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Supply chain management in the digital era: Innovations, challenges, and future directions

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ABSTRACT

This study looks at how supply chain management (SCM) has changed in the digital age by examining important breakthroughs, organizational difficulties, and potential future development paths. Results show that supply chain transparency, coordination, and operational efficiency are greatly improved by the use of Smart Supply Chain Management (SSCM), which is backed by cutting-edge technologies like IoT, big data analytics, blockchain, and cloud computing. The influence of SSCM on responsiveness and transparency is reinforced by supply chain coordination and mapping, which are essential mediators. Organizations still have to deal with a number of significant issues, such as system integration, data security threats, technological readiness, and limitations in digital competences. These obstacles emphasize the necessity of capacity building and all-encompassing digital transformation methods. All things considered, digitalization strengthens organizational competitiveness and resilience while also enhancing supply chain performance and real-time visibility. Future research directions stressing optimal digital integration, dynamic capability development, and the investigation of autonomous and sustainable supply chain ecosystems are highlighted in the study's conclusion.

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1. INTRODUCTION

Advances in digital technology have led to significant changes in a number of corporate procedures. SCM (Supply Chain Management) falls into this category (Chen et al., 2024). Digital transformation is enabled by technologies such as the Internet of Things (IoT), artificial intelligence (AI), big data analytics, blockchain, and cloud computing, which allow businesses to improve productivity, information accuracy, and real-time decision-making (Samuels, 2025). These developments enable the creation of more connected, responsive, and adaptive supply chains (Sukati et al., 2012).

Machine learning and AI automate procurement, optimize logistics, and provide risk insights. Ethical procurement and traceability are made possible by blockchain(Liangrokapart & Prakongwittaya, 2025). IoT devices track inventory and shipments comprehensively, and digital twins simulate and improve production workflows. Sustainability goals, agility, better customer service, and cost reduction are supported by these advances (Shan & Liu, 2025). Conversely, digitization raises many complex issues. Implementing the technology requires significant

investment, human resource readiness, complex system integration, and data security risks (Huang & Cheng, 2024). In addition, some organizations are not digitally ready, so delays in implementing the technology can disrupt overall supply chain performance (Alkaraan et al., 2025).

To ensure that goods, information, and services can move efficiently from suppliers to end customers, supply chain management (SCM) is a strategic function in contemporary organizations (Schwieterman & Welter, 2023). The development of digital technology over the past twenty years has significantly changed the SCM landscape. It has brought various innovations as well as new challenges. The increasing need for transparency throughout the supply chain network, rapid response to the market, and system integration are signs of this transformation (An et al., 2025).

However, digital development presents many problems that cannot be ignored. Interoperability between digital platforms, high technology investment, limited digital workforce capabilities, and cybersecurity risks are the biggest problems (Junejo et al., 2025). Increasing uncertainty and volatility in the global supply chain pose major challenges in managing risk and improving supply chain resilience. This uncertainty makes it difficult for companies to ensure smooth operations and reduce vulnerability to disruptions such as pandemics, fluctuations in demand, and other disruptions (Liu et al., 2024).

This study is significant from a social perspective since supply chain digitization directly affects economic resilience, supply stability, and the effectiveness of the distribution of necessities, particularly in the wake of severe global disruptions like pandemics and logistical crises. Minority-owned enterprises (MSMEs) can benefit from improved inclusion as a result of digitalization, but less equipped sectors run the danger of experiencing a digital divide. In order to give a thorough knowledge and facilitate more flexible and sustainable decision-making in contemporary supply chain management, this study is essential.

Therefore, the main focus is on the importance of improving transparency in the supply chain through effective integration and information sharing, which can help companies respond to risks more proactively and strengthen the overall resilience of the supply chain (Han & Um, 2024). Adapting to these conditions is an urgent necessity for companies to maintain operational stability and sustainability amid changing market dynamics (Liu et al., 2024). By examining how digital technologies such as artificial intelligence (AI), blockchain, the Internet of Things (IoT), big data analytics, and cloud computing are transforming conventional supply chain methods, this paper aims to contribute to the ongoing discussion (Bensberg & Klein, 2024). The need for efficiency, transparency, and resilience has increased as supply chains become more complex and interconnected (Deen et al., 2025).

