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Impact of Artificial Intelligence on Supply Chain Management Performance

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Abstract

Artificial Intelligence (AI) has the potential to revolutionize various aspects of business operations. AI can be used to analyze data and make predictions about demand, optimize logistics and transportation routes, and identify inefficiencies in the supply chain. This can lead to improved responsiveness to changes in demand, reduced lead times, and lower costs. This paper reviews and analyzes the applications of AI in supply chain management (SCM) using the Scopus database. The objective is to address the current research gap of AI's impact on the performance of SCM, determining the AI techniques that can enhance the performance of SCM, the SCM subfields that have high potential to be enhanced by AI, the impact of AI application on the performance of SCM, and how the performance can be described in agile-lean perspective. Scopus database was utilized to outline and identify the active countries/regions in the field of AI impact on SCM performance, subject area, and type of documents.

Keywords

Artificial Intelligence, Supply Chain Management, Performance, Scopus Database

1. Introduction

AI is having a great impact on supply chain management. Supply chain management logistics firms can benefit from AI's ability to monitor freight forwarding on a massive scale and anticipate shipping needs (Rahimi & Alemtabriz, 2022). With the help of AI, supply chain managers now get a clearer picture of the overall system, leading to smarter decisions and more attentive customer service. This trend took root with the introduction of expert systems and fuzzy logic and reached full maturity sometime after 2010. Today's state-of-the-art AI

was molded by the development of big data, analytics, and various graphics processing unit (GPU) and deep learning (DL) applications (Li, 2020).

Since early 2010, AI applications have exploded in popularity, generating both excitement and trepidation about the future of labor and corporate administration (Li, 2020). The supply chain literature appears to be playing catch-up with some recent efforts to incorporate modern AI methods within its core studies, even though businesses are embracing AI and investing in AI solutions to improve their end-to-end supply chain operations (Hartmann & Moeller, 2014). At the same time, our research revealed substantial fragmentation in AI research, highlighting the need for a reasonably acceptable and inclusive taxonomy that can guide operations and supply chain researchers in broadening their understanding of the past, present, and future scope of research into AI applications in SCM. This literature research was undertaken to answer the following questions. Where do we stand in terms of published work concerning the use of AI in supply chain management? Where have studies of AI techniques been conducted, and what kinds of supply chain settings have they examined? How might we see further research into the role of AI in supply chain management? In what areas of the supply chain do you see the most widespread adoption of these techniques? In order to answer these issues, we perform a comprehensive literature evaluation using a variety of research methods (Nayak & Choudhary, 2022). In order to comprehensively evaluate the topic and the studies associated with it, our multi-method approach begins with creating a novel taxonomy of AI applications. In-depth co-citation and network analysis will let us see the connections and patterns already present in this body of research. Meticulously crafted artificial intelligence taxonomy, a comprehensive bibliometric, a cluster analysis, and an in-depth assessment of future research routes are used in this first-of-its-kind attempt to review this literature and capture the research trends. McKinsey estimates that logistics expenses for businesses that have adopted AI-enabled supply-chain management have decreased by 15%, while inventory levels have increased by 35%, and service levels have increased by 65%. These are preliminary findings, and it's possible that AI's true promise in the supply chain lies in narrower, more predictive outputs (Camargo et al., 2020).

The objective of this article is to address the current research gap of AI's impact on the performance of SCM, determining the AI techniques that can enhance the performance of SCM, the SCM subfields that have high potential to be enhanced by AI, the impact of AI application on the performance of SCM, and how the performance can be described in agile-lean perspective. The article is organized in a way that starts with an introduction about the application of AI in SCM, and then, a second section is dedicated to AI technologies in specific applications in SCM to improve its performance; it concluded that AI has been increasingly applied in supply chain management to improve performance in an Agile and Lean perspective, section three covers some analysis of the literature regarding type of document, subject area, source type, and number of publications per country or region. Section four consists of a discussion on the impact

of AI on SCM performance, and the framework for SCM digitalization was discussed; the components of supply chain management digitalization include integration, automation, reconfiguration of supply chain networks, analysis, and SC process optimization. In section five, conclusion was stated and discussed; AI has the potential to improve performance in supply chain management from an Agile and Lean perspective by increasing responsiveness and flexibility, reducing waste, and improving collaboration and customer satisfaction.

