Mednarodno inovativno poslovanje
Journal of Innovative Business and Management

# Effect of artificial intelligence and automation on the supply chain

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***Abstract*:** Artificial Intelligence (AI) and automation have become transformative forces in global supply chain management, fundamentally reshaping how organizations plan, produce, and deliver goods and services. The aim of this review was to give an insightful overview regarding the relation of AI and supply chain. This paper examines how AI driven technologies, machine learning, robotics, predictive analytics, and the Internet of Things (IoT) improve efficiency, resilience, and sustainability across supply networks. The study identifies AI's critical role in optimizing logistics operations, forecasting demand, and managing risks through data-driven decision-making. The strategy of literature analysis was directed toward findings over the last five years. The analysis highlights both the advantages of AI implementation, greater accuracy, cost reduction, and enhanced agility and its challenges, including data integration, ethics, high investment costs, and workforce adaptation. The paper concludes with recommendations for strategic adoption of AI and automation to ensure competitiveness and sustainability in the evolving digital economy. Data processing characterised by exceptional information processing speed, which takes into account predefined parameters is the main practical advantage of AI in supply chain.

***Keywords*:** Artificial Intelligence, automation, supply chain management
***JEL classification*:** L23, M11, O33

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*DOI 10.32015/JIBM.2025.17.2.4*

*Mednarodno inovativno poslovanje = Journal of Innovative Business and Management*

*ISSN 1855-6175*

# Vpliv umetne inteligence in avtomatizacije na dobavno verigo

***Povzetek:*** Umetna inteligenca (UI) in avtomatizacija sta postali transformativni sili v globalnem upravljanju dobavnih verig in sta temeljito spremenili način, kako organizacije načrtujejo, proizvajajo in dobavljajo blago in storitve. Cilj tega pregleda je bil podati vpogled v odnos med UI in dobavno verigo. Ta članek preučuje, kako tehnologije, ki jih poganja UI, strojno učenje, robotika, napovedna analitika in internet stvari (IoT), izboljšujejo učinkovitost, odpornost in trajnost v dobavnih omrežjih. Študija opredeljuje ključno vlogo UI pri optimizaciji logističnih operacij, napovedovanju povpraševanja in obvladovanju tveganj z odločanjem, ki temelji na podatkih. Strategija analize literature je bila usmerjena v ugotovitve v zadnjih petih letih. Analiza poudarja tako prednosti uvedbe UI, večjo natančnost, zmanjšanje stroškov in izboljšano agilnost kot tudi njene izzive, vključno z integracijo podatkov, etiko, visokimi investicijskimi stroški in prilagajanjem delovne sile. Članek se zaključi s priporočili za strateško uvedbo UI in avtomatizacije za zagotovitev konkurenčnosti in trajnosti v razvijajočem se digitalnem gospodarstvu. Obdelava podatkov, za katero je značilna izjemna hitrost obdelave informacij, ki upošteva vnaprej določene parametre, je glavna praktična prednost UI v dobavni verigi.

***Ključne besede:*** umetna inteligenca, avtomatizacija, upravljanje dobavnih verig

# 1 INTRODUCTION

The main characteristics of today's business environment are complexity, uncertainty, and rapid change. The network that connects customers, suppliers, manufacturers, and distributors is called the supply chain, and there is increasing pressure on the people who do the work to do it faster, smarter, and more sustainably. In this supply chain, artificial intelligence and automation are emerging as key drivers of the next phase of industrial transformation. By integrating artificial intelligence into procurement logistics and e-commerce processes, it is changing the way organizations manage their resources. Logistics systems supported by artificial intelligence improve accuracy in warehousing and transportation, which leads to faster delivery and reduced costs. We associate the term automation with industrial machinery, but today's intelligent automation has evolved and today it combines robotics, computer vision, and machine learning to create adaptive systems for autonomous decision-making (Ivanov, 2023). Systems based on this principle learn from data, identify patterns, and optimize processes in real time. This is something that was unthinkable in supply chains without human intervention. The COVID-19 pandemic, geopolitical conflicts, and global transportation bottlenecks have exposed weaknesses in conventional models. Artificial intelligence and its forecasting provide organizations with tools to mitigate risk, ensure quality, and lower costs in the long term. Modern supply chains are expected to align with global environmental and social (ESG) standards. Artificial intelligence can follow these standards by optimizing transport routes to reduce emissions, manage energy consumption, and promote circular economy models (Dash et al., 2019). This paper aims to provide a comprehensive academic analysis of how artificial intelligence and automation are reshaping supply chain management. Key questions are how artificial intelligence and automation are impacting the operational, strategic, and environmental dimensions of supply chains, and what are the barriers and success factors that determine their effectiveness.

