Impacts of AI on Supply Chain

*Indicate Submission Type: Short Paper*

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# Abstract

Artificial Intelligence (AI) is transforming supply chain management (SCM) by enhancing integration, efficiency, sustainability, and resilience. This paper reviews recent literature to analyze AI's impacts on various aspects of SCM and identifies key contributions and challenges associated with its adoption. The findings indicate that AI significantly improves supply chain performance and sustainability, although challenges such as high implementation costs and data privacy concerns persist. This paper contributes to the existing literature by providing a comprehensive analysis of AI's role in SCM and suggesting directions for future research to address current limitations.

# Introduction

The integration of Artificial Intelligence (AI) into supply chain management (SCM) represents a significant paradigm shift in how organizations manage logistics, inventory, and overall supply chain operations. AI technologies, encompassing machine learning, predictive analytics, and intelligent automation, are increasingly being adopted to enhance supply chain efficiency, resilience, and sustainability. These technologies facilitate more accurate demand forecasting, optimized inventory management, and improved decision-making capabilities, thereby transforming traditional supply chain processes into more agile and responsive systems.

The rise of digital transformation and the increasing complexity of global supply chains have driven the need for advanced technological solutions to address challenges such as demand variability, supply disruptions, and the growing emphasis on sustainability. AI offers the potential to automate routine tasks, analyze vast datasets for actionable insights, and enhance coordination across the supply chain, significantly improving overall performance. However, the adoption of AI in SCM also presents challenges, including high implementation costs, concerns over data privacy and security, and the need for specialized skills to manage and operate AI systems effectively.

This paper aims to provide a comprehensive analysis of the impacts of AI on supply chain management by reviewing recent scholarly research. We will explore how AI contributes to enhancing supply chain integration, efficiency, sustainability, and resilience, and discuss the challenges and opportunities associated with its adoption. Additionally, this paper will identify areas for future research to further leverage AI's potential in SCM, ensuring that organizations can fully capitalize on the benefits of AI technologies.

# Literature review

## Integration and Efficiency

AI technologies significantly enhance supply chain integration and efficiency by facilitating better information sharing and coordination across supply chain networks. Studies have demonstrated that AI-enabled integration positively impacts the relationship between information sharing and supply chain integration, particularly in regions with high AI adoption rates (Kieu et al., 2022). AI-driven tools such as machine learning algorithms and predictive analytics are critical in optimizing demand forecasting, inventory management, and logistics operations, leading to substantial efficiency gains and reduced operational costs (Pournader et al., 2021).

For instance, AI applications in predictive maintenance can forecast equipment failures before they occur, thereby reducing downtime and maintenance costs. Similarly, AI-powered demand forecasting tools can analyze historical sales data and market trends to predict future demand more accurately, enabling companies to optimize their inventory levels and reduce excess stock.

## Sustainability

AI enhances the sustainability of supply chains by improving transparency, reducing carbon emissions through intelligent automation, and optimizing resource utilization to minimize waste (Pal, 2023). AI technologies such as machine learning and big data analytics enable companies to track and analyze their carbon footprint, identify inefficiencies, and implement strategies to reduce environmental impact. For example, AI can optimize transportation routes to reduce fuel consumption and emissions and improve energy efficiency in manufacturing processes.

However, there is a concern that the efficiency gains from AI could lead to increased production and consumption, potentially offsetting some sustainability benefits. This phenomenon, known as the rebound effect, underscores the importance of managing AI's environmental impacts carefully to ensure that the net effect is positive (Dauvergne, 2020). Companies must balance the pursuit of efficiency with sustainable practices to achieve long-term environmental goals.

## Resilience

AI significantly enhances supply chain resilience by improving risk management capabilities, visibility, and enabling agile responses to disruptions. Research indicates that AI can enhance business continuity by improving sourcing, distribution capabilities, and last-mile delivery, thus mitigating the impact of disruptions such as pandemics (Modgil et al., 2021). AI-driven innovations support the development of resilient supply chains capable of adapting to dynamic and uncertain environments.

For example, AI can be used to analyze data from various sources, such as weather forecasts, social media, and news reports, to predict potential disruptions and suggest proactive measures to mitigate their impact. Additionally, AI-powered supply chain visibility tools can provide real-time tracking of goods and materials, allowing companies to quickly identify and address issues as they arise (Belhadi et al., 2021).

## Performance Optimization

AI optimizes supply chain performance by automating routine tasks, enhancing decision-making through data analytics, and improving capacity planning and productivity. AI technologies facilitate real-time monitoring, error reduction, and faster innovation cycles, significantly enhancing supply chain agility (Alomar, 2022). These advancements lead to more efficient and adaptive supply chain operations.