The literature on supply chain management digitization still has a number of research gaps that have not been sufficiently addressed, according to a comprehensive evaluation of several papers. First, most research looks at digital technologies like blockchain, artificial intelligence, and the Internet of Things (IoT) in isolation without considering how these technologies may be integrated to form an intelligent and cooperative supply chain ecosystem. Second, while the long-term effects of digitization on supply chain architecture, capacities, and business models are rarely thoroughly examined, study findings often concentrate on the short-term effects of digitization. Third, the context of developed nations continues to dominate the literature, which means that the difficulties of implementing digitization in developing nations—such as organizational preparedness, infrastructure constraints, and obstacles to technology adoption—have not gotten enough attention.

Furthermore, a thorough conceptual framework that can map the link between digital innovations and their influence on supply chain performance in an integrated way has not been established by prior research. Prior studies have highlighted the advantages of digitization over its drawbacks, including cybersecurity dangers, data vulnerabilities, and ethical issues with AI-based systems. However, despite the fact that sustainability concerns are becoming a worldwide priority, there is still little empirical evidence linking digital innovation to supply chain sustainability objectives. The absence of research on the dynamics of multi-stakeholder cooperation in the digital

supply chain ecosystem, including modifications to platform-based coordination and governance patterns, has also been noted as a deficit.

This study aims to provide valuable insights into the advantages and disadvantages of digital SCM. It also seeks to offer practical advice for businesses wishing to utilize this technology. Additionally, the objective of this research is to fill gaps in the current literature by examining the future direction of digital supply chains and the strategies companies must employ to successfully navigate digital transformation. By conducting this research, the authors hope to contribute to academic knowledge and practical applications, as well as enhance understanding of how digital innovation can drive sustainable supply chain management.

2. RESEARCH METHOD

This study uses Systematic Literature Review (SLR) to find, evaluate, and interpret research findings related to research questions, topic areas, or phenomena of interest (McBride, 2016). The research began by searching for articles relevant to the research subject. The method of reviewing a particular issue involves identifying, evaluating, and selecting specific issues, as well as asking questions that are clearly answered based on predetermined criteria. Systematic reviews follow previous high-quality research that is relevant to the research questions.

This study focuses on how digital innovation can drive supply chain management. The population in this study also focuses on research results published in journals focused on supply chain management using the Springer and Emerald web media, limiting articles from 2019-2025. The search results yielded 100 articles related to SCM (supply chain management) in the Springer and Emerald databases, and 18 articles related to the topic selected in this study were selected.

A detailed analysis was conducted on the 18 articles, narrowing them down to 8 articles that were most relevant to the material to be presented. These 8 articles were found to be particularly relevant to the theme to be researched, which will be presented in the discussion and conclusion sections. The following diagram illustrates the research method:

