

SMARTER SUPPLY CHAINS: HOW TECHNOLOGY IS TRANSFORMING BUSINESS LOGISTICS

Khadija MOUFTI, Vytautas Magnus University Agriculture Academy, Faculty of Bioeconomy Development, email: khadija.moufti@vdu.lt

Abstract

Smart logistics is increasingly changing the way companies manage their supply chains in today's digital business environment. Traditional logistics systems often face a number of challenges, such as high operational costs, limited visibility across supply chain networks, slow information flows, and weak coordination between supply chain partners. These limitations can reduce efficiency and make it difficult for companies to respond quickly to market changes.

In recent years, digital technologies such as artificial intelligence (AI), blockchain, automation, and the Internet of Things (IoT) have started to play a key role in improving logistics operations. These technologies allow companies to monitor shipments in real time, analyze large amounts of data to support better decision-making, and increase transparency across logistics networks. As a result, many organizations are moving toward smart logistics systems that are more efficient, flexible, and responsive.

This study examines how smart technologies are transforming modern logistics systems and helping companies improve supply chain efficiency. The analysis is based on recent scientific research on digital transformation and logistics innovation, which highlights the growing importance of emerging technologies in building more resilient and intelligent supply chains (Helo & Thai, 2024; Jing, 2024).

Keywords: smart logistics; digital supply chains; Internet of Things (IoT); artificial intelligence; blockchain; logistics automation.

Introduction

The rapid development of digital technologies has significantly transformed modern logistics systems and supply chain operations. In today's global business environment, companies face increasing pressure to improve efficiency, reduce operational costs, and enhance coordination across supply chain networks. As supply chains become more complex and interconnected, organizations must adopt innovative solutions to improve logistics performance and remain competitive.

Traditional logistics systems often struggle with limited visibility, fragmented information flows, and slow decision-making processes. These challenges can lead to delays, higher operational costs, and reduced flexibility in responding to market changes. Therefore, companies are increasingly integrating advanced digital technologies into their logistics operations (Winkelhaus & Grosse, 2020).

Technologies such as the Internet of Things (IoT), artificial intelligence (AI), blockchain, and automation enable real-time tracking of shipments, data-driven decision-making, and improved transparency across supply chain networks. The integration of these technologies supports better coordination between supply chain partners and enhances overall logistics efficiency (Helo & Thai, 2024; Jing, 2024).

As a result, the concept of **smart supply chains** has emerged as an important approach for improving logistics performance and developing more efficient and resilient supply chain systems.

Research aim: to identify the main trends and effects of digital technologies on the transformation and efficiency of modern supply chains and logistics systems.

The following objectives have been set to achieve the aim:

1. To assess the interaction between digital technologies (such as IoT, artificial intelligence, blockchain, and automation) and logistics operations in modern supply chains
2. To assess the effect of smart technologies on supply chain efficiency, transparency, and operational performance
3. To identify the main trends and challenges associated with the implementation of digital technologies in logistics and supply chain management

Research object and methods

This study uses a qualitative research approach to examine how digital technologies are changing logistics operations and supply chain management. The research is based on the analysis of existing scientific studies and reports related to smart logistics and digital supply chains.

The study reviews different sources in order to understand the role of technologies such as the Internet of Things (IoT), artificial intelligence (AI), blockchain, and automation in improving logistics performance. These technologies are

analyzed to identify their main benefits and their influence on supply chain efficiency, transparency, and coordination between supply chain partners.

By analyzing these sources, the research provides insights into how modern technologies contribute to the development of smarter and more efficient supply chains.

Research results and discussion

The analysis of recent scientific research and technological developments demonstrates that digital technologies are playing an increasingly important role in transforming modern logistics systems and supply chain management practices (Dolgui & Ivanov, 2023; Helo & Thai, 2024). In today's globalized economy, companies operate in highly competitive markets where customer expectations regarding delivery speed, service quality, and product availability are continuously increasing. At the same time, supply chains are becoming more complex due to globalization, the growth of e-commerce, and the increasing interdependence between suppliers, manufacturers, distributors, and retailers. In such an environment, traditional logistics systems often struggle to respond quickly and efficiently to dynamic market conditions. Consequently, many organizations are investing in digital technologies to improve logistics operations, enhance supply chain visibility, and create more agile and responsive supply chain networks capable of adapting to rapidly changing business environments (Helo & Thai, 2024).

