related to horizontal and vertical integration in interorganizational value chains. (2) IOEs invest in digital-innovation resources and operate these interorganizational business processes. (3) Maturity level comprises the capability areas and targets the highest maturity level for business process excellence. (4) The capability areas of the novel DIOVC framework (Section 3) affect the effectiveness and efficiency of interorganizational value chains. (5) Digital innovations enable digital interorganizational value chains for communication between products and processes of all IOEs related to productive (value-added) activities. (6) Business process performance assumes that higher maturity levels in each area generate higher business process performance and maximize value for organizations by reducing operating costs aimed at minimizing business process output through fully compatible interorganizational value chains.

5 Discussion

5.1 Theoretical background

Digital I4.0 technologies enable full IOE integration and drive socio-technical changes related to BPM with which organizations must cope. Business processes should capitalize on technologies beyond traditional process technologies by considering the intra-organizational and interorganizational perspectives to achieve full process compatibility across IOEs. The scope of BPM should therefore be expanded to the interorganizational unit of analysis to provide BPM practitioners with knowledge about the four intersections of BPM, digital innovations, value chains, and interorganizational relationships. Our research was motivated by the observation that digital innovations call for new BPM capability areas and that extant capability frameworks need updating. We confirm that socio-technical changes require organizations to develop digitalization, technology implementation, SCM, and IOR capabilities. Although the DSC framework capabilities focus on previously made decisions to collaborate and the coordination of digital-innovation integrations, it addresses only the firm-centric perspective, even though IOR capabilities require organizations to have early involvement, to decide on IOR digitalization, and to manage IOR.

5.2 Theoretical contribution

Existing intraorganizational maturity models and their capabilities are limited to resource-based view theory, dynamic capabilities theory (Asdecker and Felch, 2018), convergence theory, process life-cycle theory, or stage theory (Felch and Asdecker, 2022). However, our results show that digital I4.0 technologies exceed the single organization and target interorganizational business processes. We contribute to the BPM literature by identifying 11 theories related to various ontological, epistemological considerations and research designs out of the interorganizational perspective. The foundation spectrum for the theoretical explanations of IOR range from economic rationale to behavioral rationale, thereby explaining the number of underlying theories (Barringer and Harrison, 2000). Our guidance and structure add new findings to the body of knowledge and researchers could use these findings to distinguish between theories according to different research perspectives and foundation spectrums (Table IV).

In a first step we defined pre-selected capabilities from existing academic frameworks underlying this SLR (Section 2.4) and presented the updated capabilities in our combined DIOVC capability framework (Section 2.5). From a theoretical perspective, the DIOVC capability framework implies that further development is required to improve business process performance through digital innovation. The DIOVC capability framework (Section 3) covers 17 capability areas, structured according to the dimensions of digitalization, technology implementation, supply chain management, and IOR. A comparison of these dimensions and capability areas to those proposed by Büyüközkan and Göçer (2018) reveals that 8 of the 17 capability areas are either new or enhanced versions of the existing capability framework (Büyüközkan and Göçer, 2018). The coded results of a large body of literature indicates that the IOR dimension, which entails governance, structure, and content, offers relevant capabilities for coping with socio-technical changes.

In the second step, we provided insight into the evolution of I4.0 digital innovations within an interorganizational setting (SLR-RQ1), the related capabilities (SLR-RQ2), and research avenues (SLR-RQ3). Our SLR confirms that organizations lack knowledge concerning IO capability areas (Jolanta and Mantas, 2018) and the interorganizational integration of I4.0 digital innovations (Liao *et al.*, 2017, Frederico *et al.*, 2020). Without holistic inclusion into the interorganizational value chains, I4.0 technologies will not contribute to their full capabilities and will prevent organizations from achieving excellence in business processes.

5.3 Practical implications

Managers and BPM practitioners can benefit from our findings that explain the four dimensions of the relevant 17 capability areas. More specifically, the conceptual model and the DIOVC capability framework enable considering all components constituting BPM due to digital innovations while addressing links between these related research topics. Our framework provides a foundation for addressing how to develop capabilities along strived objectives. Managers should focus on effective capabilities before attempting to improve the efficiency of the remaining ones.

