Challenges in Adopting Artificial Intelligence Technologies in Supply Chain Management in Romanian Companies

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Abstract

This study explores the adoption and impact of Artificial Intelligence (AI) in supply chain management (SCM) within Romanian companies, focusing on its transformative role in enhancing operational efficiency, decision-making, and resilience. Using a qualitative research approach, data were collected through focus group discussions with industry experts from diverse sectors, including telecommunications, agriculture, retail, and technology services. The findings reveal varied levels of AI adoption, highlighting its benefits in demand forecasting, inventory optimization, and logistics management. Key challenges identified include high implementation costs, data quality issues, and ethical concerns related to data privacy and algorithmic transparency. The study also emphasizes the critical role of robust data governance and regulatory compliance in successful AI integration. Emerging trends, such as AI-driven sustainability initiatives and integration with blockchain technology, are discussed. This research contributes to the academic discourse on digital transformation, offering practical insights for organizations seeking to leverage AI for competitive advantage.

Keywords: *Artificial Intelligence, Supply Chain Management, Digital Transformation, Data Quality, Ethical Considerations.*

JEL classification: O32, L23, M15, C88, D83

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1. Introduction

The continuous evolution of digital technologies has revolutionized supply chain management (SCM), fostering systems that are more efficient, transparent, and adaptable to dynamic environments. This transformation is deeply rooted in the principles of Industry 4.0, which integrates advanced technologies such as the Internet of Things (IoT), Cyber-Physical Systems (CPS), Enterprise Resource Planning (ERP) systems, Big Data analytics, and Artificial Intelligence (AI).

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Together, these innovations have cultivated highly interconnected and agile supply chain networks (Büyüközkan & Göçer, 2018; Bhargava et al., 2013).

The convergence of digital technologies like AI and blockchain has significantly redefined supply chain ecosystems, enabling greater transparency, efficiency, and data security (Queiroz & Wamba, 2019). Emerging concepts such as digital supply chain twins are increasingly being used to model and manage operational risks, particularly in volatile business environments (Ivanov & Dolgui, 2020). Industry 4.0 not only drives operational efficiencies but also fosters sustainability practices by optimizing resource utilization and reducing waste (Ghobakhloo, 2020). The integration of big data analytics with AI technologies has proven to enhance supply chain agility and responsiveness, particularly in dynamic environments (Wamba et al., 2020). Additionally, the synergy between Industry 4.0 technologies and lean manufacturing practices plays a critical role in driving sustainable organizational performance (Kamble et al., 2020). One study also provides results that shows how competitive advantage is generated through digitalisation by investment in innovation, stakeholder engagement, product development cost reduction and improving organizational reputation (Pinzaru et al., 2021). By offering a strategic framework, streamlining procedures, standardizing operations, boosting data management, improving customer experience, encouraging continuous improvement, and investing in staff competencies, the implementation of digitalization strategies has a direct impact on the caliber of business digitalization processes (Cristache et al., 2024). Organizations must work with the ecosystem and modify their business model globally in order to increase their competitiveness in the market, as digitalization is occurring everywhere on a global scale and everything is interconnected in the global economy (Gruia et al., 2020). Employee capabilities and their effectiveness in using AI tools were found to be significantly correlated, and one study's findings offer a better understanding of the ways in which employees' performance with AI tools is influenced by their technical, managerial, social, personal, and digital skills (Popa et al., 2023).

Among these transformative technologies, AI has emerged as a pivotal driver of change, offering remarkable advancements in operational efficiency, predictive accuracy, and strategic decision-making across various supply chain functions. Its applications span from predictive analytics and machine learning to process automation and intelligent robotics, addressing challenges related to demand forecasting, inventory optimization, logistics coordination, and quality management (Toorajipour et al., 2021). The ability of AI to process extensive datasets and generate actionable insights enhances supply chains' capacity to swiftly adapt to market fluctuations, thereby minimizing inefficiencies and boosting overall performance (Dubey et al., 2019). Nevertheless, the effective deployment of AI hinges on critical factors such as data quality, ethical considerations, and regulatory compliance (Ahmad et al., 2019; Matin et al., 2023).

This study investigates the adoption and influence of AI within supply chain management practices in Romanian enterprises. It employs qualitative research, drawing on insights from industry experts across multiple sectors. The research focuses on understanding the current applications of AI, the perceived advantages and obstacles to its implementation, the role of data integrity, and the ethical and regulatory landscapes influencing AI adoption. Furthermore, it explores emerging trends and potential future developments in AI-driven supply chain management.

By merging theoretical frameworks with empirical evidence, this paper aims to enrich the academic discourse on AI in supply chain contexts while providing strategic insights for practitioners. The findings are expected to inform effective AI integration strategies, ultimately contributing to enhanced competitiveness and operational excellence in Romanian supply chains.