One of the most influential technological developments contributing to this transformation is the Internet of Things (IoT). IoT technologies rely on networks of interconnected sensors, smart devices, and communication platforms that continuously collect and transmit real-time information related to logistics processes. Through the use of IoT-enabled tracking devices and sensors, companies are able to monitor the exact location, status, and environmental conditions of goods during transportation and storage. For instance, sensors can detect temperature variations, humidity levels, or potential damage to sensitive products during transit. This capability is particularly important in industries such as pharmaceuticals, food logistics, and high-value electronics, where maintaining product quality throughout the transportation process is critical. Real-time monitoring significantly increases supply chain transparency and allows organizations to quickly identify and address potential disruptions, such as transportation delays or inventory shortages. Furthermore, the large volume of operational data generated by IoT devices enables companies to perform advanced data analysis in order to identify inefficiencies and improve logistics performance. As a result, IoT technologies contribute significantly to improving operational control, risk management, and decision-making processes within modern supply chains (Jing, Fan, 2024).

Another major technological innovation influencing modern logistics systems is artificial intelligence (AI). AI technologies enable organizations to process and analyze large volumes of logistics data generated across different stages of the supply chain. Through advanced algorithms, machine learning models, and predictive analytics tools, AI systems can identify patterns in data and generate valuable insights that support strategic and operational decision-making (Dubey et al., 2020; Kache & Seuring, 2017). For example, AI technologies are widely applied in demand forecasting, where predictive models analyze historical sales data, market trends, and seasonal variations in order to estimate future demand more accurately. Accurate demand forecasting allows companies to optimize inventory levels, reduce stock shortages, and minimize unnecessary inventory holding costs. In addition, AI-based route optimization systems help logistics providers determine the most efficient transportation routes, taking into account factors such as traffic conditions, fuel consumption, and delivery schedules. These intelligent systems help reduce transportation costs, shorten delivery times, and improve the overall efficiency of logistics operations. Moreover, AI-powered decision support systems assist logistics managers in evaluating different operational scenarios and selecting the most efficient logistics strategies. As a result, artificial intelligence significantly enhances supply chain agility and supports the development of data-driven logistics management practices (Dubey et al., 2020).

In addition to IoT and artificial intelligence, blockchain technology has emerged as a powerful tool for improving transparency, traceability, and security in supply chain networks. Blockchain systems operate through decentralized digital ledgers that record transactions and logistics activities in a secure and immutable manner. Every transaction recorded in a blockchain network is verified and stored across multiple nodes, which makes it extremely difficult to alter or manipulate the stored information. This feature makes blockchain particularly valuable in supply chain environments where multiple actors interact and exchange information across different organizational boundaries. By providing a shared and secure database of transactions, blockchain technology improves trust and collaboration between supply chain partners. Companies can use blockchain systems to track the origin of products, verify the authenticity of shipments, and ensure compliance with regulatory requirements. In addition, blockchain-based systems reduce administrative costs by eliminating the need for intermediaries and simplifying documentation processes in logistics transactions. As a result, blockchain technologies contribute to improving both transparency and efficiency in modern supply chain networks (Queiroz et al., 2021).