Our results provide organizations with descriptive knowledge to develop their interorganizational BPM capabilities and to manage these across IOEs. From a practical standpoint, Managers and BPM practitioners need to think from an interorganizational business process perspective and enter into business process standardization to communize process activities across IOEs (Goel *et al.*, 2021). Organizations should define collaborative business process performance indicators based on standard definitions to enable comparability in evaluating performance across their value chain.

Value chains are not legal entities; the legal imperative for governance is not present as it is for a single organization (Provan and Kenis, 2008). Intraorganizational governance focuses on the board of directors' role in covering and protecting the interests of single organizational shareholders—however, digital Innovations such as Industry 4.0 address new legal challenges. A single organization should not define the governance of digital I4.0 innovations by itself; instead, a shared interorganizational stakeholder approach to govern digital I4.0 innovations across the value chain is necessary and requires the management of IOR structures across IOEs. Furthermore, organizations and Policymakers could extend existing standards such as Standard Reference Architectural Model Industry 4.0 (IEC PAS 63088) (Alcácer and Cruz-Machado, 2019) beyond the technical objects and their implementation by the other dimensions of our DIOVC framework to cope with the socio-technical changes.

5.4 Research limitations

We acknowledge certain research limitations that are typical of the SLR research methodology. Our work focuses on scientific articles within highly ranked journals published in English during a period spanning the past ten years (2011–2021). Even though the findings are not exhaustive, we consider them comprehensive, as they are based on highly ranked academic journals. Moreover, our themes were coded qualitatively, based on text analysis. Follow-up research should include empirical studies to validate our deductive findings. Nonetheless, our proposed research agendas can serve as a guide toward promising research avenues. Given the inherent limitations of the SLR research method, further research should consider applying qualitative research designs (e.g., Delphi studies) to validate these DIOVC capabilities against the conceptual model.

6 Conclusion

Emerging digital innovations are requiring academics and practitioners to rethink and streamline BPM from an interorganizational perspective. Organizations require updated knowledge and frameworks to identify and evaluate their capabilities. This paper aims to explore the current state of research regarding the use of I4.0 digital innovations within interorganizational settings. Based on the comprehensive outcomes of our investigation, the following conclusions can be drawn. Our first contribution of this SLR is a conceptual model from the themes generated and the synthesis that could help organizations to understand the complicated concepts. The second and most important contribution is the development of the DIOVC capability framework. Although a strong link exists between current and future capabilities, several new and enhanced capabilities are required for BPM to improve business process performance through digital innovation. Our framework provides a basis for researchers and practitioners to consider digital technologies as an instrument, and not as a goal, and to distinguish between effective and efficient capabilities related to interorganizational value chains. The third contribution concerns the theoretical background of the research domains in BPM, digital innovation, value chains, and interorganizational work.

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APPENDICES

Appendix A: decomposed DSC framework dimensions

Dimension	Capability	Sub-capability				
Digitalization	Strategy	Digital goal setting		Ditigal strategy formulation		Digital strategy implementation
	Organization and Culture	Analyse the current organization and culture		Digital organization and culture management		Transform into digital organization and culture
	Operations	Worker Enablement		Digital operations management		Digital operations implementation
	Products and Services	Customer requirement lifecycle		Products and service ecosystem		Customization and personalization
	Customer Experience	Customer understanding		Customer touchpoints		Top-line growth
Technology implementation	Technology enablers	Initiate process		Implement process		Evaluate process
	Project Management Systems	User Training		Human and technology interaction		Humand and technology collaboration
	Human and Technology	Organization infrastructure		Process infrastructure		Product infrastructure
	Technology Infrastructure	Process enablers		Product enablers		Technological solutions
SCM	Integration	Information sharing		Coordination and resource sharing		Organizational linkage
	Reconfiguration	Robotic technologies		Process automation		Intelligent Processes
	Auomation	Organizational reconfiguration		Supply chain network reconfiguration		Interorperability
	Analytics	Real-time execution decisions		Proocess optimization		Advanced forecasting
	Processes	Plan	Source	Make	Deliver	Return

