

# Opportunities and Challenges of Digital Technologies on Supply Chain Management: A State-of-the-Art Review

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## Abstract

The article examines the findings of previous studies concerning the opportunities and challenges posed by digitalization in Supply Chain Management (SCM). The primary aim is to aggregate and categorize these opportunities and challenges, shedding light on the evolving landscape of Digital Supply Chain Management (DSCM) across various industries.

The article analyses a wide range of qualitative and quantitative studies, conceptual frameworks, and state-of-the-art analyses. It categorizes findings based on types of research, including reviews, qualitative studies, and quantitative studies. Drawing from over 500 studies, which include reviews and qualitative and quantitative research, it highlights key takeaways that show a dynamic interplay of opportunities and challenges in DSCM.

The review uncovers common opportunities such as enhanced supply chain capabilities, operational performance, and customer service, alongside shared challenges like technical constraints, resource limitations, and institutional resistance.

The value of the article lies in its ability to comprehensively gather and categorize diverse opportunities and challenges scattered across various studies. Moreover, the article highlights critical gaps in existing literature reviews. For instance, it illuminates deficiencies in the measurement of certain challenges, identifies contextual gaps, and underscores industrial disparities. Moreover, the article points out recent changes in what researchers are studying, especially after Covid-19. There's a noticeable move towards quantitative studies and focusing more on specific industries.

The article highlights the importance of Digital Technologies for Supply Chain enhancement in term of performance and capabilities. It also emphasizes that implementing digital technologies within Supply Chain should be approached with consideration for organizational culture and existing resources.

## Keywords

Digital supply chain management, digital supply chain, digitalization, opportunities, challenges.

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## Introduction

In 2001, the publication of the article “Defining Supply Chain Management” marked a milestone in the literature of the Supply Chain domain. Cited more than 10,000 times, it defined the Supply Chain as “*a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer*” (Rashed, 2017). However, the dynamic nature of market trends and rapid technological advancements has necessitated a re-examination of the Supply Chain concept. In other words, the advent of Industry 4.0 and digitalization has brought about a transformation in the literature, steering the focus from Supply Chain towards Digital Supply Chain (DSC).

Starting from 2015, a third generation of Supply Chain Management (SCM) is poised to emerge, characterized by its adaptation to the digitalized economy (Farahani, Meier and Wilke, 2017). Frazzon et

al. (2019) conducted a bibliometric analysis and defined DCSM as “*the integration and synchronization of the product’s entire value chain across different companies, using smart technologies (IoT, Ios and others) to build an interconnected and transparent system with real-time communication that can manage flows and optimize itself, leading to an autonomous, adaptive, intelligent, agile, and dynamic network that focuses on customers’ requirements*” (Frazzon et al., 2019, p.189).

The article examines the findings of previous studies concerning the opportunities and challenges posed by digitalization in Supply Chain Management (SCM). The primary aim is to aggregate and categorize these opportunities and challenges, shedding light on the evolving landscape of Digital Supply Chain Management (DSCM) across various industries. Therefore, an analysis of a wide range of qualitative and quantitative studies, conceptual frameworks, and state-of-the-art analyses have been conducted. The literature elaborates on how the integration of advanced digital technologies into supply chains significantly increases transparency, traceability, and security (Saberi et al., 2019). However, Chowdhury et al. (2021) demonstrates the need for more focused research on the implementation of these technologies to tackle systemic shocks, specifically COVID-19. The new scholarship has also focused on digitalization in enhancing operation, collaboration, and general effectiveness in supply chain management, including work by Li & Zhang (2023) and Srivastava (2024). Finally, Rahamneh et al., 2023, highlight some of the opportunities for digital technology in enhancing supply chain flexibility, lean manufacturing, and sustainability. However, the exact type of integration into an effective strategy remains a gap in research.

#### Research Questions

1. How have digital technologies transformed the operational and strategic aspects of SCM?
2. What are the persistent challenges in integrating digital technologies into SCM, and how can they be addressed?