For instance, AI-powered inventory management systems can automatically adjust stock levels based on real-time sales data, reducing the risk of stockouts and overstocking. AI-driven quality control systems can detect defects and anomalies in products more accurately than traditional methods, ensuring higher product quality and reducing waste (Dash et al., 2019).

## Why is artificial intelligence so important for solving supply chain problems?

For years, many logistics organizations have been planning to go digital in some way. In fact, 23% of warehouse administrators intend to implement automation technologies in 2019 (FDM4, n.d). While AI is still a new technology, it fits exactly what they were looking for. It is one of the few technologies capable of processing the enormous volume of data generated by the logistics process. It can collect, process and analyze information from hundreds of sources without overloading itself. Speed is another thing that sets AI apart from similar technologies: very few alternatives can process, analyze and output data as quickly as it can. It can look at millions of possibilities in seconds and respond to interactions in real time. The main advantage of AI over other technologies is its ability to automate tasks and act autonomously. It can operate autonomously around the clock and rarely requires human intervention, which is ideal during times of labor shortage. This technology is also cost effective. According to one study, 63% of logistics businesses using artificial intelligence in supply chain management generated more revenue. Moreover, 61% reported a decrease in operating expenses (Mohsen, 2023). While many technologies can automate tasks, process data quickly, or operate autonomously, very few can do everything at once. This is why AI is such a promising solution to supply chain disruptions and delays.

# Findings

## Examples of Using AI in the Supply Chain

### AI-powered surveillance and barcode scanners

AI-powered surveillance systems and barcode scanners are crucial for preventing product defects and counterfeits from spreading through logistics channels. These systems are typically placed on or near conveyor belts to monitor and track inventory effectively. AI enhances the accuracy of these surveillance systems, leading to improved quality control and reduced losses due to counterfeit products (Bas et al., 2023).

### Integration with IoT sensors

### Logistics companies are increasingly integrating AI with Internet of Things (IoT) technologies. For example, AI can be used to analyze data from IoT packaging sensors, allowing companies to track shipments and monitor conditions such as temperature and humidity in real-time. This integration helps in maintaining product quality and optimizing supply chain operations (Klumpp, 2018).

### Administrative AI

### AI is also transforming administrative tasks within supply chains, including internal accounting, management, document processing, and information exchange. AI systems can process invoices, order supplies, renew contracts with suppliers, send requests for proposals, and schedule workers. This automation reduces administrative burdens, enhances accuracy, and improves operational efficiency (Zeng & Yi, 2023).

### Autonomous vehicles

### One of the cutting-edge applications of AI in supply chains is in the development of autonomous vehicles. Self-driving trucks and drones use machine learning to respond to their environment in real-time, enhancing the efficiency and safety of logistics operations. While the development of fully autonomous vehicles is still progressing, proof of concept exists, showcasing AI's potential in this field (Tsolakis et al., 2018).

### AI in last-mile delivery

AI-powered technologies are revolutionizing last-mile delivery through the use of robots, drones, and autonomous vehicles. These technologies optimize delivery routes, reduce delivery times, and enhance customer satisfaction by providing more reliable and efficient services (Sorooshian et al., 2022).

## Case studies of AI in the Supply Chain

Several organizations have already tried AI by optimizing its use in the supply chain, with mostly positive results. Amos (2020) found that some companies even report that AI speeds up order fulfillment up to 6.7 days compared to their traditional methods.

### Stella McCartney and google

Several fashion industry players have collaborated with Google, including Stella McCartney. Together they developed a tool using data analytics and machine learning. Candeloro (2020) found that the tool provides a clear understanding of the environmental impact of the supply chain, helping fashion brands select sustainable raw materials and production technologies.

### Starbucks

Starbucks has demonstrated its commitment to sustainable coffee. The company has implemented artificial intelligence and blockchain to provide consumers with bean-to-cup traceability (Warnick, 2020). Consumers can now track the origin of their coffee ensuring sustainable sources of beans and fair compensation to farmers.

### Unilever

Given the widespread use of palm oil in products, Unilever is using satellite monitoring, artificial intelligence and geolocation data to monitor its palm oil supply chain (Labbe, 2020). The goal is to combat deforestation associated with palm oil production. This technology provides real-time alerts on deforestation risks, guiding the company towards sustainable solutions.

### Walmart

Walmart has implemented a system based on artificial intelligence and blockchain to track the origin of food in its stores (Vitasek et al., 2022). In addition to ensuring food safety, the system allows Walmart to identify sustainable suppliers and prioritize their business.