Appendix B: decomposed DIOVC framework dimensions

Dimension	Capability	Sub-capability					
Digitalization	Strategy	Digital goal setting		Ditigal strategy formulation		Digital strategy implementation	
	Organization and Culture	Analyse the current organization and culture		Digital organization and culture management		Transform into digital organization and culture	
	Operations	Worker enablement		Digital operations management		Digital operations implementation	
	Products and Services	Customer requirement lifecycle		Product and service ecosystem		Customization and personalization	
	Customer Experience	Customer understanding		Customer touchpoints		Top-line growth	
Technology implementation	Technology enablers	Initiate process		Implement process		Evaluate process	
	Project Management Systems	User Training		Human and technology interaction		Humand and technology collaboration	
	Human and Technology	Organization infrastructure		Process infrastructure		Product infrastructure	
	Technology Infrastructure	Process enablers		Product enablers		Technological solutions	
SCM	Integration	Information sharing		Coordination and resource sharing		Organizational linkage	
	Reconfiguration	Robotic technologies		Process automation		Intelligent Processes	
	Auomation	Organizational reconfiguration		Supply chain network reconfiguration		Interorperability	
	Analytics	Real-time execution decisions		Proocess optimization		Advanced forecasting	
	Processes	Modeling	Deployment	Optimization	Management	Culture	Structure
IOR	Governance	Trustworthiness and equity understanding		Incentive structure and objective management		Contract and IOR management	
	Content	Resource sharing		Knowledge integration and information sharing		Resource and information flow management	
	Structure	IOE diversity linkage		Type and stability understanding		Density of relations	

Appendix C: Concept matrix from literature review

		Digitalization					Technology Implementation				Supply chain (SC) Management										Inter-Organizational relation (IOR)		
	Dimension	Digitalization Strategy (DS)	Digital Orga-nization and Culture (DO&C)	Digital Operations (DO)	Digital Products and Services	Digital Customer Experience	Technology enablers	Project Manage-ment Systems	Human and Technology Relation-ship	Formation of Technology Infra-structure	SC Integration	SC Reconfi-guration	SC Auomation	SC Analytics	SC Business Process (BP)						IOR Governance	IOR Content	IOR Structure
Author															BP Modeling	BP Deployment	BP Optimization	BP Management	BP Culture	BP Structure			
R1		X	X	-	-	-	X	-	X	-	X	-	-	-	-	-	-	X	-	X	-	X	X
R2		-	-	-	-	-	X	-	X	X	X	-	-	-	-	-	-	X	-	X	X	-	-
R3		X	X	-	-	-	X	-	-	X	-	-	-	-	-	-	-	X	-	-	X	X	X
R4		-	-	-	-	-	X	-	X	-	X	-	-	-	-	-	-	X	-	-	X	-	X
R5		-	-	-	-	-	X	-	X	-	X	X	-	-	-	X	-	X	-	-	X	-	X
R6		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-
R7		X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	X	-	X
R8		X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	X	-	X
R9		X	-	X	-	-	X	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X	-
R10		X	-	-	X	X	X	-	-	-	X	X	-	-	-	-	-	X	-	-	-	X	X
R11		-	X	-	-	-	-	-	X	-	X	-	-	X	-	-	-	X	-	-	X	X	X
R12		-	X	X	-	-	-	-	-	-	X	-	-	-	-	-	-	X	X	-	X	X	X
R13		X	-	X	-	-	X	-	-	-	X	-	-	-	-	-	-	X	-	-	X	-	X
R14		-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	X	-	-
R15		-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-
R16		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	X	X	X
R17		X	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	X	-	-	X	X	X
R18		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
R19		X	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	X	-	X
R20		X	X	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-	-	X	-	-
R21		X	-	-	X	-	X	-	-	-	-	-	-	X	X	-	-	X	-	-	-	X	-
R22		X	X	-	-	-	X	-	X	-	-	-	-	-	-	-	-	X	-	-	-	-	-
R23		X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	X	X	X
R24		X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	X	-	X
R25		-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X
R26		-	-	X	-	-	X	X	X	-	-	-	-	-	-	-	-	X	-	-	-	-	X
R27		-	-	-	-	-	X	-	-	-	-	-	X	-	-	-	-	-	-	-	X	X	-
R28		-	-	-	-	-	X	-	-	X	X	X	-	X	-	-	-	X	-	-	-	-	-
R29		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-
R30		X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-
R31		-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	X	-	-	-	X	X	X
R32		X	X	-	-	-	X	-	X	X	-	-	-	-	-	-	-	X	-	-	X	X	-
R33		X	-	-	-	-	-	-	X	X	X	-	-	-	-	-	-	X	-	-	X	X	X
R34		-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-
R35		-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	X	X	X
R36		X	X	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	X	-	-
R37		-	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	X	X	X	-	-	X
R38		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-
R39		-	-	-	-	-	X	-	-	-	X	-	-	-	-	-	-	X	-	-	X	-	X
R40		-	X	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	X	-	-
R41		-	X	-	-	-	X	-	X	-	-	-	-	-	-	-	-	X	X	-	-	-	X
R42		X	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
R43		-	-	-	-	-	X	-	X	-	X	-	-	-	-	-	-	-	-	-	X	X	-
R44		X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	X
R45		X	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	X
R46		X	X	-	-	-	X	-	-	-	X	-	-	-	-	-	-	X	-	-	-	X	-
R47		X	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-
R48		-	-	-	-	-	X	-	-	-	X	-	X	X	-	-	-	-	-	X	X	X	-
R49		X	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X
R50		-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	X	-
R51		-	-	-	-	-	X	-	-	-	X	-	-	X	-	-	-	-	X	-	X	-	X
R52		-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
R53		-	-	X	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	X	-	X	-
R54		-	X	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	X	-	-	-
R55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	X
R56		X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
R57		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
R58		-	-	-	-	-	-	-	X	-	X	X	-	-	X	-	-	X	-	X	X	-	-

