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Impact of digitalization on supply chain performance in the manufacturing industry: A literature review

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Abstract
Purpose: Currently, challenges such as a volatile external environment, resource scarcity, and globalization have driven the process of digitalization in the manufacturing industry. This paper aims to explore the literature related to supply chain digitalization and supply chain performance in manufacturing and build a research framework.
Design/methodology/approach: This paper investigates and consolidates the relevant literature that has been published in the Scopus and Web of Science databases within the last five years, utilizing keyword searches.
Findings: This paper proposes that research on supply chain digitalization in the context of manufacturing manifests itself in four different forms, such as Industry 4.0, digital technology, digital transformation, and digital supply chain, and uses this as the basis for constructing a research framework map to further assess the status and future paths of research on supply chain digitalization on supply chain performance.
Research limitations/implications: This paper provides a systematic research framework and future research directions for current and future researchers interested in advancing supply chain digitalization and supply chain research.
Practical implications: This paper can be used as a guide for supply chain managers to increase awareness, understanding and acceptance of the potential benefits and impacts of digitalization among supply chain members.
Originality/value: This paper provides a theoretical foundation and inspiration for future research on supply chain digitalization and performance.

Keywords: Supply Chain Digitalization, Supply Chain Performance, Digital Transformation, Industry 4.0, Manufacturing Industry

Introduction

Digitalization is becoming the new "must" for manufacturing in the global digital economy (Chiarini et al., 2020). It can make manufacturing processes more effective and efficient, increase productivity and resource use efficiency, help companies reduce costs, and increase competitiveness (Sūdžiūtė & Jakubavičius, 2022).
The impact of digitalization on supply chain management has attracted increasing attention, as the supply chain is a crucial aspect of the development of the manufacturing industry (MI). The

level of the supply chain determines the efficiency of the company's production operations (Oubrahim et al., 2023). Deciding whether a product gains a competitive advantage is vital and is usually reflected by supply chain performance (SCP) (Reddy. K et al., 2019). SCP refers to the measurement and quantification of an organization's effectiveness in the operation of each link in the supply chain and the overall operational efficiency in a changing environment (Delic & Eyers, 2020; Sundram et al., 2020; Zhao et al., 2023). Organization can enhance their comprehension and enhancement of supply chains, diminish superfluous resource activities, augment customer satisfaction and delivery efficiency, and propel their supply chains toward heightened velocity, thereby bolstering competitiveness through the evaluation and optimization of SCP (Lehyani et al., 2021; V. Sharma et al., 2022).

Industry 4.0 (I4.0) is the foundation for the drive towards digitalization, with strategy, employee and corporate culture, and technology being the predecessors for the deployment of I4.0, facilitating a more interconnected supply chain across functional areas (Erboz, Yumurtacı Hüseyinoğlu, et al., 2021; Tortorella et al., 2023). Emerging technologies such as additive manufacturing (AM), big data analytics (BDA), and artificial intelligence (AI) and their application in supply chain management contribute to operational flexibility and competitive advantage (Bahrami et al., 2022; Belhadi et al., 2021; Delic et al., 2019; Delic & Eyers, 2020). Digital transformation enables better connectivity between organizations and improves supply chain traceability, collaboration, and responsiveness, enhancing supply chain capabilities (Ning & Yao, 2023; Oubrahim et al., 2023; Zhou et al., 2023). The digital supply chain (DSC) can enhance the agility and flexibility of an organizational supply chain and improve competitive advantage (Lee et al., 2022; Shahadat et al., 2023). Therefore, on the basis of the categorization criteria of Núñez-Merino et al. (2022) for the topic of supply chain digitalization (SCD), this paper argues that I4.0, digital technology, digital transformation, DSC, etc., are different forms of supply chain digitalization-related research.

Drawing upon an extensive analysis of relevant scholarly sources, this paper discusses the definition of SCD and different research perspectives, explores the relationship and framework between various forms of SCD and SCP in the MI, and provides a blueprint for future research.

Methods

In academic research, a systematic and accurate literature review is essential to the foundational elements (Alcácer & Cruz-Machado, 2019). It guides future development by reviewing and evaluating the relevant literature to comprehend the current state of research in a particular field (Núñez-Merino et al., 2022). For these reasons, this paper reviews previous research on SCD and performance. First, this paper selects two databases, Scopus and Web of Sciences, which are widely recognized by academics, to collect valuable information on SCD and performance based on keywords. This study focuses on the period from 2018--2023, and the key search terms are "digitalization", "supply chain performance," and "manufacturing industry," all in English.

