



AI Applications in Supply Chain Management: Present Scenario and Future Prospects

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Abstract

A well-functioning supply chain is a key to success for every business organization. In recent years Artificial Intelligence (AI) has been proved to become an extension of our mind, expanding our cognitive abilities to levels that we never thought would be possible. Though many believe AI will replace humans, it is not true. AI has been integrated into many sectors of business and been proved to reduce costs, increase revenue, and enhance asset utilization. The study focuses on recent trends, major gaps and opportunities with reference to Artificial Intelligence (AI) applications in Supply chain Management (SCM). This research offers a comprehensive overview of how AI is influencing the present and future state of SCM. It provides vital insights for researchers, practitioners and decision-making who are involved in this dynamic and everchanging field. This paper critically evaluates the role of AI in supply chain management. It also discusses AI applications on sub fields of Supply chain management and the challenges related to implementation of AI in SCM.

Keywords : Artificial Intelligence, Supply Chain Management, Logistics, Implementation of AI, Planning

1. INTRODUCTION

In today's competitive global marketplace, companies must operate their organizations focussing on maintaining growth. Businesses that employ transformative artificial intelligence (AI) technologies have a strategic advantage in overcoming challenges and effectively managing their supply chains. By taking advantage of AI, companies can improve cost efficiency, enhance operational performance, and elevate the customer experience. AI has the capability to accurately anticipate future demand, enabling companies to optimize inventory, streamline supply chain processes, and mitigate the risks associated with stockouts or overstocking.

The integration of Artificial Intelligence (AI) into supply chain management (SCM) has revolutionized traditional practices, bringing about significant advancements in efficiency and strategic decision-making. AI technologies, such as machine learning, predictive analytics, and autonomous systems, have shown immense potential in optimizing supply chain operations.

These technologies improve demand forecasting, streamline logistics, and enhance overall operational efficiency, thereby maintaining competitiveness in a dynamic business environment.

Focus areas are

- Enhancement of Operational Efficiency
- Challenges and Strategic Implementation
- Real-World Applications and Insights

AI is essential for automation and digitalization of supply chain activities and the subsequent improvement of supply chain productivity (Dolgui and Ivanov 2021). In particular, the use of AI in SCM can fundamentally metamorphose current business practices and managerial tasks.

AI is deployed by thousands of organizations around the world, the business potential of AI still remains untapped (Brynjolfsson and McAfee 2017). As AI emerges from theoretical backgrounds to become the frontier of game-changing technologies, there is an urgent need for systematic development and implementation of AI to see its real impact in the next generation of data-driven supply chains.

Applications have recently gained interest among researchers because of their capability to rapidly and intelligently manage big data and handle nonlinear problems that are widespread in real-world supply chains (Riahi et al. 2021; Tirkolaei et al. 2021). This supports decision-making by exploiting both historical and real-time data with only minor human involvement (Zeba et al. 2020), improves performance (Fosso Wamba et al. 2021), and enhances competitive advantage (Dubey et al. 2020).

2. LITERATURE REVIEW

AI is a good tool to determine the price elasticity for every item and automatically adjust prices according to the chosen product strategy (Khorram 2019). In the retail industry, AI is been extensively used to optimize, update, and tailor it to each shopper in real time. AI program is been exploited which looked for clues about what the shopper will like based on previous purchases, age, home address, web browsing habits, and mounds of other data. This kind of insights-based selling, including personalized promotions, optimized assortment, and tailored displays, increase sales substantially (Mathur 2019, Bughin et al, 2017).

In recent years, artificial intelligence has enabled pricing solutions to track buying trends and determine more competitive product prices (Paolanti et al 2018). AI-driven pricing software has been included in various sectors including consumer goods, fashion, hospitality, and transportation (Meng et al 2018).

Amazon has embedded AI at the core of its operations. In the retailer's warehouse at Seattle, machine learning algorithms steer thousands of products over a maze of conveyor belts and deliver them to humans just in time to fill shopping bags. Other robots whisk bags to delivery vans whose drivers are guided by an AI application that picks the best route based on weather and traffic conditions (Fildes et al 2018, Burgess A 2018).