Another important dimension of smart logistics systems is the growing use of automation and robotics in logistics operations. Automation technologies have become increasingly common in warehouse management, order fulfillment processes, and inventory handling activities. Automated storage and retrieval systems (AS/RS), robotic picking technologies, and autonomous mobile robots (AMRs) allow logistics facilities to operate with higher speed, accuracy, and efficiency. These technologies significantly reduce manual labor requirements and minimize the risk of human error in logistics operations. Automation is particularly important in large distribution centers that handle high volumes of

orders, especially in the rapidly expanding e-commerce sector. With the increasing demand for fast delivery services, companies must process thousands of orders within short timeframes. Automated systems enable warehouses to process orders more quickly while maintaining high levels of accuracy in inventory management. Furthermore, robotics technologies can operate continuously without interruptions, which increases overall operational productivity and improves warehouse capacity utilization. As a result, automation technologies play a crucial role in the development of modern smart logistics systems and contribute to the creation of more resilient and efficient supply chains capable of adapting to fluctuations in demand and unexpected disruptions (Ivanov et al., 2019).

Overall, the integration of digital technologies such as IoT, artificial intelligence, blockchain, and advanced automation systems is fundamentally transforming traditional logistics operations into more intelligent, interconnected, and data-driven supply chain networks (Tiwari et al., 2024). These technologies enable organizations to improve supply chain transparency, optimize resource utilization, and enhance collaboration between supply chain partners. In addition, digital technologies support faster and more accurate decision-making processes by providing real-time operational data and predictive analytics capabilities. As supply chains continue to evolve in response to globalization and digital transformation, the adoption of smart logistics technologies will become increasingly important for maintaining competitiveness in the global marketplace. Companies that successfully implement these technologies will be better equipped to manage supply chain risks, respond to market disruptions, and create more sustainable and flexible logistics systems capable of meeting the demands of modern customers.

Table 1. Smart Technologies and Their Impact on Logistics Systems

Example Company	Main Impact on Logistics	Technology
UPS	Real-time tracking and improved supply chain visibility	Internet of Things (IoT)
Amazon	Demand forecasting and route optimization	Artificial Intelligence
Maersk	Secure and transparent information sharing in supply chains	Blockchain
Alibaba	Faster order processing and improved warehouse efficiency	Automation and Robotics

Source: Compiled by the author based on Helo & Thai (2024); Jing, Fan, 2024 (2024); Dubey et al. (2020); Queiroz et al. (2021); Ivanov et al. (2019)

The information presented in Table 1 shows how different digital technologies are influencing modern logistics systems and supply chain management. Technologies such as the Internet of Things (IoT), artificial intelligence, blockchain, and automation help companies improve the way they manage logistics activities and coordinate supply chain operations. By using these technologies, companies can track shipments in real time, analyze logistics data more effectively, and make faster and more informed decisions.

In addition, the adoption of these technologies helps organizations increase supply chain transparency and improve operational efficiency. For example, IoT devices allow companies to monitor shipments during transportation, while artificial intelligence supports better demand forecasting and route optimization. Blockchain technology also improves information security and transparency between supply chain partners. As a result, these technologies play an important role in the development of smarter and more efficient supply chains (Helo & Thai, 2024).

Challenges and Strategic Implementation of Smart Logistics

Despite the many advantages offered by smart logistics technologies, their implementation in supply chain systems also presents several challenges for organizations (Ivanov et al., 2019; Tiwari et al., 2024). Moving from traditional logistics systems to digitally integrated logistics environments require significant financial investment, advanced technological capabilities, and important organizational changes. Many companies encounter difficulties when trying to adapt their existing logistics structures to new digital technologies. Therefore, the successful implementation of smart logistics depends not only on technological innovation but also on careful planning and organizational readiness (Ivanov et al., 2019).

One of the most common challenges is the high cost associated with the adoption of advanced digital technologies. Implementing solutions such as artificial intelligence (AI), Internet of Things (IoT) devices, robotics, and automated warehouse systems often requires major investments in infrastructure, digital platforms, and data management tools. For many companies, these investments represent a significant barrier to digital transformation in logistics. Research shows that more than 60% of logistics companies consider the high cost of digital transformation to be one of the main obstacles to adopting smart logistics solutions (Jing, Fan, 2024). This challenge is particularly significant for small and medium-sized enterprises, which often have limited financial resources compared to large multinational companies.