#### Purpose and Objectives

- i. Evaluate the impact of digital technologies on SCM effectiveness and flexibility.
- ii. Examine the integration challenges of digital technologies in SCM and suggest potential solutions.

The findings show that, although there are some issues pertaining to technical barriers and resistance to change by institutions, digital technologies massively improve the performance of a supply chain. The wave of digital solutions following COVID-19 makes it imperative to conduct targeted research in the digital domain of SCM. The present literature review contribution to SCM literature was the full explanation of DSCM, finding the most critical areas of concern, and suggesting the direction for future research. This book is particularly useful for professionals and academicians who want to increase the resilience and sustainability of their supply chains through a digital medium. This paper contrasts traditional SCM with DSCM, focusing on the definitions, characteristics, and impacts of the technology. The paper then examines the evolution of SCM frameworks, scrutinizes the literature on digitalization's impacts, and provides a summary of key opportunities and challenges. Moreover, in the conclusion, research limitations are discussed, and a few areas for further study are suggested as a summary of the critical developments and future directions in SCM.

## 1. Overview on Digital Supply Chain

### 1.1. Definition and Features of Digital Supply Chain

The literature review lacks a singular definition for Digital Supply Chain (DSC). Nevertheless, the diverse definitions all share a common attribute, the progression of supply chain operations through the utilization of advanced digital technology (Pyun and Rha, 2021). Pyun and Rha (2021) categorized the definitions of DSC into three categories:

**Table no. 1. Categorization of DSC Definition**

<b>Category 1: Definitions based on Transformation of Business Processes</b>	A digital supply chain is characterized as a platform that can be proactively executed or one centered around the ecosystem (van den Burg et al, 2021).
	A web-based system departing from conventional practices by avoiding the amalgamation of paperwork-based and IT-based processes (Kinnet, 2015).
	A value-driven intelligent network, a digital supply chain integrates analysis and technology using innovative approaches to generate fresh profits and business value (Wu et al, 2016).

	“The development of information systems and the adoption of innovative technologies strengthening the integration and the agility of the supply chain and thus improving customer service and sustainable performance of the organization” (Fu et al., 2022).
<b>Category 2: Definitions based on Collaboration using Digital Technology</b>	Intelligent optimized-technology systems that process massive data, promote collaboration, and synchronize interactions among organizations using digital hardware and software (Büyüközkan and Göçer, 2018).
	A system that mediates partner activities globally through software, hardware, and communication networks, supporting processes like purchase, production, storage, transport, and sale of goods (Muzafar et al, 2023).
	A system designed to enhance stability, agility, and efficiency by enabling extensive information, excellent collaboration, and communication through a digital platform (Cagliano et al; 2021).
<b>Category 3: Definitions based on Advancement of operations management</b>	A system encompassing functions such as planning, sourcing, making, and delivering. This system integrates the SCOR model with big data analytics, CPS-based networks, additive manufacturing, and advanced tracking and tracing systems (Ivanov, Dolgui and Sokolov, 2019).
	A self-thinking system that continuously monitors performance. It achieves this by predicting and detecting risks through the analysis of massive data collected from various sources (Calatayud et al., 2019).
	An optimal technology supporting and synchronizing supply chain processes. The primary goal is to minimize environmental waste resulting from high-demand fluctuations and risks (Kearney, 2015).

*Source: Pyun and Rha, 2021*

Büyüközkan and Göçer (2018) have outlined eleven pivotal features that DSC strive to attain: speed; flexibility; global connectivity; real-time inventory; intelligent decision-making; transparency; cost-effectiveness; scalability; innovative integration; proactive solutions; and eco-friendly practices. Büyüközkan and Göçer (2018) provide insightful perspectives on the key features of digital supply chains, emphasizing the evolving nature of SC in the digital era. Both perspectives provide a comprehensive understanding of the evolving landscape of DSC, covering key features.