AI technologies like Virtual reality in manufacturing link thousands of different parts most importantly, it provides transparency on supplier machine availability, performance, and downtime, etc. It helps in balancing the supply chain and optimize inventories in real time (Kraus et al 2018).

AI has helped manufacturing plants around the globe in supply chains, and value chains which are more interconnected and collaborative (Klumpp 2018). AI is also not far behind in agriculture. The concept of "e-plants in a box" is a reality which is great for small-scale, low-capital-expenditure, mobile plants that can produce a limited range of products at a competitive cost.

Table 1. Application areas and domains of AI

Domain	Application area	Author(s)
Industrial Systems and Engineering	Machine fault diagnosis	Liu et al. (2018)
Data Science	Explainable AI	Adadi and Berrada (2018)
Societal impacts of AI	AI applications across different sectors	Makridakis (2018)
Developmental history of AI	AI perspective	Pan (2016)
Industry 4.0 based manufacturing systems	AI ecosystem design in smart manufacturing	Lee et al. (2018)
Supply chain	Risk management	Baryannis, Dani, and Antoniou (2019a)

The integration of artificial intelligence (AI) into supply chain management has emerged as a transformative force, offering innovative solutions to address the complexities and uncertainties inherent in modern supply networks (Farooq et al., 2022). This literature study provides a comprehensive analysis of the main applications of artificial intelligence (AI) in supply chain management. The analysis conducts a thematic examination of notable articles, identifying areas of research that are deficient and emerging patterns in this swiftly developing field. The literature reveals several AI applications that contribute to various facets of supply chain management.

The existing body of research examines the impact of artificial intelligence (AI) on enhancing transparency within supply chains and mitigating the adverse consequences of interruptions in last-mile delivery. The focus on last-mile delivery underscores the significance of AI in delivering customized and efficient logistics solutions (Singh et al., 2023; Modgil et al., 2022).

Yang et al. (2021) have investigated the use of AI-based methods to improve the ability of supply chains to withstand and recover from extreme weather events and interruptions. The findings underscore the capacity of artificial intelligence (AI) in proactive risk management, as exemplified by the studies conducted by Effah et al. (2023) and Gupta et al. (2021).

The area of Multiagent Systems and Collaboration focuses on utilizing multiagent systems to tackle the challenges of distributed artificial intelligence in supply chains. It provides useful perspectives on collaboration approaches across diverse enterprises. This highlights the importance of AI in fostering collaboration and facilitating the flow of knowledge.

In this study, Mukherjee et al. (2023) analyze the impact of artificial intelligence (AI) on micro, small, and medium companies (MSMEs) in India. They establish a theoretical framework through empirical investigation. This research offers essential insights for smaller companies looking to deploy AI-driven projects.

Olan et al. (2022) investigate the utilization of artificial intelligence (AI) in sustainable supply chain financing, providing both theoretical and practical insights to improve performance. This adds another dimension to the utilization of artificial intelligence in the financial elements of supply chain management.

3. RESEARCH OBJECTIVES

1. To understand the concept of Artificial Intelligence (AI).
2. To identify the need of AI Integration in Supply Chain Management.
3. To explore AI's role in enhancing Supply Chain Efficiency.
4. To analyse AI's Impact on Industry's competitive Landscape.
5. To evaluate the opportunities and challenges with reference to implementation of AI in SCM.

4. RESEARCH METHODOLOGY

Due to the development of AI tools and considering its widespread role in Supply chain management, several enterprises have begun implementation of AI in their Supply chain structure. However, there has been little research about present scenario with reference to AI applications in Supply chain management. The companies' intention towards AI as well as relationship between the intention and actual implementation of AI is also debatable.

Considering the nature of the research, it is based on the secondary data of national and international journals, government reports, articles, books, newspapers and magazines, covering the wide collection of academic literature on AI implementation in the supply chain context.