Appendix D: Complete list of articles included in the SLR (1/2)

ID	Authors (last name, first name)	Source	Title	Journal or conference title	Publication year	Volume	Pages	DOI
R1	Abdalla S., Nakagawa K.	SCOPUS	The interplay of digital transformation and collaborative innovation on supply chain ambidexterity	Technology Innovation Management Review	2021	11	45-56	10.22215/TIMREVIEW/1428
R2	Aulkemeier, F.; Iacob, M.-E.; van Hillegersberg, J.	SCOPUS	Platform-based collaboration in digital ecosystems	Electronic Markets	2019	29	597-608	10.1007/s12525-019-00341-2
R3	Barrane F.Z.; Ndubisi N.O.; Kamble S., Karuranga G.E.;	SCOPUS	Building trust in multi-stakeholder collaborations for new product development in the digital transformation era	Benchmarking	2021	28	205-228	10.1108/BIJ-04-2020-0164
R4	Benzidia, S.; Makaoui, N.; Subramanian, N.	SCOPUS	Impact of ambidexterity of blockchain technology and social factors on new product development: A supply chain and Industry 4.0 perspective	Technological Forecasting and Social Change	2021	169	1-13	10.1016/j.techfore.2021.120819
R5	Benzidia, S.; Makaoui, N.; Bentahar, O.	SCOPUS	The impact of big data analytics and artificial intelligence on green supply chain process integration and hospital environmental performance	Technological Forecasting and Social Change	2021	165	1-13	10.1016/j.techfore.2020.120557
R6	Bisogno, M.; Nota, G.; Saccomanno, A.; Tommasetti,	SCOPUS	Improving the efficiency of Port Community Systems through integrated information flows of logistic processes	International Journal of Digital Accounting Research	2015	15	1-31	10.4192/1577-8517-v15_1
R7	Caputo, A.; Fiorentino, R.; Garzella, S.	SCOPUS	From the boundaries of management to the management of boundaries: Business processes, capabilities and negotiations	Business Process Management Journal	2019	25	391-413	10.1108/BPMJ-11-2017-0334
R8	Chakravorti, S.	SCOPUS	Enhancing interfirm relationship and performance through internet driven management of knowledge processes	International Journal of Value Chain Management	2012	6	93-114	10.1504/IJVCM.2012.048377
R9	Chauhan, C.; Singh, A.; Luthra, S.	SCOPUS	Barriers to industry 4.0 adoption and its performance implications: An empirical investigation of emerging economy	Journal of Cleaner Production	2021	285	1-15	10.1016/j.jclepro.2020.124809
R10	Chester Goduscheit, R.; Faullant, R.	SCOPUS	Paths Toward Radical Service Innovation in Manufacturing Companies—A Service-Dominant Logic Perspective	Journal of Product Innovation Management	2018	35	701-719	10.1111/jpim.12461
R11	Chong, A.Y.-L.; Zhou, L.	SCOPUS	Demand chain management: Relationships between external antecedents, web-based integration and service innovation performance	International Journal of Production Economics	2014	154	48-58	10.1016/j.ijpe.2014.04.005
R12	Ciulli, F.; Kolk, A.; Boe-Lillegraven, S.	SCOPUS	Circularity Brokers: Digital Platform Organizations and Waste Recovery in Food Supply Chains	Journal of Business Ethics	2020	167	299-331	10.1007/s10551-019-04160-5
R13	**de Corbière, F., Rowe, F.; Saunders, C.S.**	SCOPUS	Digitalizing interorganizational relationships: Sequential and intertwined decisions for data synchronization	International Journal of Information Management	2019	48	203-217	10.1016/j.ijinfomgt.2019.04.005