## 1.1 Evolution and applications of AI and automation in supply chains

The concept of automation is not new, it has existed since the industrial revolution, but the integration of Artificial Intelligence (AI) has brought a paradigm shift in how global supply chains are designed and managed. Early automation focused on mechanization and standardization, whereas today’s intelligent automation integrates robotics, data analytics, and cognitive computing. This combination allows systems to not only execute predefined tasks but also learn, adapt, and optimize continuously based on feedback loops (Ivanov, 2023). The transition from Industry 3.0 to Industry 4.0, and now toward Industry 5.0, marks a new phase where human machine collaboration takes centre stage. Industry 4.0 focused on digitalization using data, sensors, and the Internet of Things (IoT) while Industry 5.0 emphasizes human centric, sustainable innovation (Ivanov and Dolgui, 2019). AI technologies are the backbone of this evolution, enabling real-time decision-making, predictive analytics, and autonomous operations. AI-driven systems have already replaced traditional managerial decision-making processes in logistics and procurement. These technologies not only increase precision and speed but also allow for self-optimization, where systems adjust parameters without human intervention. As a result, AI has redefined the competitive landscape by creating smarter, more adaptive, and resilient supply chains.

AI applications in supply chains span multiple operational areas—procurement, production, inventory, logistics, and customer service. Predictive analytics enables more accurate demand forecasting, helping companies avoid stockouts or overproduction. Machine learning models process historical and real time data to anticipate demand fluctuations with a precision previously unattainable through human intuition alone. In logistics, autonomous mobile robots (AMRs) and automated storage and retrieval systems (AS/RS) have revolutionized warehouse management. These systems increase throughput, reduce human

error, and optimize space utilization. Logistics planning lead by artificial intelligence improves order accuracy and delivery punctuality which leads to improving customer satisfaction. AI also plays a critical role in transportation and routing optimization. Tools based on machine learning can analyse millions of variables, from weather conditions to fuel prices to determine the most efficient delivery routes. AI-driven route optimization in the oil and gas industry has reduced operational costs by up to 30%, while also lowering $CO_2$ emissions (Shamsuddoha et al., 2025). Beyond logistics, Robotic Process Automation (RPA) has streamlined repetitive administrative tasks, such as invoice processing, shipment tracking, and compliance reporting. This enables managers to focus on strategic planning rather than data entry (Smyth et al., 2024). Moreover, AI-based chatbots and virtual assistants are improving supply chain communication by automating routine queries and enabling real-time information flow between suppliers and customers.

## 1.2 AI in risk mitigation and supply chain resilience

One of the most significant contributions of AI lies in risk management. Global supply chains face increasing exposure to disruptions, from pandemics to geopolitical instability and natural disasters. Traditional risk management methods, often reactive and manual, cannot keep up with today's complex networks. By employing digital twins, AI creates virtual replicas of physical supply chains that can simulate disruptions and test response strategies (Ivanov and Dolgui, 2019). This technology provides real-time insights into the consequences of different decisions, enabling firms to make proactive adjustments. AI enhances risk communication and transparency throughout the supply chain ecosystem. For example, blockchain integrated AI systems allow traceability of goods, providing visibility from the raw material source to the end consumer. Such transparency not only mitigates operational risk but also builds consumer trust and regulatory compliance. AI-based predictive maintenance is another key enabler of resilience. Through sensor data analysis, AI systems can detect anomalies in machinery or logistics equipment, scheduling maintenance before failures occur. This reduces downtime and ensures smoother operations across global facilities (Zeb and Lodhi, 2025).