The findings show that many papers have dealt with SCD and SCP during the last five years. In this paper, after reviewing, screening, eliminating, summarizing, and organizing, we describe and discuss the literature on different forms of SCD and their impact on SCP. A review of the scientific literature published in recent years enables us to build on previous research, provides a unique perspective on the research framework between digitalization and SCP, and helps us identify gaps in the current literature.

Literature Review

Drawing upon prior research, this section initially presents a comprehensive overview of the conceptualization of SCD. On the basis of the classification criteria of Núñez-Merino et al. (2022) and Deepu & Ravi (2023) for the topic of SCD, these papers argue that I4.0, digital

technology, digitalization, and DSC are distinct types of SCD-related research. Table 1 provides a concise overview of the primary contributions found in the literature pertaining to the chosen domains.

Definition of SCD

Supply chain digitalization can lead supply chains to a new stage of development and is a current research hotspot (Ning & Yao, 2023). Owing to the different studies focused on SCD, there is no unified opinion on the definition of SCD. Zhao et al. (2023) consider data an essential element in driving decisions and define SCD as integrating innovative technologies into supply chain activities, resulting in a "data-driven decision-making" operational process. Some definitions focus on technology-induced outcomes; Ageron (2020) sees SCD as a concrete transformation of supply chain processes brought about by the application of technology. Gharaibeh et al. (2022) argue that SCD is an outgrowth of I4.0 technologies, which can be considered to be Supply Chain 4.0, focusing on using different digital technologies by firms to generate products. Furthermore, Zhou et al. (2023) argue that what is applied in SCD is not a specific technology but a unified structure of integrated digital information infrastructure. Therefore, from his research perspective, SCD is how organizations adopt intelligent and interconnected digital information systems to transact with node members.

After reviewing the literature, this study defines supply chain digitalization (SCD) as the level at which an organization integrates emerging technologies into decision-making and management across all supply chain functions, including procurement, manufacturing, warehousing, and logistics.

I4.0 & SCP in the MI

I4.0 originated from the German government's strategic advocacy program for the future of manufacturing in 2011 (R. Sharma et al., 2022). The fourth revolution of industry succeeded the preceding three revolutions, which were instigated by the introduction of mechanization, electrification, and automation in manufacturing processes (Fatorachian & Kazemi, 2021; Yu et al., 2021). I4.0 plays a dominant role in manufacturing and significantly impacts the whole supply chain (Reischauer, 2018). It changes our perception of traditional supply chain management, further influencing the positions and jobs of future supply chain practitioners (Shukor et al., 2021). Managers use technology to continuously develop new areas and functions of the business to drive organizations to derive greater value and resource utilization from them (Erboz, Huseyinoglu, et al., 2021). I4.0 improves supply chain management and reshapes interorganizational processes by introducing advanced digital technologies that support the interconnectivity of supply chain partners (Deepu & Ravi, 2023; Rad et al., 2022). The impact of I4.0 on the SCP has triggered extensive discussions among scholars. Li et al. (2020) conducted an empirical study based on information processing theory with Chinese manufacturing enterprises. They reported that I4.0 technologies positively impact the economic performance and environmental performance of manufacturing enterprises. Qader et al. (2022) conducted a quantitative study on manufacturing firms such as food, beverage, and pharmaceutical companies in Pakistan and concluded that the adoption of I4.0 technologies (Internet of Things, Machine Learning, Block Chain Technology) has an important effect on SCP and can effectively improve operational performance and financial performance. Tortorella et al. (2023) innovatively proposed the division of I4.0 technologies into sensing and communication technologies and processing and education technologies, guided by resource dependence theory, during the period of New Crown Pneumonia in Brazil and India as the research background, the empirical study concludes that the adoption of these technologies will effectively improve SCP of the healthcare industry. In addition, Erboz et al. (2021) proposed considering the dimensions of strategy, employees and culture, and technology adoption of I4.0

on SCP in Turkish manufacturing firms and empirically determined that I4.0 effectively improves performance in terms of resources, output, and flexibility.

Digital Technology & SCP in the MI

At the heart of SCD is the use of digital technology to develop the supply chain. Technology is a powerful enabler of manufacturing, and digital technology is essential for optimizing organizational processes and improving organizational efficiency (Ardolino et al., 2022). Ivanov et al. (2018) suggested that the success of the supply chain is dependent mainly on digital technology. Information technology can effectively facilitate information sharing in manufacturing supply chains, improving performance and, ultimately, organizational performance (Sundram et al., 2020). Deepu and Ravi (2023) analysed SCD research from 2012--2022 and summarized 12 digital technologies. Through a literature review, Rad et al. (2022) proposed 11 core technologies for I4.0 to improve SCP.