# The future of AI in the supply chain

Since artificial intelligence (AI) is still a relatively new phenomenon, its penetration rate in supply chains is expected to remain low for several years. Despite this, AI holds substantial promise for transforming supply chain management by enhancing efficiency, sustainability, and resilience.

### Current sentiments

According to a study by Do Trung et al. (2020), 73% of logistics companies are optimistic about the potential of new technologies, including AI. However, 50% of these companies plan to delay adoption until they perceive the risks to be lower. This cautious approach suggests that many firms are waiting for more clarity on ideal use cases, potential gaps, and best practices (Do Trung et al., 2020).

### Future expectations

Despite initial hesitation, there is a growing belief in the necessity of AI for future operations. Thormundsson (2023) notes that while only 11% of logistics executives considered AI critical in 2022, this number is expected to rise to approximately 38% by 2025. This indicates a significant shift towards recognizing the strategic importance of AI in supply chain management (Thormundsson, 2023).

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| **Figure 2.** |

Also, AI is poised to streamline supply chain processes, enhancing operational efficiency through advanced data analytics and predictive modeling. AI applications are expected to automate routine tasks, optimize logistics, and improve inventory management, leading to significant cost reductions and efficiency gains (Boute & Udenio, 2021).

Nevertheless, AI technologies provide real-time insights and predictive analytics, which are crucial for informed decision-making in complex supply chain environments. This capability helps organizations anticipate market demands, optimize resource allocation, and mitigate risks (Pournader et al., 2021).

In addition, AI contributes to sustainability by optimizing resource use and reducing waste. AI-driven systems can enhance the efficiency of logistics operations, leading to lower carbon emissions and a reduced environmental footprint. However, it is important to manage these technologies carefully to avoid rebound effects that could negate sustainability gains (Dauvergne, 2020).

# Challenges and recommendation

As AI systems often handle large volumes of sensitive data, ensuring data privacy and robust cybersecurity measures is critical. Companies must develop comprehensive strategies to protect data and comply with privacy regulations such as the General Data Protection Regulation (GDPR) and the California Consumer Privacy Act (CCPA). Implementing robust encryption, secure data storage, and access control mechanisms are essential to safeguarding sensitive information (Richey et al., 2023). Also, ethical issues such as transparency, fairness, and accountability need to be addressed to ensure the responsible use of AI in supply chains. Developing ethical guidelines and standards for AI deployment is essential for maintaining trust and integrity in supply chain operations. This includes establishing clear policies on algorithmic transparency, bias mitigation, and accountability for AI decisions. Additionally, engaging stakeholders in the development and oversight of AI systems can enhance ethical governance (Vasiliki & Apostolos, 2023).

In addition, to facilitate the wider adoption of AI, investments in digital infrastructure and AI readiness are crucial. This includes enhancing technological capabilities, such as high-speed internet and cloud computing, as well as upgrading hardware and software to support AI applications. Additionally, companies should focus on developing workforce skills through training programs in AI and data science, and fostering a culture of innovation that encourages AI experimentation and integration. Organizational readiness involves aligning business processes with AI capabilities and establishing cross-functional teams to oversee AI implementation (Klumpp, 2018).

# Conclusion

Artificial Intelligence (AI) is profoundly impacting supply chain management, driving substantial improvements in integration, efficiency, sustainability, and resilience. As AI technologies such as machine learning, predictive analytics, and intelligent automation continue to evolve, their applications in supply chains are becoming increasingly sophisticated and widespread.

AI significantly enhances supply chain integration and efficiency by optimizing logistics, inventory management, and demand forecasting. These improvements lead to streamlined operations, reduced costs, and enhanced decision-making capabilities. AI’s role in promoting sustainability is also noteworthy, as it enables companies to optimize resource utilization, reduce carbon footprints, and enhance transparency across the supply chain.

Despite the clear benefits, the adoption of AI in supply chains faces several challenges, including data privacy and security concerns, high implementation costs, and the need for robust ethical guidelines and infrastructure development. Addressing these challenges is crucial for realizing the full potential of AI in supply chains.

Looking ahead, as companies invest in digital infrastructure and enhance their technological capabilities, the adoption of AI is expected to accelerate. This will lead to more adaptive, efficient, and sustainable supply chains, capable of meeting the demands of a dynamic global market. By embracing AI, organizations can achieve significant competitive advantages, driving innovation and growth in the supply chain sector.