### 1.2. Digital Technologies in Supply Chain

Throughout the years, various technologies have contributed to the evolution of DSC (Attaran, 2020). Büyüközkan and Göçer (2018) have identified eleven novel technologies and analytical methods that SC managers can leverage, Robotics (R), Sensor Technology (ST), Augmented Reality (AR), Big Data (BD) Internet of Things (IoT), Cloud Computing Technology, (CCT), 3D Printing, Omni Channel, Self-Driving Vehicles, Unmanned Aerial Vehicle, Nanotechnology.

. These technological enablers have been referred to in most scientific articles tackling the DSC. Some of the articles have been focusing on enablers more than others.

## 2. Conceptualization of Supply Chain Management and Digital Supply Chain Management

The sections delve into the theoretical understanding and formulation of both traditional Supply Chain Management (SCM) and Digital Supply Chain Management (DSCM). The frameworks of SCM and DSCM diverge significantly in their conceptual approaches.

### 2.1. Proposed Frameworks of Supply Chain Management

Donlon (1996) delineates the contemporary evolution of SCM practices, encompassing elements such as supplier partnership, outsourcing, cycle time compression, continuous process flow, and information technology sharing. In Tan et al.'s (1998) study, contributions to SCM practices were made through the examination of purchasing, quality, and customer relations. Tan (2001) further explored the components of an integrated SC, emphasizing the flow of materials and information among suppliers, manufacturers, and customers, along with the implementation of product postponement and mass customization. According to Tan et al. (2002), factors influencing SCM practices include supply chain integration, characteristics, information sharing, customer service management, total quality management, geographical proximity, and JIT capability. More recently, Garay-Rondero et al. (2020) conducted a qualitative meta-analysis on the 18 selected models from the Theoretical Foundations of Supply Chain Management. They introduced a model that gained popularity within the scientific community, evidenced by numerous citations, views, and downloads. The conceptual model posits that SCM comprises four fundamental constructs (Garay-Rondero et al., 2020). Richey et al. (2022) proposed a conceptual framework of SCM based on a responsiveness view or perspective. The article has captured the attention of academics and researchers since it has been cited more than hundreds of times. The authors defined responsiveness in the context of SCM as “the

process and outcome of organizational adjustments achieved as individual organizations within a supply chain alter behaviors, norms, and/or policies to help place a supply chain and its members in a favourable position to achieve customer value under dynamic environmental conditions” (Richey et al., 2022).

## 2.2. Proposed Frameworks of Digital Supply Chain Management

Concerning conceptual frameworks, several research have proposed models regards DSCM each bring a unique focus to the evolving landscape. Farahani, Meier and Wilke (2017) transitioned from Porter's value chain model to the realm of DSCM to offer a visual representation and an introduction to its various dimensions: digital customer, digital logistics and inventory, digital production, and digital supplier. Alongside these, there are two secondary dimensions: digital IT and technology, and digital performance measurement. Büyüközkan and Göçer (2018) performed a comprehensive literature review, culminating in the development of a framework decomposing DSC into three essential components: Digitalization, SCM, and Technology Implementation. Each component has been decomposed into interconnected different areas. Queiroz et al. (2021) introduced the concept of Digital Supply Chain Competence (DSCC). It encapsulates a set of capabilities essential for organizations to cultivate, sustain, enhance, and innovate, thereby elevating their competitiveness in the digital era. Mohsen (2023) developed a conceptual model for achieving long-term DSC transformation. The model recognizes that not all organizations succeed in implementing digital supply chain projects, emphasizing the need for careful planning when streamlining supply chain management processes. Rather than solely focusing on technology, the model stresses the importance of a proactive approach and highlights that technology alone cannot be the solution to all challenges. Together, these frameworks provide a comprehensive understanding of DSCM, covering dimensions, integration, capabilities, and long-term strategic considerations in the digital supply chain landscape. However, it is noteworthy that the field of DSCM appears to be in its early stages within the literature review, and there is a lack of consensus among researchers.