2. Literature Review

2.1 Digital Transformation in Supply Chain Management

The shift towards digital supply chain management (SCM) reflects a profound transformation spurred by rapid technological advancements. This evolution, closely linked to Industry 4.0, integrates innovative technologies such as the Internet of Things (IoT), Cyber-Physical Systems (CPS), Enterprise Resource Planning (ERP) systems, Big Data analytics, and Artificial Intelligence (AI), fostering supply chains that are more dynamic, responsive, and interconnected (Büyüközkan & Göçer, 2018; Bhargava et al., 2013). One study shows that digitalization and sustainability are directly related and digitalization affects sustainability practices, and internal and external variables that drive the adoption of sustainability affect businesses' digital transformation (Pinzaru et al., 2021).

A defining characteristic of modern supply chains is their ability to utilize real-time data for enhanced decision-making and operational transparency (Preindl et al., 2020). The deployment of IoT devices facilitates continuous monitoring of assets and inventory, reducing inefficiencies and optimizing resource distribution (Ben-Daya et al., 2017). Moreover, cloud computing plays a pivotal role by enabling seamless collaboration among supply chain partners, thus improving coordination and strategic planning (Lamba & Singh, 2017).

The convergence of IoT and blockchain technologies has been pivotal in enhancing supply chain transparency and traceability, reducing operational risks, and improving data integrity (Rejeb et al., 2021). In data-driven agricultural supply chains, AI technologies have demonstrated their potential to improve sustainability performance through enhanced forecasting and resource optimization (Kamble et al., 2019). Blockchain technology plays a crucial role in promoting sustainable supply chain management practices by enabling secure, transparent, and immutable data transactions (Saberi et al., 2019).

2.2 The Impact of Artificial Intelligence on Supply Chain Management

Artificial Intelligence (AI) stands out as a transformative force within SCM, offering a spectrum of applications that boost efficiency, accuracy, and strategic agility. From machine learning algorithms to predictive analytics and robotics, AI is increasingly employed to tackle complex supply chain challenges, including demand forecasting, inventory control, logistics optimization, and quality assurance (Toorajipour et al., 2021). The growing relevance and impact of AI in business and management research is demonstrated in a study done by Vidu (2024), which shows that the publishing output is growing over time at a very high rate of 31.9%, greater than the compound annual growth rate for general publications in the majority of nations. In one study it was determined that SCIPs (supply chain innovative practices) are essential instruments that significantly and favorably improve customer satisfaction in the manufacturing SMEs that were surveyed. Customer satisfaction is based on the timely and cost-effective delivery of items to clients made possible by SCIPs (Lelo & Israel, 2024).

One of AI's most significant contributions is its capacity to analyse vast datasets, generating insights that improve forecasting and strategic decision-making. For example, predictive analytics powered by AI can refine demand forecasting, allowing businesses to align inventory with market needs, thereby minimizing surplus and stockouts (Dubey et al., 2019). Additionally, automation technologies, such as robotic process automation (RPA) and autonomous transport systems, streamline logistics, enhance productivity, and reduce human error (Ivanov et al., 2019).

The effectiveness of AI in SCM heavily relies on the quality of data. Reliable, high-quality data is critical for training AI models to produce accurate, actionable insights. The adage "garbage in, garbage out" underscores the necessity of robust data governance to ensure data integrity and consistency (Matin et al., 2023). Furthermore, ethical and regulatory frameworks, including compliance with data protection regulations like GDPR, significantly influence the adoption and integration of AI technologies (Ahmad et al., 2019).

Big Data analytics enhances supply chain decision-making processes by enabling real-time data processing, predictive insights, and performance optimization (Gonzalez & Martins, 2020). The application of blockchain in manufacturing has shown promising results in improving data security, enhancing supply chain visibility, and reducing fraud (Li et al., 2019). Big Data analytics supports supply chain resilience by providing early warning systems, predictive risk assessments, and adaptive response strategies during disruptions (Papadopoulos et al., 2019).

2.3 Evaluating the Value of AI in Supply Chain Processes

The integration of AI into SCM extends across key operational domains, enhancing procurement, production, inventory management, logistics, and customer engagement. AI's analytical prowess and predictive capabilities significantly improve operational efficiencies and strategic outcomes.

In Procurement and Supplier Relationships AI revolutionizes procurement processes through advanced supplier analytics, risk management, and contract optimization. By analysing historical performance data and market trends, AI systems can identify the most reliable suppliers, assess potential risks, and optimize sourcing decisions (Chae et al., 2020). Automation tools further streamline procurement operations, reducing administrative burdens and increasing process efficiency (Kumar et al., 2020).