## 1.3 AI for sustainability and circular economy

In the supply chain, it is no longer enough to be as efficient as possible, but it must also be sustainable. Pressures to reduce the carbon footprint of organizations are increasing, and artificial intelligence is an excellent tool. Smart logistics systems can significantly reduce energy consumption and emissions by optimizing routes and carrying capacity. Artificial intelligence can support the transition from linear models ("take-make-dispose") to circular supply chains, where materials are reused, recycled and reintroduced into production (Dash et al., 2019). Artificial intelligence systems enable better waste tracking and predictive modelling for end-of-life product recovery. In manufacturing, artificial intelligence supports eco-design, the development of products optimized for energy efficiency and recyclability. Automation also helps monitor and control production processes to reduce environmental impacts. Sustainable integration of artificial intelligence not only meets environmental goals, but also improves long-term economic resilience, since efficient resource management is directly related with profitability (Chen et al., 2025). Automated data collection and analysis contribute to environmental, social and management reporting on sustainability metrics. Such increasingly strict regulatory standards are easier to meet with the help of artificial intelligence and automation.

Environmental sustainability has become an essential goal of corporate supply chain strategy. With mounting regulatory pressure and consumer awareness, AI and automation now serve as critical tools for achieving green logistics and sustainable resource use. AI-driven route optimization and energy-efficient transportation systems can cut fuel consumption by up to

15%, while automated scheduling minimizes empty runs (Dash et al., 2019). Similarly, predictive analytics supports inventory right sizing, reducing waste associated with overproduction. Automation also improves traceability and compliance with sustainability standards by enabling real-time monitoring of $CO_2$ emissions, material usage, and ethical sourcing. For instance, IoT devices embedded in vehicles and facilities track performance metrics that feed directly into AI systems, generating ESG reports automatically (Zeb and Lodhi, 2025). Furthermore, AI enhances recycling and reverse logistics, identifying opportunities for reusing components or reintroducing materials into the production cycle. This supports the shift from linear to circular supply chain models, which reduce environmental impact and align with the principles of Industry 5.0 (Ivanov, 2023).

## 1.4 Ethical, social, and regulatory challenges

Despite its transformative potential, acceptance of AI raises ethical and regulatory issues. One concern is algorithmic tendency when AI systems reproduce or amplify existing human biases present in data (Ledro et al., 2022). This can lead to unfair or wrong decision making, especially in supplier selection or workforce management. Another major challenge is workforce displacement. As AI and automation replace repetitive tasks, employees in logistics and manufacturing sectors face uncertainty about job security. While automation may eliminate some roles, it simultaneously creates demand for new ones related to AI oversight, data analysis, and system maintenance. However, such a transition requires continuous education and reskilling, which many organizations are slow to implement. Data privacy is also a pressing issue. AI systems rely on vast quantities of data, often collected from IoT devices and tracking systems. Without strict data governance, sensitive information may be exposed or misused (Smyth et al., 2024). Finally, regulatory frameworks are still evolving. Governments and international bodies are developing ethical guidelines for AI deployment to ensure transparency, accountability, and human oversight. Successful AI integration must align with both corporate ethics and public policy objectives, striking a balance between innovation and responsibility (Ivanov, 2023; Lindholm, 2025).

## 1.5 Operational efficiency and decision-making

AI and automation have fundamentally changed how organizations achieve efficiency within supply chains. Traditional supply chains were characterized by manual operations, linear workflows, and limited visibility, often leading to inefficiencies in inventory, production, and transportation. In contrast, AI-enabled supply chains function as adaptive ecosystems that continuously analyse data, forecast demand, and optimize processes in real time (Shamsuddoha et al., 2025). Machine learning algorithms enable predictive forecasting based on both structured and unstructured data sources, such as market trends, weather patterns, and consumer behaviour. Predictive analytics can increase forecast accuracy leading to lower holding costs and improved customer service levels. Automation in logistics through robotic handling systems and automated picking has drastically reduced processing time and human error. Another major aspect of efficiency is processing transparency. With the integration of IoT sensors and cloud computing, supply chain data can now be monitored in real time, enabling informed decision-making across multiple stakeholders. This increased visibility not only reduces waste but also facilitates collaboration between suppliers, distributors, and retailers (Smyth et al., 2024). In procurement and production, AI-driven optimization tools assist managers in selecting suppliers based on cost, reliability, and sustainability metrics. As a result, decision-making has become data-driven rather than intuition-based, leading to measurable gains in productivity and accountability (Stradner and Brunner, 2020).