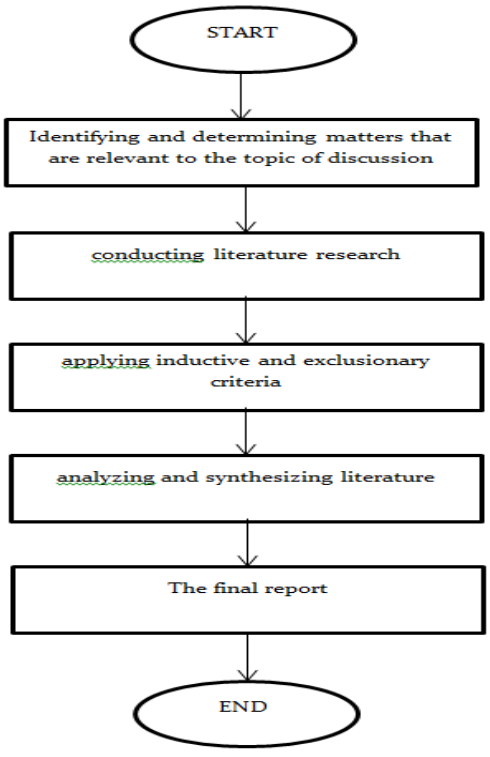

Figure 1. Flowchart

3. RESULTS AND DISCUSSIONS

Research findings indicate that digital transformation in supply chain management is driven by several key technologies. The results show that businesses are not only focused on efficiency; they are also focused on integration, visibility, and predictive capabilities. Therefore, it is crucial for researchers and business practitioners to understand SCM innovations and challenges in the digital age. Scientific studies on SCM digitalization trends can help businesses develop better strategies to adapt to global dynamics. A holistic approach is needed to balance the opportunities of technological innovation with the risks and difficulties of implementation. A comprehensive analysis helps businesses reap the benefits of digitalization while avoiding the challenges of supply chain transformation (Shan & Liu, 2025).

Research Gap

Table 1. Research gap

Research and Year	Article Title	Research Findings
(An et al., 2025)	The impact of smart supply chain management on supply chain transparency: a dynamic resource-based view	Three key findings emerged from this study, which examined the hypothetical model using data from 243 fashion companies in China. First, intelligent supply chain management significantly improves supply chain transparency. Second, supply chain coordination and mapping play a mediating role in the relationship between intelligent supply chain management and supply chain transparency, whereby companies acquire specific capabilities to improve transparency. This study enhances our understanding of how transparency and intelligent supply chains correlate with each other. Furthermore, it provides a theoretical basis and recommendations for companies implementing risk management.
(Deen et al., 2025)	Revolutionizing Supply Chain Management in the Digital Era	This article discusses the revolution in supply chain management in the digital age. Research shows that digital technologies such as AI, blockchain, the Internet of Things, big data analytics, and cloud computing have improved efficiency, visibility, risk management, and supply chain decision-making around the world. However, there are issues such as system integration problems, cybersecurity risks, and high implementation costs. Nevertheless, companies that strategically adopt digital transformation can gain a competitive advantage and improve their business. Autonomous supply chains, drone-based logistics, AI-based automation, and sustainable SCM solutions are trends that will continue to shape the industry.
(Kumar et al., 2024)	Assessing risk and sustainability factors in spice supply chain management	The objective of this study is to identify the main hazards that cause SCM to malfunction in the spice supply chain (SSC). The results show that financial, ergonomic, and operational and management risks are significant causal risks, which raise practical concerns throughout the SCM. In addition, important sub-risks that attract the attention of practitioners are price fluctuations, diseases and pests, human contamination, spice counterfeiting, and loss of food quantity and quality. According to this study, policymakers and practitioners should create regulations, improve farmers' knowledge of the best ways to control pests, and create a sustainable fertilizer distribution system.
(Tian & Cui, 2025)	Supply chain resilience and digital transformation: perspectives from a supply chain network	The results of the study show that digitization is an important component that determines supply chain resilience. The pilot program for supply chain digitization in China significantly and sustainably improved business resilience within the supply chain network. The research results are more pronounced in companies with geographically dispersed supply chains, lower supply chain hierarchies, and higher supply chain transparency due to increased corporate data processing capacity, recovery capabilities, and inventory turnover efficiency. Overall, digitization strengthens the relationship between operational and informational aspects and enables organizations to shift from passive disruption management to proactive resilience development in the face of uncertainty.
(Jerbi & Benjeddou, 2025)	Supply Chain Risk Management with Discrete-event Simulation: Insights into Methodological	With the aim of improving understanding and practice in this field, this article analyzes the use of discrete-event simulation (DES) in supply chain risk management (SCRM). This review covers three stages: formulating research questions, systematically selecting relevant studies, and conducting detailed