## 3. Methodology: Opportunities and Challenges of Digitalisation on Supply Chain Management and Supply Chains

This is an attempt to review and synthesize existing literature concerning the opportunities and challenges of digital technologies in SCM. Therefore, this analysis will identify the view of where, exactly, DSCM, and, in particular, DSCM after COVID-19, has reached and will direct further scholarly inquiry. This study is adopting a systematic literature review methodology in order to substantiate this goal, which is particularly suited to ensuring the most complete coverage of the field. Consequently, this methodological choice will be crucial for managing the vast amount of information from the research process, ensuring reproducibility and transparency in the selection of articles for review, and mitigating bias by using predetermined criteria for article inclusion and analysis. Systematic literature reviews are the backbone of SCM, allowing the arrangement and synthesis of voluminous and quickly growing information in the field in a structured and rigorous manner. The use of a strict set of criteria in the inclusion of articles reduces bias, enhances transparency, and ensures objectivity towards the study at hand, thereby satisfying the need for a rigorous and comprehensive literature search, among other things (Seuring & Gold, 2012; Gligor & Holcomb, 2012; Durach et al., 2017). This helps to identify knowledge gaps that are relevant for further development of the field of SCM. This fills in the gaps in the fragmented SCM knowledge, guiding future research towards a more holistic understanding of SCM issues and practices (Queiroz et al., 2019; Kakhki & Gargeya, 2019). Of great importance in finding scientific studies for the purposes of this review are databases such as Web of Science, Scopus, Google Scholar, and JSTOR. We chose these databases because they provide excellent coverage of peer-reviewed journals in the business and technology fields. To ensure that the articles retrieved about technological implementations and theoretical advancements in SCM are relevant and broad enough, the research used the following keywords: "Digital Supply Chain Management," "Digital Transformation in SCM," "SCM Digital Technologies," "Digitalization Challenges in Supply Chain," and "Supply Chain Operational Performance." The review comprised a total of 240 articles published post-2018, sourced for their relevance to the research questions and for adding to the contributions of the field under study.

Categorizing the data collected from the reviewed papers led to the development of themes of opportunities and challenges. Opportunities for improved operational performance and supply chain agility would enable better customer satisfaction and be highly reliant on advanced digital technologies such as IoT, AI, and big data analytics. So, problems would come from technical and technological limits, a lack of resources, and institutional and technical resistance to change. This shows that strategic management and a shift in the way organizations work are needed for digital transformation. This review emphasizes that the SCM sphere

can effectively implement digital technologies, but it requires a strategic approach that takes into account the available organizational culture and resources. It identifies a significant shift in research focus post-COVID-19 towards more specific, industry-focused studies addressing unique challenges and opportunities. The limitations of this study are the exclusion of research conducted prior to 2018 and the focus on articles written in English, which may miss important contributions written in another language or from prior periods. This study identifies emerging themes, specifically sustainability and lean management within DSCM, and explicitly conducts a propositional study on these dimensions by recognizing them as multi-dimensional issues.

### 3.1. Reviews and State-of-the-art

Büyükközkcan and Göçer (2018) reviewed the stated of art to provide a list of opportunities and challenges of implementing digitalisation in SCM. The list of challenges and opportunities in implementing DSC practices is comprehensive. Rajab (2018) stated that the integration of new technologies into global procurement practices holds the promise of enhancing competitiveness, transparency, and risk reduction. Despite these advancements, the adoption of new technologies hindered by resistance to change, a reluctance to shift from existing systems, and a general lack of technological awareness. Adding, Ivanov, Dolgui and Sokolov (2019) investigated the impact of digital enablers on the ripple effect. They suggested that digital enablers enhance the SC visibility and flexibility and reduce its structural complexity. However, they also discussed that digital technologies imply higher exposure to external risks. Stank et al. (2019) grouped opportunities that digitalization brings to SCM in three groups: “Seeing”; “Thinking”; and “Acting”. First, “Seeing” refers to the enhancement of the quality of demand information. Second, “Thinking” refers to the development of analytical capacities and capabilities. Third, “Acting” denotes operational flexibility and reduced cycle time.