## 1.6 Resilient supply chains and risk mitigation

Resilience has emerged as a central pillar of modern supply chain strategy. Global disruptions such as the COVID-19 pandemic, the Suez Canal blockage, and geopolitical tensions have highlighted the fragility of traditional supply networks. AI-driven tools can identify vulnerabilities and predict potential failures before they occur. Predictive risk models, built using big data analytics, allow companies to simulate disruption scenarios and design proactive responses. Digital twins virtual models of physical supply chains are particularly effective for testing different strategies under varying market conditions (Ivanov and Dolgui, 2019). By integrating these simulations with real-time sensor data, firms can predict the impact of transport delays, demand shocks, or supplier shortages, and respond with agility. AI also supports predictive maintenance, which is critical to operational resilience. For instance, machine learning algorithms can detect anomalies in equipment behaviour and signal the need for repairs before breakdowns occur. Predictive maintenance programs can reduce unplanned downtime by up to 40%, significantly improving operational continuity (Shamsuddoha et al., 2025). Another key element of resilience is information flow. Automation enables the synchronization of data across suppliers and partners, minimizing information asymmetry. Blockchain-based systems further ensure transparency and traceability, reinforcing both risk management and regulatory compliance (Smyth et al., 2024).

## 2 COMPARISON OF TRADITIONAL VS. AI-DRIVEN SUPPLY CHAINS

The table 1 shows few dimensions through AI fundamentally changes the speed, accuracy, and adaptability of decision-making processes. While traditional models rely on manual work, historical data, and reactive decision making, AI-based systems use real time analytics, automation, and predictive modelling to enhance efficiency and agility. Automation enhances performance but human oversight remains essential, especially in strategic decision contexts. The future of supply chain management will likely depend on synergistic cooperation between humans and intelligent machines rather than full automation.

Table 1. Differences between traditional supply chain and AI supply chain

(Source: Authors, 2025)

| Dimension | Traditional Supply Chain | AI-Driven Supply Chain |
|---|---|---|
| Forecasting | Based on historical data and averages | Predictive analytics using machine learning and real-time inputs |
| Decision-Making | Manual, reactive, intuition-based | Automated, proactive, and data-driven |
| Logistics | Human scheduling and manual tracking | Autonomous routing and IoT-enabled visibility |
| Risk Management | Reactive crisis response | Predictive modelling and digital twin simulations |
| Sustainability | Limited focus on environmental factors | Carbon tracking, energy optimization, and circular economy integration |
| Workforce Involvement | High manual labour | Human–AI collaboration and reskilling needs |

## 2.1 AI in e-commerce supply chains

The rise of e-commerce has accelerated the adoption of AI and automation across logistics, warehousing, and customer service. Online retailing requires real time inventory tracking, rapid order fulfilment, and personalized customer experiences, challenges that traditional systems could not efficiently meet. AI plays a key role in improving e-commerce logistics through dynamic demand prediction and automated warehouse management. Machine learning algorithms forecast product demand per region, allowing firms to pre-position inventory close to customers, reducing delivery times and shipping costs. AI-powered chatbots and virtual assistants also contribute to customer relationship management, providing instant support and automating thousands of customer inquiries daily (Smyth et al., 2024). This not only reduces operational costs but also enhances service satisfaction and brand loyalty. In e-commerce supply chains, real time data analytics is crucial for managing supplier networks, last-mile delivery, and reverse logistics. Automation in return processing and customer data analysis helps firms manage sustainability concerns by minimizing waste and optimizing resource use. Moreover, AI contributes to fraud detection and payment verification, improving transactional security in online commerce. The combination of blockchain and AI ensures transparency and authenticity across digital transactions factors increasingly valued by consumers and regulators alike. Overall, AI's integration into e-commerce represents the most dynamic frontier of supply chain automation, where real time responsiveness and customer personalization converge.