This study also utilizes a variety of secondary data sources to provide a comprehensive analysis of AI's role in Supply chain management including Academic papers, Industry reports and case studies.

Considering the research objectives, we have used descriptive research design to ensure rigorous analysis of research study. Available secondary data was extensively used for academic research only. Scope of the paper is limited to AI applications in Supply chain management considering certain parameters. This study also presents the information about the impact of AI technology adopted by the business organizations. Due to practical and time constraints the research provides a review of AI implementation in supply chain based on the secondary data only.

5. DATA ANALYSIS

5.1 Impact of AI on Supply Chain Management Performance

In order to achieve long-term objectives, it is crucial to evaluate the extent to which needs are satisfied, and resources are used effectively. Focusing on a single firm's performance in the supply chain, a supply chain review considers the interdependencies between all the businesses involved. It gives context for understanding the whole system, shapes how people act, and reveals how efficient stakeholders and supply chain actors are. Management relies heavily on the creation and use of performance measures. Transparency and extensive familiarity with the supply chain are aided by using performance measurement tools. Inside the company supply chain effectiveness may be measured by keeping tabs on key indicators, including lead time, fill rate, and on-time performance (Yu et al.,2017).

An artificial intelligence program may assist reduce wasteful inventory expenses by anticipating customers' needs. Automation can greatly improve warehouse efficiency, which is essential for effectively running the supply chain. Automating warehouse processes using AI might save time and money by reducing the need for human workers.

The components of supply chain management digitalization include integration of information, resources, and networks, automation using robotics technology, process automation, and intelligent processes, reconfiguration of supply chain networks, an adjustment in the structure of the organization, and supply chains to improve performance, supply chain analytics that assure real-time execution, decisions, process optimization, and advanced forecasting, supply chain process with repetition of a plan, source, make, deliver, and return.

AI can effectively improve the performance of supply chain management. It was reported by Mohsin 2023, digital supply chain utilizes AI, big data, blockchains, cloud and IoT. Blockchain technology improves supply chain management by facilitating improved process monitoring, simplified regulatory compliance and more reliable reporting. The cloud enables activities to be carried out rapidly, flexibly, at scale and fully view all parties involved. IoT helps supply chain

professionals like inventory planners, production managers, and procurement managers have more accurate information and forecasts to make strategic decisions regarding the buying, creating, and selling of goods.

McKinsey and Company 2021 study found that AI-enabled real-time monitoring and control of production and logistics processes can lead to increased responsiveness and flexibility in supply chain management. This can help companies to quickly adapt to changes in demand and other disruptions leading to improved performance.

AI can enhance transparency in supply chain management by providing real-time visibility into logistics and production processes. This can help companies to identify and respond to problems more quickly, reducing waste and increasing efficiency. AI has the potential to significantly improve the performance of supply chain management in several ways. AI can be used to analyze large amounts of data from various sources, such as sensor data, weather forecasts, and social media, to predict future demand and optimize inventory levels.

AI can be used to optimize logistics, such as transport routes, and scheduling of production and delivery, reducing costs, and improving efficiency. AI can be used to predict when equipment will fail and schedule maintenance, accordingly, reducing downtime and costs. It can be used to identify and mitigate potential risks in the supply chain, such as natural disasters and supply shortages

AI can be used to monitor and inspect products during production and transportation, ensuring quality and reducing the risk of defects or damage. It can be used to automate repetitive tasks. AI can help companies to improve their supply chain performance by increasing efficiency, reducing costs, and improving the quality of products and services.

5.2 AI applications in Supply Chain Management

5.2.1 Inventory Control and Planning

AI techniques such as expert systems offer a promising new approach to inventory control and planning problems of great magnitude and complexity due to their powerful knowledge representation language that is capable of capturing inventory patterns throughout the entire SC at all levels of detail. The capturing of such dynamic complexity in the inventory database enables human experts such as inventory managers to estimate the desirable level of inventory at each stocking point without causing a bullwhip effect.

Another important application of AI techniques to inventory control and planning includes the study of Teodorovic et al. (2002) who developed fuzzy logic rules to make online, intelligent,

airline seat inventory control decisions as to whether to accept or reject any passenger request for seating arrangements.