In their 2021 study, Amentae and Gebresenbet explored the impacts of digitalization on Agro-Food SCM by conducting an integrative literature review of 76 relevant journal articles. The key advantages included traceability, sustainability, resilience to crises like the Covid-19 pandemic, and the reduction of food waste. Challenges were identified, encompassing issues related to infrastructure and cost, knowledge and skill, and the characteristics of technologies. Adding, Rad et al. (2022) conducted an analysis of 221 articles covering the period from 2005 to 2021, examining the benefits, challenges, and critical success factors of implementing 11 core digital enablers among different industries. Rather than offering broad, generalized conclusions, their approach centered on providing insights into the advantages, obstacles, and crucial success factors specific to each core industry, particularly in how they relate to supply chain management performance.

### 3.2. Qualitative Studies

In a study conducted by Kache and Seuring in 2017, the Delphi Methodology was employed, drawing insights from 20 international experts. The research identified opportunities at the corporate and SC levels. The authors then grouped the opportunities in two main constructs: Supply Chain Visibility and Transparency; and Operations efficiency and Maintenance. The researchers also identified a set of challenges and categorized them into two main groups: IT capabilities and infrastructure, and Information and cyber security concerns (Kache and Seuring, 2017). In 2021, De Vass et al. conducted a qualitative study through semi-structured interviews with Australian managers to examine the potential operation benefits of the IoT in the retail industry. By employing the organizational capability theory, the researchers argued that the deployment and implementation of the IoT increase the SC integration capabilities such as the visibility, the automation, the intelligence, and the information sharing and collaboration. In the same context of retail industry, in 2024, Ishfaq et al. provided a conceptual framework of the impact of digitalization on retail supply chain, on the strategic and operational level. The authors started the study by documentation research to identify retailers in the USA that have explicitly announced their implementation to a digitization strategy. Then, they conducted semi-structured interviews with 15 senior supply chain executives who had direct responsibility to develop a digital supply chain strategy. The results were grouped into three main propositions: the implementation of digital technologies requires an internal collaboration and trust; the implementation of digital technologies enhances customer centricity, through the improvement of speed and agility; and the implementation of digital technologies enhances operational performance of the SC through effective decision making.

Moreover, in 2021, Annosi et al. conducted a qualitative study by mobilizing 18 in depth interviews with managers working in multinational and local organizations in Greece to understand the barriers of digitalization on supply chain in food industry. They identified barriers are lack of organizational capabilities (physical and financial resources), lack of technological knowledge, lack of human competencies, resistance to change, perception of risk, and lack of trust (Annosi et al., 2021).

### 3.3. Quantitative Studies

Bienhaus and Haddud (2018) aimed to investigate the impact of digitization on procurement and its role within SCM, recognizing the diverse approaches organizations adopt in response to the industry 4.0. Employing a quantitative approach, data were collected from 414 participants in high developed countries in Europe. The findings underscore the benefits of digitizing procurement, including support for daily tasks, facilitation of complex decision-making, a shift toward strategic decision focus, and contribution to organizational efficiency and profitability. Additionally, identified barriers to digitization include existing procedural, process, capacity, and capability challenges. Note that the quantitative study employed in this research can be characterized more specifically as a descriptive study rather than a correlational one.

In 2021, Asamoah et al. examined the impact of the Inter Organizational System (IOS) usage on an organization's SCM capabilities and SC performance. Analysing data from 193 respondents across various manufacturers and distributors of fast-moving consumer goods, the study reveals the dual effect of IOS use in improving operational supply chain performance, SCM capabilities, and highlight the mediating role of SCM capabilities. Ye et al. (2022) examined if Chinese companies that have higher levels of Digital Technology have a higher level of SC performance. The study concluded that the breadth and depth of digital technology deployment increases the SC visibility and agility, which impacted positively the SC performance as an overall.