R14	Di Vaio, A.; Varriale, L.	SCOPUS	Digitalization in the sea-land supply chain: experiences from Italy in rethinking the port operations within inter-organizational relationships	Production Planning and Control	2020	31	220-232	10.1080/09537287.2019.1631464
R15	Fosso Wamba, S.; Queiroz, M.M.; Trinchera, L.	SCOPUS	Dynamics between blockchain adoption determinants and supply chain performance: An empirical investigation	International Journal of Production Economics	2020	229	1-15	10.1016/j.ijpe.2020.107791
R16	Gadde, L.-E.; Snehota, I.	SCOPUS	What does it take to make the most of supplier relationships?	Industrial Marketing Management	2019	83	185-193	10.1016/j.indmarman.2019.07.003
R17	Galera-Zarco, C.; Opazo-Basáez, M.; Marić , J.; García-	SCOPUS	Digitalization and the inception of concentric strategic alliances: A case study in the retailing sector	Strategic Change	2020	29	165-177	10.1002/jsc.2319
R18	Götz, M.	SCOPUS	The industry 4.0 induced agility and new skills in clusters	Foresight and STI Governance	2019	13	72-83	10.17323/2500-2597.2019.2.72.83
R19	Handfield, R.	SCOPUS	Shifts in buyer-seller relationships: A retrospective on Handfield and Bechtel (2002)	Industrial Marketing Management	2019	83	194-206	10.1016/j.indmarman.2019.08.012
R20	Hänninen, M.; Luoma, J.; Mitronen, L.	SCOPUS	Information standards in retailing? A review and future outlook	International Review of Retail, Distribution and Consumer Research	2021	31	131-149	10.1080/09593969.2020.1845224
R21	Herbst, T.D.	SCOPUS	Component suppliers in the commodity battle: Can digital technology in multi-tier supply chains help to transform liabilities into opportunities?	International Journal of Business Science and Applied Management	2021	16	22-45	NA
R22	Hong, J.; Guo, P.; Deng, H.; Quan, Y.	SCOPUS	The adoption of supply chain service platforms for organizational performance: Evidences from Chinese catering organizations	International Journal of Production Economics	2021	237	1-13	10.1016/j.ijpe.2021.108147
R23	Hwang, S.; Kim, H.; Hur, D.; Schoenherr, T.	SCOPUS	Interorganizational information processing and the contingency effects of buyer-incurred uncertainty in a supplier's component development	International Journal of Production Economics	2019	210	169-183	10.1016/j.ijpe.2019.01.019
R24	Kamalaldin, A.; Linde, L.; Sjödin, D.; Parida, V.	SCOPUS	Configuring ecosystem strategies for digitally enabled process innovation: A framework for equipment suppliers in the process	Technovation	2021	105	1-18	10.1016/j.technovation.2021.102250
R25	Koch, T.; Windsperger, J.	SCOPUS	Seeing through the network: Competitive advantage in the digital economy	Journal of Organization Design	2017	6	1-30	10.1186/s41469-017-0016-z
R26	Kosmol, T.; Reimann, F.; Kaufmann, L.	SCOPUS and	You'll never walk alone: Why we need a supply chain practice view on digital procurement	Journal of Purchasing and Supply Management	2019	25	1-17	10.1016/j.pursup.2019.100553
R27	Kozma, D.; Varga P.	SCOPUS	Supporting digital supply chains by iot frameworks: Collaboration, control, combination	Infocommunications Journal	2020	25	22-32	10.36244/ICJ.2020.4.4
R28	Li, Y.; Dai, J.; Cui, L.	SCOPUS	The impact of digital technologies on economic and environmental performance in the context of industry 4.0: A moderated mediation	International Journal of Production Economics	2020	12	1-13	10.1016/j.ijpe.2020.107777