AI can help supply chains provide more powerful optimization capabilities that lead to more precise capacity planning, increased productivity and quality, greater capacity at lower cost, and improved SCP (Alomar, 2022). On the basis of information processing theory, Belhadi et al. (2021) developed a conceptual framework to elucidate the interplay between AI and the supply chain. They suggested that AI can improve SCP in a short period. The performance-based information processing theory and the results of a study of 279 companies from various industries around the world suggest that AI can improve SCP in a short period. BDA can help organizations improve their responsiveness and reliability and thus better serve their customers (Fernando et al., 2018). Through an empirical study of Brazilian MI, Bahrami et al. (2022) suggest that BDA capabilities can change SCP. Nevertheless, their operation is opaque and affects the SCP in several ways. Cloud computing technologies facilitate seamless exchange and accessibility of information, hence facilitating the transfer of vast quantities of data across various entities within the supply chain and contributing to improved supply chain management efficiency by increasing responsiveness (Fatorachian & Kazemi, 2021). Radio frequency identification, as a global technology, can improve SCP by shortening the transport time and response rate, which significantly improves the total efficiency of the supply chain and has gained wide application in the supply chain of various industries (Unhelkar et al., 2022). The Internet of Things is extensively used in many segments of the supply chain and is anticipated to bring disruptive changes to supply chain management by enhancing the transparency of operational operations within corporations. Delic et al. (2019), for the EU automotive industry, based on resource-based theory, reported that the adoption of AM positively affects SCP, which in turn affects firm performance.

DSC & SCP in the MI

The DSC is a proactive and efficient process that utilizes new technologies to integrate chain activities and meet customer needs (Büyüközkan & Göçer, 2018). It involves digitalization to ensure seamless delivery and visibility across the supply chain, as well as employee engagement, strategic alignment, employee training and development, technology awareness, and project management systems (Agrawal & Narain, 2018). Overall, the DSC is a solution to global disruption that enables supply chain collaboration, reduces closure risk, and enables organizations to create new revenue streams and business value.

Lee et al. (2022) concluded that most manufacturing firms in Malaysia lack an understanding of the mechanism of the DSC, the SCP, and organizational performance; therefore, by conducting an empirical study on the Federation of Malaysian Manufacturers listed firms, the conclusion suggests that the DSC can better improve organizational performance by facilitating the mediating factor of SCP. Shahadat et al. (2023) studied 150 firms in readymade garment MI in Bangladesh and concluded that the DSC has a crucial effect on SCP.

Digital Transformation & the SCP in the MI

Digital transformation refers to firms' use of technologies to reconfigure strategic decisions, processes, and structures inside and outside the organization at the source to enhance economic value generation with greater efficiency (Reddy & Reinartz, 2017).

The digital transformation of organizations, both internally and externally, has driven the research process in supply chain management (Holmström et al., 2019). Furthermore, digital transformation has a more pronounced effect on organizations' operational and business performance (Aninda & Karyani, 2022; L. Li et al., 2022). Ning and Yao (2023) suggested that firms with greater digital transformation have better competitive performance, moderated by external uncertainties. Gupta et al. (2020) identified and ranked 25 key enablers of digital transformation via a qualitative research approach; in addition to "big data," "product tracking" and "appropriate and feasibility studies to help select and adopt big data techniques and technologies" are the top three digital enablers that organizations need to focus on to improve SCP. Zhao et al. (2023) studied 210 manufacturing companies in. They concluded that digital transformation can positively impact SCP by improving cost-effectiveness and enhancing information and communication efficiency on the basis of dynamic capability theory. Son et al. (2021), using information processing theory, attempted to explore the effect of digital transformation on SCP and the role of agility and traceability during this relationship. A survey study of 225 manufacturing firms in China-proposed that digital transformation can improve SCP.

Table 1: Main contributions from the literature review

Focus	Main contribution	Reference
I4.0 technology and SCP	Exploring the influence of applying I4.0 technology on supply chain resilience and SCP in Pakistani	(Qader et al., 2022)
I4.0 and SCP	Proposes to consider the effect of I4.0 on SCP in the Turkish in terms of the dimensions of strategy, employees and culture, and technology adoption.	(Erboz et al., 2021)
I4.0 technology and financial and environment performance	Investigating the impact of applying I4.0 technology on economic performance and environmental performance in the China’s MI	(Y. Li et al., 2020)
Information technology, SCP and organisational performance	An investigation into the influence of information sharing and information technology on SCP and organisational performance in Malaysia	(Sundram et al., 2020)
AI and SCP	Exploring the mechanisms at play between AI and SCP	(Alomar, 2022)
AI and SCP	Exploring the mechanisms at play between artificial intelligence, information processing capabilities, supply chain resilience, and SCP	(Belhadi et al., 2021)
BDA capabilities and SCP	Exploring how BDA capabilities in Brazilian manufacturing affect SCP and the mediating effect of supply chain resilience and innovation	(Bahrami et al., 2022)