Alvarenga, Oliveira and Oliveira (2023) investigated the mediating role of SC memory in the relationship between the use of digital technologies and the levels of SC resilience and robustness. Drawing responses from 257 SC managers through a questionnaire, the study indicates that SC memory becomes less efficient in maintaining operational performance during extraordinary disruptive events like Covid-19. Adding, in 2023, Cui et al. investigated the impact of digital technologies on firm resilience and the mediating role of the SC integration among Chinese manufacturing located in northern, southern eastern and western regions, in a post covid environment. The results revealed that digital technologies positively impact the firm capabilities (responsiveness, agility, warning capability, flexibility, and visibility) and the firm resilience.

## 4. Findings

### 4.1. Common Identified Opportunities

The extensive literature review reveals that the prevailing opportunities in the field can be effectively categorized into three overarching concepts: Supply Chain (SC) capabilities, and Supply Chain (SC) operational performance and Customer Service Performance.

- **Supply Chain Capabilities:** “Supply chain capabilities refer to the ability of an organization to identify, utilize, and assimilate both internal and external resources/information to facilitate the entire supply chain activities” (Wu et al, 2006). Wu et al. (2006) introduced a conceptualization of these capabilities: SC Information Exchange (including Decision-making improvement and trust), SC Integration, SC Coordination (collaboration among different SC Stakeholders), and SC Responsiveness (Flexibility, Adaptability, Improvisation, Agility, and Resilience).

- **Supply Chain Operational Performance:** The operational performance of a supply chain can be scientifically defined as the holistic measure of its efficiency, cost management, and error mitigation strategies (Wu et al, 2006).

- **Customer Service Performance:** It is the systematic enhancement of these factors that leads to a quantifiably improved customer satisfaction level within the framework of customer service performance (Annosi et al., 2021). This includes quantifiable factors such as the traceability of production processes and the temporal aspects of delivery and transportation.

### 4.2. Common Identified Challenges

Challenges involve macro-environmental and institutional challenges, as well as internal collaboration and trust issues during the digitalization process. The impact of disruptive events, like the Covid-19 pandemic, is recognized as a shared challenge affecting supply chain memory and operational performance across different industries. Thereby, challenges could be categorized as follows:

- **Technical and Technological Challenges:** The implementation of digital technologies demands a robust technical infrastructure and compatibility with existing systems. This integration process proves intricate, with issues ranging from system interoperability to concerns about data security and privacy.

- **Resource Constraints:** Allocating the requisite financial, human, and temporal resources for digital technology implementation in SCM proves to be a demanding task.

- **Institutional and Organizational Challenges:** Resistance to change, bureaucratic obstacles, and the necessity for a cultural shift within organizations can impede the seamless implementation of digital solutions.

### Conclusion: Implications and Limitations

The studies reviewed in this paper highlight both the common challenges and opportunities related to the implementation of digital technologies within SCM. The article highlights the importance of Digital Technologies for Supply Chain enhancement in term of performance and capabilities. It also emphasises that implementing digital technologies within Supply Chain should be approached with consideration for organizational culture and existing resources.

Moreover, the article points out recent changes in what researchers are studying, especially after Covid-19. There's a noticeable move towards quantitative studies and focusing more on specific industries. However, it is evident that there exist notable gaps in the existing body of research. These gaps manifest primarily in two forms: conceptual disparities in the study of related concepts and contextual limitations, particularly in the underrepresentation of developing countries.

It is important to note the limitations of the paper is related that it excludes research conducted prior to 2018. Additionally, while the literature in the DSCM present prominent themes such as sustainability and lean management, the paper does not delve into the intricacies of these themes. This strategic omission does not diminish the significance of sustainability or lean management; rather, it acknowledges their complexity and highlights the need for dedicated and profound exploration.

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