## 2.2 Strategic barriers and implementation frameworks

Although this paper mainly lists the benefits of artificial intelligence and automation, there are also negative things that need to be highlighted. The biggest obstacles for organizations are the high investment costs in purchasing technology, the lack of qualified experts to manage the systems, and resistance to change within the organization.

In addition, management often underestimates how much time is needed to invest in training and digital transformation. To avoid these problems, it is necessary to go through several implementation phases: The readiness assessment phase where key performance indicators are defined, second is integration phase where tools are gradually adopted, optimization phase is third where predictive and prescriptive analytics are used for continuous performance improvement. The last phase is the sustainability phase where ESG metrics are incorporated into AI-driven decision-making systems (Ivanov, 2023; Stradner and Brunner, 2020). These phases show that the adoption of AI is not just a technological upgrade but represents a strategic transformation that requires management commitment and cooperation between people in the organization. Strategic AI Resilience Framework is aimed at identifying vulnerabilities, and development of resilience strategies (Smyth et al., 2024). In their model, AI-based predictive analytics improves decision-making process. In addition, it emphasize the effect of AI in driving chain performance. Consequently, it contributes to agility, visibility and resilience.

Future research should provide empirical validation and comparative analysis of AI adoption in different industrial sectors. Specific research topics could include measuring the relationship between AI-driven decision making and supply chain resilience during crises, evaluating social and employment impacts of automation, developing governance framework for ethical AI integration. Mixed method approaches, combining quantitative modelling and qualitative case studies, would enhance the robustness of future results. From a practical perspective, future studies should also explore policy mechanisms and training strategies that support ethical, transparent, and sustainable AI adoption in supply chain management.

The practical implications of AI in the context of supply chain would be reducing the possibility of human mistakes. The main advantage manifests in time reducing manual work of people in supply chain. Positive consequence of this change is more dedication to other important aspects of work like negotiations, strategic thinking and planning.

## 3 CONCLUSION

Automation and artificial intelligence represent a revolutionary power in modern supply chain management in a way that logistics planning, demand forecasting, risk management are completely redefined than they were before. Artificial intelligence allows organizations to act in real time instead of reactive decision-making. Predictive models and digital twins allow companies to simulate scenarios, identify bottlenecks and optimize resource allocation before disruptions occur (Ivanov and Dolgui, 2019). Today, agility and the ability to quickly adapt are key in determining competitiveness. Given this, the supply chain is now much more resilient to change. These technologies no longer only provide increased efficiency but also ensure continuity even under global disruptions. A supply chain driven by artificial intelligence and automation outperforms traditional systems in speed, flexibility and precision. AI-driven logistics minimizes energy consumption and emissions, while predictive analytics support circular economy models that encourage waste reduction and product reuse (Dash et al., 2019). Such industry principles correspond to the principles of Industry 5.0, combining digital intelligence with human-centered innovation. In addition to the above advantages, there are also challenges that need to be highlighted, as high costs, a lack of qualified experts and data management problems remain insurmountable obstacles for many organizations. Ethical issues such as data privacy and job losses must continue to receive equal attention as the benefits of use to ensure that the transformation is responsible. In order for organizations to have as many benefits as possible with as few negative impacts as possible, it is necessary to gradually integrate AI, invest in education and retraining of the workforce, strengthen data management and increase cybersecurity, promote the ethical use of AI and integrate sustainable business goals into the AI system. Also, encouraging collaboration and knowledge sharing is one of the most important items where industries, academia and governments can accelerate innovation and share good practices. As supply chains evolve from reactive systems to intelligent networks, the future belongs to those who not only adopt artificial intelligence but also understand how it works, invest in knowledge, and meaningfully integrate it into their organizations.

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