Another important challenge concerns data security and cybersecurity risks. As supply chains become more digitalized, large amounts of operational data are shared among different actors in the supply chain, including manufacturers, logistics providers, distributors, and retailers. This high level of digital connectivity increases the risk of cyberattacks and data breaches. Studies indicate that nearly half of supply chain organizations view cybersecurity risks as a major concern when implementing digital logistics systems (Queiroz et al., 2021). For this reason, companies must invest in secure digital infrastructures and reliable data protection systems to ensure safe information exchange between supply chain partners.

Organizations also face challenges related to workforce skills and technological adaptation. The effective use of smart logistics technologies requires employees to develop new digital competencies, such as data analysis, digital system

management, and the use of automated decision-support tools. However, many companies still experience difficulties in finding employees with the necessary digital skills. Research suggests that around 45% of companies implementing smart logistics technologies report a shortage of qualified personnel capable of operating advanced digital systems (Ivanov et al., 2019). Without proper training programs and continuous professional development, organizations may struggle to fully benefit from the potential of smart logistics technologies.

Another challenge relates to the integration of digital systems between different supply chain partners. Smart logistics depends heavily on real-time data exchange and digital collaboration between organizations. However, many companies still rely on fragmented information systems that are not fully compatible with modern digital platforms. This lack of integration can reduce the effectiveness of digital logistics solutions and limit the overall visibility of supply chain operations (Helo & Thai, 2024).

To address these challenges, companies need to adopt a well-structured strategic approach when implementing smart logistics technologies. This includes investing in modern digital infrastructure, strengthening cybersecurity systems, and developing employee training programs focused on digital skills. In addition, companies should encourage stronger collaboration between supply chain partners through digital platforms that allow real-time information sharing and coordination. By following these strategies, organizations can overcome implementation challenges and improve the efficiency, transparency, and resilience of their supply chain operations (Helo & Thai, 2024).

Table 2 summarizes the main challenges related to the implementation of smart logistics technologies and presents the strategic solutions that companies can adopt in order to successfully support the digital transformation of supply chain systems.

Table 2. Key challenges and strategic solutions in smart logistics implementation

Challenges	Strategic Solutions
High cost of digital technologies	Long-term investment in digital infrastructure
Data security and cybersecurity risks	Secure digital systems and blockchain solutions
Lack of digital skills	Employee training and digital skill development
Integration difficulties between partners	Digital collaboration platforms

Source: Author's compilation based on Jing & Fan, 2024 (2024); Queiroz et al. (2021); Ivanov et al. (2019); Helo & Thai (2024).

Table 2 outlines the key challenges that arise during the implementation of smart logistics technologies. It also highlights practical strategies that organizations can adopt to address these barriers. By applying these solutions, companies can better support the successful digital transformation of their supply chain systems and improve the overall efficiency and resilience of their logistics operations.

Conclusions

1. The review of recent scientific literature made it possible to identify the main digital technologies used in smart logistics systems, including artificial intelligence (AI), the Internet of Things (IoT), big data analytics, and automation technologies. These technologies support real-time monitoring of logistics activities and improve the quality and speed of decision-making in supply chain operations.

2. The analysis demonstrates that smart logistics technologies play a significant role in improving supply chain efficiency and overall operational performance. Through the integration of digital technologies, organizations are able to increase supply chain visibility, optimize transportation and inventory management, and strengthen coordination among different actors within the supply chain network.

3. The findings indicate that the successful implementation of smart logistics technologies depends not only on technological innovation but also on organizational readiness. Investment in digital infrastructure, the development of employees' digital skills, and the effective integration of information systems are essential factors that enable companies to fully benefit from the potential of smart logistics solutions.

4. The study highlights several challenges that may limit the wider adoption of smart logistics technologies. High implementation costs, cybersecurity risks, limited digital competencies among employees, and difficulties related to integrating information systems between supply chain partners remain significant barriers for many organizations.

5. Finally, the research suggests that smart logistics will continue to play an increasingly important role in the future development of supply chain systems. Continuous advancements in technologies such as blockchain, advanced analytics, and intelligent automation are expected to further enhance supply chain transparency, flexibility, and resilience within global logistics networks.

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