For manufacturing and production optimization, AI facilitates predictive maintenance, process optimization, and stringent quality control. Machine learning models predict equipment failures, enabling proactive maintenance that minimizes downtime and operational disruptions (Jeschke et al., 2017). AI also enhances production planning by dynamically adjusting schedules based on real-time data, thereby maximizing resource utilization (Wang et al., 2019). Moreover, AI-driven quality management systems improve defect detection, ensuring consistent product standards and reducing waste (Zhong et al., 2017).

AI's role in inventory management is pivotal, offering sophisticated demand forecasting and stock optimization capabilities. By analysing trends and external variables, AI helps maintain optimal inventory levels, reducing costs associated with overstocking and stockouts (Hofmann & Rüsch, 2017). In logistics, AI optimizes route planning and enhances warehouse operations, leading to significant cost savings and efficiency gains (McKinsey & Company, 2017).

Thematic analysis remains a cornerstone for qualitative research, ensuring methodological rigor and trustworthiness when analysing complex data sets (Nowell et al., 2017). Blockchain's dynamic capabilities can significantly enhance supply chain performance through improved information sharing, operational transparency, and real-time monitoring (Queiroz et al., 2020).

Enhancing customer experience through AI also transforms customer interactions, enabling personalized service and responsive support. AI-driven chatbots and virtual assistants handle customer inquiries efficiently, improving satisfaction and operational scalability (Liu et al., 2020). Additionally, AI analyses customer behaviour to tailor marketing strategies and product recommendations, fostering deeper customer engagement and loyalty (Huang & Rust, 2018).

In summary, AI's integration into SCM processes delivers substantial benefits, from operational efficiencies to strategic insights. Its ability to enhance decision-making, streamline operations, and improve customer experiences positions AI as a cornerstone of modern supply chain strategies. As AI technologies continue to evolve, their impact on supply chain dynamics is expected to grow, driving innovation and competitive advantage across industries.

3. Methodology

This research employs a qualitative methodology to investigate the adoption and impact of Artificial Intelligence (AI) in supply chain management (SCM) within Romanian companies. The qualitative approach was selected to provide an in-depth understanding of industry experts' experiences and perspectives on AI integration, revealing nuanced insights that quantitative methods might overlook (Creswell & Poth, 2018).

3.1 Research Design

Focus group discussions were employed as a data collection method to facilitate dynamic interactions and capture diverse perspectives, as recommended in qualitative research guidelines (Krueger & Casey, 2015). This method was chosen for its ability to capture dynamic interactions, enabling participants to build on each other's ideas and provide rich, multifaceted data (Krueger & Casey, 2015). The focus group format encourages the exchange of diverse viewpoints, offering a comprehensive exploration of AI's role in SCM.

3.2 Participant Selection

Participants were purposively selected from various sectors, including telecommunications, agriculture, retail, sports goods, and technology services. The selection criteria emphasized individuals with expertise in supply chain management, technology implementation, and AI adoption. Key personas included supply chain managers, IT managers, operations managers, logistics coordinators, procurement specialists, AI implementation consultants, and regulatory compliance officers. This diverse representation ensured a broad spectrum of insights into AI's applications and challenges across different industries.

3.3 Data Collection

Data was collected through semi-structured interviews within the focus group sessions. This format allowed for flexibility in probing deeper into specific topics while maintaining consistency across discussions. The interview guide covered core areas such as: “Current applications of AI in supply chain operations” “Perceived benefits and strategic value of AI integration” “Challenges and barriers to AI adoption” “The role of data quality in AI effectiveness” “Ethical considerations and regulatory compliance issues” “Anticipated future trends and innovations in AI for SCM”. Semi-structured interviews within the focus groups allowed for flexibility in exploring emergent topics, fostering rich data collection (Guest et al., 2017).

3.4 Data Analysis

The collected data were analysed using thematic analysis, a method well-suited for identifying, analysing, and reporting patterns within qualitative data (Braun & Clarke, 2006). The process involved coding the transcripts to categorize key themes and sub-themes related to AI adoption. Themes were developed inductively, allowing insights to emerge organically from the data. This analytical approach provided a comprehensive understanding of the factors influencing AI implementation in supply chains. Trustworthiness in qualitative research was ensured through strategies that address credibility, transferability, dependability, and confirmability, as suggested by (Guba & Lincoln, 1994).

3.5 Ethical Considerations

Ethical integrity was maintained throughout the research process. Participants provided informed consent, ensuring they understood the study's purpose and their role within it. Confidentiality and anonymity were upheld, with all data securely stored and participant identities anonymized in the reporting. The study adhered to ethical guidelines for qualitative research, ensuring respect for participants' rights and data protection standards. Ethical considerations were integral to the research design, ensuring informed consent, confidentiality, and data protection in compliance with qualitative research ethics (Israel & Hay, 2006).