AM, SCP, and firm performance	Investigating the relationship of AM on SCP and firm performance for the EU automotive industry	(Delic et al., 2019)
DSC, SCP, and organisational performance	A survey of the Malaysian MI to explore the linkage of DSC, SCP, and organisational performance	(Lee et al., 2022)
DSC and SCP	An empirical study of manufacturing firms in Bangladesh to explore the relationship between DSC and SCP	(Shahadat et al., 2023)
Digital transformation and competitive performance	Exploring the relationship between digital transformation and competitive performance	(Ning & Yao, 2023)
Digital transformation and SCP	Aiming to study the correlation between digital transformation and SCP, and the significance of agility and traceability in this connection, a survey was conducted on 225 Chinese manufacturing firms.	(Son et al., 2021)
SCD and SCP	A survey of China's manufacturing firms to investigate the relationship among SCD, supply chain resilience, and SCP	(Zhao et al., 2023)

Discussion and Conclusion

This study aims to analyze existing research pertaining to the influence of SCD on the SCP in MI. Using two major databases, Scopus and Web of Science, to screen and summarize the relevant literature published between 2018 to 2023. Accordingly, a definition of SCD is given, and it is proposed that research on SCD in the context of MI manifests itself in different forms and explores the impact of SCD on performance from different perspectives. As shown in Figure 1, this paper presents a research framework diagram that offers an overview of the existing research on SCD and its influence on SCP on the basis of categorization.

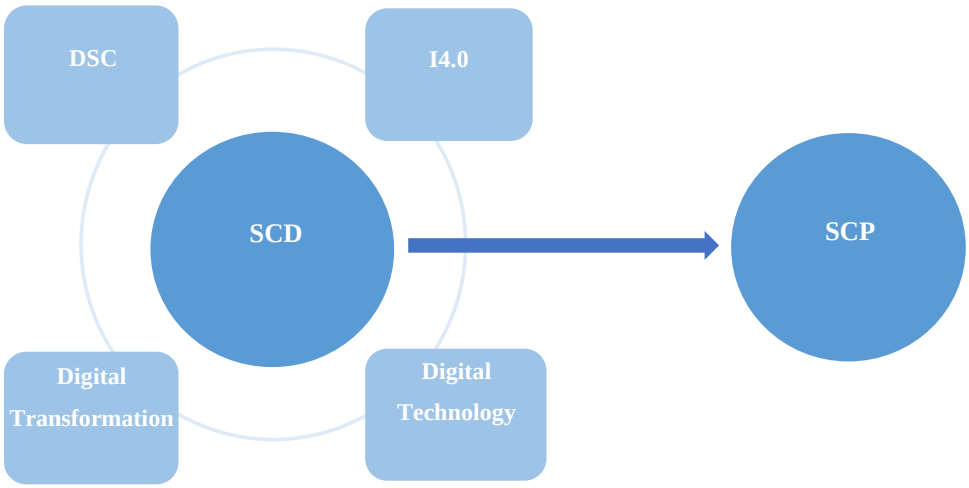

Figure 1: SCD and its influence on SCP

Theoretical Implications

The following presents a series of implications from academic, managerial, and governmental perspectives. First, from an academic standpoint, this study offers a structured research

framework for researchers interested in SCD and performance research and suggests future research directions with particularly valuable.

Practical and Social Implications

In terms of practical applications in business management, this research can serve as guidance for managers to increase awareness, understanding, and acceptance of the potential benefits and impacts of supply chain digitalization among team members. Secondly, it is important to emphasize the key role that government departments can play in ensuring the success of SCD at both corporate and supply chain levels. The government can facilitate the development and implementation of pilot projects for supply chain digitization by increasing policy and financial support for companies.

Limitations and Suggestions for Future Research

Although most of the literature shows the positive impact of SCD on SCP, some scholars still suggest that digitalization may have specific negative effects, such as the asymmetry of digital capabilities that creates a problem for SMEs' development (Son et al., 2021), the purchase of digital equipment that increases the financial burden (Yang et al., 2021), and the potential for digitization to lack enduring beneficial effects on SCP (Belhadi et al., 2021). Some even argue that the effect of SCD on the SCP is negligible (Kim & Lee, 2021).

Therefore, on the basis of the gaps in the literature that emerged from our analyses, we propose the following research agenda to provide some crucial questions for future research:

- Does SCD have a negative effect on SCP in the manufacturing sector?
- Does digital transformation have a direct influence on sustainable SCP?
- How to ensure SCD has a sustained positive impact on SCP.
- What barriers are encountered in implementing SCD, and how can they be removed?
- How can SCD be helpful in different industrial sectors, such as service industry companies?

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