5.2.2 Transportation network design

AI technique can be applied successfully to handle well-known network design problems including the vehicle routing problem.

5.2.3 Purchasing and Supply management

Due to the complexity, the make-or-buy decision calls for systematic decision aid tools. Such tools include an expert system, for example, Humphreys et al. 2002 developed an expert system that could assist the purchasing manager in evaluating the performance of prospective suppliers, enhancing information exchange among the purchasing personnel, and reducing the time to make or buy decisions.

Nissan and Sengupta 2006 proposed intelligent software agents that could automate the processes of searching for prospective suppliers through online catalogs, evaluating suppliers with respect to multiple attributes, screening qualified suppliers and completing the purchase order.

5.2.4 Demand Planning and forecasting

Yu et al (2002) proposed a dynamic pattern matching procedure within the agent-based system framework that combines human expertise and data mining techniques to predict the demand for new products. Their experiments indicated that the dynamic pattern matching procedure outperformed exponential smoothing techniques with respect to forecasting accuracy.

Jeong et al. 2002 improved forecasting accuracy without relying heavily on historical data by introducing a genetic algorithm-based causal forecasting technique that outperformed traditional regression analysis.

5.2.5 Order-picking problems

Order-picking problem has often been tackled by simulation models and mathematical models in the past, the use of AI techniques such as an intelligent agent-based system may better handle the added complexity caused by the increasing adoption of value-added services and e-fulfillments due to their inherent learning capability.

5.2.6 Customer relationship management

CRM is referred to as the business practice that is intended to improve service delivery, build social bonds with customers, and secure customer loyalty by nurturing a long-term, mutually

beneficial relationship with valued customers, selected from a pool of more than a few customers (Min 2006).

Baxter et al. 2003 proposed an agent-based model that simulated interaction between members of customer populations and business environments in which they were contained. Their agent-based model considered the communication of customer experiences between members of a social network and then incorporated the powerful influence of word-of-mouth reputation on the purchase of products and services. By doing so, it aided the firm in assessing the extent of its return on investment in CRM and enhancing its customer acquisition efforts.

6. FINDINGS & CONCLUSION

1. The application of AI in supply chain management is growing significantly.
2. The role of AI in supply chain management is admirable and has a positive impact on different sub-fields of supply chain management, which include demand forecasting, distribution and transportation, logistics hub management, sales, marketing, founding, production and inventory.
3. The implementation of AI in supply chain management requires significant resources and expertise and also raises important ethical concerns, such as data privacy and security.
4. There is a lack of standardization in the implementation of AI in supply chain management, making it difficult to compare results and impact across different organizations.
5. There is a challenge in integrating AI systems with existing supply chain management systems, which can lead to limitations in data availability and accuracy.
6. There is limited research on the ethical and privacy implications of AI in supply chain management, including the potential for discrimination and the protection of sensitive data.
7. It is predicted that there will be a shift towards a human-centered approach in AI-driven supply chain management, with a greater focus on training and development for the workforce, as well as considering the human impact of automation and AI-driven processes.
8. AI tools will focus on strategic alliances among supply chain partners, supply chain coordination, collaborative demand planning and business-to-business negotiations that have been overlooked by more traditional analytical models.

7. SUGGESTIONS

AI will have a promising future in the SCM area. Based on projected AI trends, we suggest the following:-

1. To ensure effective utilization of AI in supply chain management, there is need of training & development programs for the work force.
2. Need to develop clear and effective AI implementation plan in Supply chain.
3. More investment on infrastructure and skill development for effective and decisive implementation of AI.
4. A need of ethical guidelines and regulatory framework for AI implementation in supply chain.
5. Business organizations should focus on developing a culture of innovation and continuous improvement in business practices with the help of AI applications.
6. AI can be integrated with existing legacy system of various supply chain partners without disrupting information flows across the supply chain.
7. Business Organizations should focus on understanding the challenges with respect to AI applications in supply chain management.

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