Appendix D: Complete list of articles included in the SLR (2/2)

ID	Authors (last name, first name)	Source	Title	Source title	Publication year	Volume	Pages	DOI
R29	Lokuge, S.; Sedera, D.; Grover, V.; Dongming, X.	SCOPUS	Organizational readiness for digital innovation: Development and empirical calibration of a construct	Information and Management	2019	56	445-461	10.1016/j.im.2018.09.001
R30	Mosch, P.; Schweikl, S.; Obermaier, R.	SCOPUS	Trapped in the supply chain? Digital servitization strategies and power relations in the case of an industrial technology supplier	International Journal of Production Economics	2021	236	1-14	10.1016/j.ijpe.2021.108141
R31	Müller, J.M.; Veile, J.W.; Voigt, K.-I.	SCOPUS / WoS	Prerequisites and incentives for digital information sharing in Industry 4.0 – An international comparison across data types	Computers and Industrial Engineering	2020	148	1-14	10.1016/j.cie.2020.106733
R32	Muller, M.; Ostern, N.;	SCOPUS	Trust Mining: Analyzing Trust in Collaborative Business Processes	IEEE Access	2021	9	65044-65065	10.1109/ACCESS.2021.3075568
R33	Neale O', Connor; Paul Benjamin, Lowry;	SCOPUS / WoS	Interorganizational cooperation and supplier performance in high-technology supply chains.	Heliyon	2020	6	1-16	10.1016/j.heliyon.2020.e03434
R34	Omar, I.A.; Jayaraman, R.; Salah, K.; Debe, M.; Omar M.	SCOPUS	Enhancing vendor managed inventory supply chain operations using blockchain smart contracts	IEEE Access	2020	8	182704-182719	10.1109/ACCESS.2020.3028031
R35	Papadonikolaki, E.	SCOPUS	Loosely Coupled Systems of Innovation: Aligning BIM Adoption with Implementation in Dutch Construction	Journal of Management in Engineering	2018	34	1-43	10.1061/(ASCE)ME.1943-5479.0000644
R36	Papadonikolaki, E.; Vrijhoef, R.; Wamelink, H.	SCOPUS	The interdependences of BIM and supply chain partnering: empirical explorations	Architectural Engineering and Design Management	2016	12	476-494	10.1080/17452007.2016.1212693
R37	Ringen, Geir;Paalsrud, Frode;Lod	Springer Link	Interorganizational Learning in Manufacturing Networks	Advances in Production Management Systems	2020	591	680-686	10.1007/978-3-030-57993-7_77
R38	Roxanne, Piderit; Stephen, Flowerday;	EBESCO	Enabling information sharing by establishing trust in supply chains: A case study in the South African automotive industry.	South African Journal of Information Management	2011	13	1-8	10.4102/sajim.v13i1.473
R39	Ruey-Jer Bryan, Jean, Daekwan, Kim, Yung-Chih, Lien and	SCOPUS	The moderating effect of virtual integration on intergenerational governance and relationship performance in international	International Marketing Review	2020	37	579-592	10.1108/IMR-03-2019-0102
R40	Scuotto, V.; Caputo, F.; Villasalero, M.; Del Giudice, M.	SCOPUS	A multiple buyer–supplier relationship in the context of SMEs' digital supply chain management*	Production Planning and Control	2017	19	1378-1388	10.1080/09537287.2017.1375149