# References

Alomar, M. 2022. "Performance Optimization of Industrial Supply Chain Using Artificial Intelligence,” in *Computational Intelligence and Neuroscience.*

Amos, Z. 2020. “AI in Supply Chain Applications: 5 Real-Life examples,” in *Rehack.*

Bas, T., Astudillo, P., Rojo, D., and Trigo, A. 2023. “Opinions Related to the Potential Application of Artificial Intelligence (AI) by the Responsible in Charge of the Administrative Management Related to the Logistics and Supply Chain of Medical Stock in Health Centers in North of Chile,” in *International Journal of Environmental Research and Public Health*, pp. 20.

Belhadi, A., Mani, V., Kamble, S., Khan, S., and Verma, S. 2021. “Artificial intelligence-driven innovation for enhancing supply chain resilience and performance under the effect of supply chain dynamism: an empirical investigation,” in *Annals of Operations Research*, pp. 1 - 26.

Boute, R., & Udenio, M. 2021. “AI in Logistics and Supply Chain Management,” in *PROD: Empirical (Supply).*

Candeloro, D. 2020. “Towards Sustainble Fashion: The role of Artificial Intelligence – H&M, Stella McCartney, Farfetch, Moosejaw: A Multiple Case Study,” in *ZoneModa Journal*, 10(2), pp. 91–105.

Dash, R., McMurtrey, M., Rebman, C., and Kar, U. 2019. “Application of Artificial Intelligence in Automation of Supply Chain Management,” in *Journal of Strategic Innovation and Sustainability*.

Dauvergne, P. 2020. “Is artificial intelligence greening global supply chains? Exposing the political economy of environmental costs,” in *Review of International Political Economy*, 29, pp. 696-718.

Do Trung, K., Kotivirta, J., Norell, V., and Gammelgaard, B. 2020. “Sustainable Business Model Innovation in Last Mile Logistics,” in *Department of Operations Management, Copenhagen Business School.*

FDM 4. n.d. “ERP and Supply Chain Trends”

Kieu, M., Nayak, R., and Akbari, M. 2022. “AI-enabled Integration in the Supply Chain,” in *Journal of Resilient Economies* *(ISSN: 2653-1917).*

Klumpp, M. 2018. “Innovation Potentials and Pathways Merging AI,” in *CPS and IoT*, 1, pp. 5.

Labbe, M. 2020. “Google, Unilever partnership uses AI for sustainable sourcing,” in *TechTarget*.

Modgil, S., Singh, R., and Hannibal, C. 2021. “Artificial intelligence for supply chain resilience: learning from Covid-19,” in *The International Journal of Logistics Management*.

Mohsen, B. 2023. “Impact of Artificial Intelligence on Supply Chain Management Performance,” in *Journal* *of Service Science and Management*, 16, pp. 44-58

Pal, S. 2023. “Integrating AI in Sustainable Supply Chain Management: A New Paradigm for Enhanced Transparency and Sustainability,” in *International Journal for Research in Applied Science and Engineering Technology.*

Pournader, M., Ghaderi, H., Hassanzadegan, A., and Fahimnia, B. 2021. “Artificial intelligence applications in supply chain management,” in *International Journal of Production Economics*, pp. 241.

Richey, R., Chowdhury, S., Davis‐Sramek, B., Giannakis, M., and Dwivedi, Y. 2023. “Artificial intelligence in logistics and supply chain management: A primer and roadmap for research,” in *Journal of Business Logistics.*

Sorooshian, S., Sharifabad, S., Parsaee, M., and Afshari, A. 2022. “Toward a Modern Last-Mile Delivery: Consequences and Obstacles of Intelligent Technology,” in *Applied System Innovation*.

Thormundsson, B. 2023. “Artificial Intelligence rate in supply chain and manufacturing businesses worldwide in 2022 and 2025,” in *Statista*.

Tsolakis, N., Bechtsis, D., and Srai, J. 2018. “Intelligent autonomous vehicles in digital supply chains,” in *Bus. Process. Manag. J.,* 25, pp. 414-437.

Vasiliki, S., and Apostolos, P. 2023. “AI Technology in the Field of Logistics,” in *2023 18th International Workshop on Semantic and Social Media Adaptation & Personalization (SMAP)18th International Workshop on Semantic and Social Media Adaptation & Personalization (SMAP 2023)*, pp. 1-6.

Vitasek, K., Bayliss, John., Owen, Loudon., and Srivastava, N. 2022. “How Walmart Canada Uses Blockchain to Solve Supply-Chain Challenges,” in *Harward Business Review*.

Warnick, J. 2020. “AI for humanity: How Starbucks plans to use technology to nurture the human spirit,” in *Starbucks stories & news*.

Zeng, X., and Yi, J. 2023. “Analysis of the Impact of Big Data and Artificial Intelligence Technology on Supply Chain Management,” in *Symmetry*.