Research and Year	Article Title	Research Findings
	Limitations	analysis. To better anticipate and manage risks in a dynamic supply chain landscape, improved modeling accuracy and rigorous validation processes are needed. Future research can refine DES in SCRM and support theoretical insights and practical applications of supply chain management.
(Gu et al., 2025)	Supply chain digitalization and transparency: the privacy calculus perspective	This study shows that supply chain digitization (SCD) has a significant correlation with supply chain transparency (SCT), but this correlation can be reduced by data security orientation and supplier concentration. Companies with high data security orientation and high supplier concentration tend to reduce the negative impact of supply chain digitization on supply chain transparency.
(Alsolbi et al., 2023)	Big data optimisation and management in supply chain management: a systematic literature review	This study shows that the use of big data in supply chain management improves operational performance in two main dimensions: data optimization and data management. In the optimization dimension, big data has been shown to improve forecasting accuracy, logistics efficiency, decision quality, and cost control. In the data management aspect, big data has been shown to improve logistics efficiency, forecasting accuracy, and mathematical programming. The research shows that technologies such as Hadoop, MapReduce, Cassandra, and cloud-based data architecture are essential for processing large amounts of heterogeneous and unstructured data. Overall, the research shows that the use of unstructured big data and the lack of empirical studies hinder supply chain integration and performance.

Based on the results of the eight journals above, it can be concluded that this study found that supply chain transparency increased significantly when Smart Supply Chain Management (SSCM) was implemented. Supply chain mapping and coordination serve as important mediators in the relationship between SSCM and supply chain transparency; organizations gain the specific ability to increase transparency through acceptance and learning from external sources. In addition, digital supply chain strategies support basic and "front-end" technologies and play an important role in the process of continuous dynamic adaptation. SSCM, supply chain coordination, and digital strategies are essential for improving supply chain transparency and effectiveness, according to this study.

Challenges Faced by Organizations in Implementing SCM Digitalization

Organizations face many challenges when implementing supply chain management (SCM) digitization, including changes in technology, habits, human resources, and data security issues (Li et al., 2025). Many organizations, especially small and medium-sized ones, still use traditional systems, which are difficult to integrate with new digital technologies. One of the main obstacles to optimizing digital SCM is a lack of technological infrastructure (Hariyadi et al., 2025). The transition from manual to automated systems, which enable better data analytics and decision-making, is a clear example of this problem. This is in line with research conducted by (Alsolbi et al., 2023) where the results of the study say that with technological advances and tools such as Hadoop, MapReduce, Cassandra, and cloud-based data architecture, it is very important to process large amounts of data, which will pose challenges and infrastructure issues for SCM (Yoga et al., 2022).

Organizations must maintain the security and privacy of their data to prevent legal violations or leaks of important data. Digital system data management must comply with strict data protection regulations. Data fragmentation often occurs due to a lack of integration between information systems such as ERP, which can hinder real-time decision making (Yin et al., 2025). Furthermore, even after implementing technology, many companies are still unable to maximize the use of all digital technology features, causing them to fail to achieve optimal efficiency levels (Kumar et al., 2024).

Overall, the issues that arise when implementing SCM digitization include infrastructure and technology readiness, changes in organizational culture and human resources, investment costs, data security, and optimal integration and utilization of technology. For SCM digitization to be successful and provide maximum benefits, organizations must manage these elements with a mature digital transformation strategy.

The Impact of Digitalization on Supply Chain Performance

With technologies such as the Internet of Things (IoT) and big data analytics, digitization enables real-time monitoring of every supply chain process, which improves operational efficiency, reduces the risk of stock shortages or surpluses, and speeds up product delivery times to customers. Studies show that the implementation of digitization improves operational efficiency and delivery speed (Deen et al., 2025).

Digitization enables businesses to have complete visibility from upstream to downstream in the supply chain. The use of blockchain technology and IoT sensors increases data transparency, which facilitates the tracking of goods and risk management(Kohli & Malik, 2025). It also helps reduce disruptions in the supply chain and encourages faster and more accurate decision making. Digitalization helps stakeholders collaborate better through digital platforms that enable real-time communication and coordination (Junejo et al., 2025). A more efficient supply chain improves a company's competitiveness as it can adapt to changes in market demand and operational disruptions (An et al., 2025).