3.6 Findings and Discussion

The qualitative analysis of the focus group discussions revealed several key themes regarding AI adoption in supply chain management (SCM) within Romanian companies. The findings provide insights into the current state of AI implementation, perceived benefits, existing challenges, the importance of data quality, ethical considerations, and future trends.

Current state of AI adoption across the participating companies varies significantly. Some organizations, particularly in retail and agriculture, have integrated AI-driven tools for inventory management, demand forecasting, and warehouse automation. In contrast, industries like telecommunications are in the exploratory phase, focusing on evaluating the costs, benefits, and potential risks associated with AI implementation. The sports goods sector demonstrated advanced AI integration, leveraging technologies like RFID and robotics for real-time supply chain monitoring.

Perceived benefits of AI highlighted several benefits associated with this technologies adoption. These include improved operational efficiency, enhanced decision-making capabilities, and increased responsiveness to market changes. AI-driven predictive analytics have proven valuable for demand forecasting, while automation tools have streamlined logistics and inventory management processes, reducing errors and operational costs.

Despite the recognized benefits, participants identified numerous barriers to AI adoption. High implementation costs, data security concerns, and the complexity of integrating AI with legacy systems were common challenges. Additionally, the lack of skilled personnel to manage AI technologies and the need for continuous training were noted as significant hurdles. Regulatory compliance, particularly concerning data privacy and ethical considerations, also emerged as critical challenges.

Impact of data quality was emphasized as a fundamental factor influencing AI effectiveness. Participants agreed that poor data quality undermines AI performance, leading to inaccurate predictions and suboptimal decision-making. Companies with advanced data governance practices reported better outcomes from their AI initiatives. The "garbage in, garbage out" principle was frequently cited, highlighting the necessity of maintaining high data integrity and consistency.

Ethical and regulatory considerations issues, including data privacy, algorithmic transparency, and bias in AI models, were key concerns among participants. Compliance with regulations such as GDPR was identified as both a challenge and a priority. Companies expressed the need for clear guidelines to navigate the ethical landscape of AI, emphasizing the importance of accountability and transparency in AI-driven decision-making processes.

Looking ahead, participants anticipate that AI will play an increasingly strategic role in SCM. Emerging trends include the integration of AI with blockchain for enhanced traceability, the use of AI-powered robotics in warehouse operations, and the development of more sophisticated predictive models. Participants also highlighted the potential of AI to drive sustainability initiatives by optimizing resource use and reducing waste.

4. Conclusion

The adoption of Artificial Intelligence (AI) in supply chain management (SCM) represents a pivotal shift towards more data-driven, agile, and resilient operations. This study reveals that AI contributes significantly to enhancing supply chain efficiency, predictive capabilities, and decision-making processes, while also highlighting critical challenges related to implementation, data integrity, and ethical considerations.

One of the core findings underscores the transformative potential of AI in optimizing supply chain functions such as demand forecasting, inventory management, and logistics coordination. AI-driven predictive analytics and automation tools enable companies to anticipate market fluctuations, streamline operations, and reduce operational costs, aligning with global best practices in digital supply chain transformation (Christopher, 2022).

However, the successful integration of AI technologies is not without challenges. High implementation costs, data security risks, and the complexity of legacy system integration are significant barriers, consistent with findings from prior research on digital transformation hurdles (Kache & Seuring, 2017). Moreover, the study highlights the critical role of data quality, as poor data integrity can undermine AI performance, leading to inaccurate insights and suboptimal decisions (McAfee & Brynjolfsson, 2012).

Ethical and regulatory concerns also play a pivotal role in shaping AI adoption strategies. Issues such as algorithmic transparency, data privacy, and compliance with regulations like GDPR necessitate robust governance frameworks to ensure ethical AI deployment (Zeng et al., 2022). Companies must prioritize ethical considerations alongside technological advancements to maintain stakeholder trust and regulatory compliance.

Looking forward, the potential of AI in SCM is vast, with emerging trends pointing towards increased integration with technologies like blockchain for enhanced traceability, advanced robotics for automation, and AI-driven sustainability initiatives aimed at optimizing resource utilization (Ivanov & Dolgui, 2020). To fully leverage these opportunities, organizations must invest in continuous learning, cross-functional collaboration, and strategic planning that aligns with the evolving digital landscape.

In conclusion, this study contributes to the growing body of knowledge on AI in SCM, providing valuable insights for both academic and practical applications. The findings emphasize the need for holistic strategies that address technological, organizational, and ethical dimensions to maximize the benefits of AI. Future research should explore longitudinal impacts of AI adoption and the interplay between emerging technologies in driving supply chain resilience and innovation.

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