R41	Seebacher, Stefan;Schüritz, Ronn	Springer Link	Towards an understanding of technology fit and appropriation in business networks: evidence from blockchain implementations	Information Systems and e-Business Management	2021	19	183-204	10.1007/s10257-020-00485-1
R42	Seethamraju, R.	SCOPUS	Enterprise systems and demand chain management: A cross-sectional field study	Information Technology and Management	2014	15	151-161	10.1007/s10799-014-0178-0
R43	Sharma, A.; Khanna, P.	SCOPUS	Relevance of adopting emerging technologies in outbound supply chain: New paradigm for cement industry	Operations and Supply Chain Management	2020	13	210-221	10.31387/OSCM0410263
R44	Sjödin, D.; Parida, V.; Kohtamäki, M.; Wincent, J.	SCOPUS	An agile co-creation process for digital servitization: A micro-service innovation approach	Journal of Business Research	2020	112	478-491	10.1016/j.jbusres.2020.01.009
R45	Sklyar, A.; Kowalkowski, C.; Tronvoll, B.; Sörhammar, D.	SCOPUS	Organizing for digital servitization: A service ecosystem perspective	Journal of Business Research	2019	104	450-460	10.1016/j.jbusres.2019.02.012
R46	Standing, S.; Standing, C.	SCOPUS	Service value exchange in B2B electronic marketplaces	Journal of Business and Industrial Marketing	2015	30	723-732	10.1108/JBIM-05-2014-0112
R47	Suleykin, Alexander; Bakhtadze,	Springer Link	Agent-Based Architectural Models of Supply Chain Management in Digital Ecosystems	Intelligent Systems and Applications	2021	1252	115-127	10.1007/978-3-030-55190-2_9
R48	Varriale, V.; Cammarano, A.; Michelino, F.; Caputo, M.	SCOPUS	Sustainable supply chains with blockchain, IoT and RFID: A simulation on order management	Sustainability (Switzerland)	2021	13	1-23	10.3390/su13116372
R49	Vendrell-Herrero, F.; Bustinza, O.F.; Parry, G.; Georgantzis, N.	SCOPUS	Servitization, digitization and supply chain interdependency	Industrial Marketing Management	2017	60	69-81	10.1016/j.indmarman.2016.06.013
R50	Vilko, Jyri; Hallikas, Jukka	Springer Link	Supply Networks Going Digital – Causalities of Value Production in Digitalized Systems	Human Centred Intelligent Systems	2021	244	26-35	10.1007/978-981-16-3264-8_3
R51	Wang, M.; Wu, Y.; Chen, B.; Evans, M.	SCOPUS	Blockchain and supply chain management: A new paradigm for supply chain integration and collaboration	Operations and Supply Chain Management	2021	14	111 – 122	10.31387/oscm0440290
R52	Wautelet, Y.	SCOPUS	Representing, modeling and engineering a collaborative supply chain management platform	International Journal of Information Systems and Supply Chain Management	2012	5	1-23	10.4018/jisscm.2012070101
R53	Wei, Z.; Sun, L.	SCOPUS	How to leverage manufacturing digitalization for green process innovation: an information processing perspective	Industrial Management and Data Systems	2021	121	1026-1044	10.1108/IMDS-08-2020-0459
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