In addition, digital transformation in the supply chain improves overall company performance through better integration between functions, cost reduction, and better customer service. Furthermore, digitization helps the supply chain survive in crisis situations by increasing cost efficiency and improving communication responsiveness (Liangrokapart & Prakongwittaya, 2025). Supply chain digitization improves operational efficiency, timeliness, transparency, collaboration, and responsiveness. Ultimately, this enhances supply chain performance and the company's competitive advantage

4. CONCLUSION

This study found that digitization and the implementation of Smart Supply Chain Management (SSCM) improve supply chain transparency, effectiveness, and performance. This is achieved through improved supply chain mapping and coordination, which serves as a mediation mechanism to connect SSCM with overall performance. By supporting the integration of core and front-end technologies, digital strategies improve an organization's ability to adapt dynamically. This enables companies to respond to environmental changes more quickly and accurately.

This research points up a number of methodological flaws that restrict how broadly the results may be applied. Relevant literature is overlooked because the articles' coverage is restricted to particular databases and publication periods. Stricter quality evaluation processes can reduce interpretation bias caused by methodological variations and situational variability. By including local literature, the emphasis on English-language publications can enhance global representation, especially from emerging nations. Furthermore, statistical generalization of inter-variable connections is prohibited by the descriptive character of SLR in the absence of quantitative analysis. The results' external validity may be strengthened by additional research using a meta-analytic methodology.

Future supply chain research might go in a number of different areas. First, research on how to build a smart supply chain ecosystem by integrating technologies like blockchain, IoT, AI, and digital twins. Second, long-term empirical studies to assess how organizational structure and performance are affected by digital transformation. Third, research in emerging nations to comprehend adoption hurdles and disparities in innovation capacities. Fourth, a crucial agenda item is investigating cybersecurity governance and digital hazards in supply chains. Green supply chains can also benefit from studies on sustainability and digitalization. Finally, to comprehend the dynamics of coordination in contemporary supply chain ecosystems, examination of multi-stakeholder cooperation models via digital platforms is required.

Despite the many benefits of digitization, organizations still face numerous challenges, particularly related to technological readiness, system integration, data security, cultural change, and human resource skills. These challenges highlight the importance of planning a digital transformation strategy, investing in adequate infrastructure, and improving internal digital capabilities. Overall, SCM digitalization improves efficiency, visibility, and collaboration in the

supply chain while enhancing organizational competitiveness and resilience in the face of market dynamics and operational risks. Therefore, the success of digitalization depends heavily on the collaboration between technology, strategy, and organizational readiness to adapt continuously.

The Theoretical Implications

The study's findings have several important theoretical ramifications for the advancement of supply chain and management expertise. The discovery that supply chain management can be made more effective and efficient by integrating digital technologies like blockchain, big data analytics, artificial intelligence (AI), and the Internet of Things (IoT) supports the theoretical understanding of digitalization's role as a strategic enabler in Smart Supply Chain Management (SSCM). This study also demonstrates that when digital technology is fully integrated, supply chain visibility and transparency rise significantly.

Furthermore, the discovery that supply chain coordination and mapping act as significant intermediaries between digital technology and transparency adds fresh perspectives to the body of knowledge on supply chain visibility and the dynamics of inter-organizational cooperation. By highlighting digital capabilities as a crucial component of organizational resilience in the face of environmental unpredictability, research on the role of technology in enhancing supply chain agility and resilience expands the theoretical framework of dynamic capabilities. Additionally, by emphasizing obstacles like data security, implementation costs, human resource preparedness, and technological competence gaps as crucial elements in the effective adoption of digitalization, this study contributes to the theoretical conversation on digital transformation.

These findings strengthen theoretical understanding of the role of digitization in creating adaptive, cooperative, and sustainable supply chains while providing opportunities for the development of new conceptual models that integrate elements of technology, coordination, transparency, and sustainability in the context of supply chain management in the digital age.

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