2. Methodology

According to Awuzie and McDermott (2017), when the author collects data to explore a phenomenon, identifying themes and explaining patterns to generate a new or modified existing theory can be subsequently tested through additional data collection. The author has applied the exact process in this study; the secondary data was used to review the impact of AI applications on the performance of SCM. The secondary data was limited to peer-reviewed articles the from SCOPUS database.

Scopus provides a powerful search engine that allows different search parameters such as "Document search", "Author search", "Affiliation search", and "Advanced search" for many fields such as "Article Title, Abstract, Keywords", "Source Title", "Year of Publication", etc. The keywords used in this study are simply "Artificial Intelligence" and "Artificial Intelligence in Supply Chain Management Performance" in document search. Results were researched to include publications in those fields of research during the period 2012-2023. The retrieved data was used to obtain the following facts: type of document, subject area, source type, the number of publications per country or region, and number of publications per year.

3. Artificial Intelligence

Since its inception in 2012, AI has seen both development and collapse due to several factors. The last two decades have seen a resurgence in the interest and uses of AI across several industries as a result of the increased flow of data and complexity that has evolved in business scenarios (Scholten et al., 2014). The potential of AI in many business functions is being explored in light of current needs and future goals. AI is defined as a network of computers that can simulate human intellect while making decisions on how to approach a business problem (Huang & Rust, 2018). AI helps with business system design thinking and learns from data to gain insights without human input. With the help of AI, organizations can pinpoint the weak points in their supply chain management and allocate resources accordingly (FossoWamba & Akter, 2019). By rapidly extracting client expectations, sensing the market, utilizing failure modes, optimizing internal and external supply chains, and encouraging a more creative workforce through the automation of routine tasks, AI has the potential to help businesses build the best possible goods (Jabbour et al., 2020). There has been a

steady uptake of AI by industries as diverse as manufacturing and e-commerce to solve supply chain problems. Most supply chains experienced a new level of resilience testing during COVID-19 as they were challenged to handle increasingly complicated jobs (Zouari et al., 2021). Customers in the modern corporate world want supply chains to provide both customized solutions and reliability. With the use of AI, a system has been designed to detect client profiles and provide individualized products without compromising security or privacy. In conclusion, the application of AI is expanding at a rapid rate, and supply chains and organizations that don't recognize and capitalize on AI in their operations may soon be unable to achieve the necessary supply chain resilience in the dynamic business market that can emerge because of COVID-19-like scenarios.

"Expert systems", also known as "knowledge-based systems", are a subfield of artificial intelligence that focuses on the development of software that gives computers the ability to perform tasks that have historically been carried out by humans with the assistance of specialized instruction and knowledge in supply chain management (Pournader et al., 2021). The components of an expert system that are outlined by Kusiak (2019) are as follows: Knowledge reorientation, which is where knowledge is framed, the interface engine, which describes the control strategy, and knowledge acquisition, which enables the system to collect data and knowledge for the purpose of problem-solving in supply chain management.

Methods that are rule-based, fuzzy, frame-based, and hybrid are some examples of expert system approaches that can be utilized in conjunction with one another to obtain optimal outcomes of AI in supply chain management (Zarbakhshnia et al., 2018). According to the research that has been done by Jakupović et al. (2014), expert systems perform very well in fields in which human intelligence may be formally organized. If not formally captured, the efficiency of expert systems may drastically decrease (Haenlein & Kaplan, 2019). This difficulty becomes even more obvious when attempting to solve cognitive impairments with the help of expert systems.

In recent years, there has been a rise in interest in the practice of applying AI techniques to the modeling and simulation of complicated systems in supply chain management (Chen et al., 2022). Through the utilization of AI in the form of modeling and simulation, one can obtain a more in-depth grasp of how a system functions, hence enhancing their ability to make better decisions (Bennett & Hauser, 2013). Agent-based computing techniques could be a valuable tool for describing the interaction of system components and analyzing performance in real-world scenarios in supply chain management (Zamani et al., 2022).

AI has been increasingly applied in supply chain management to improve performance in an Agile and Lean perspective. Many companies are investing in digital solutions to optimize their supply chain operations, **Figure 1** (Statista, 2022) depicts the global AI adoption rate in supply chain and manufacturing businesses. Literature has shown that AI can provide companies with the ability

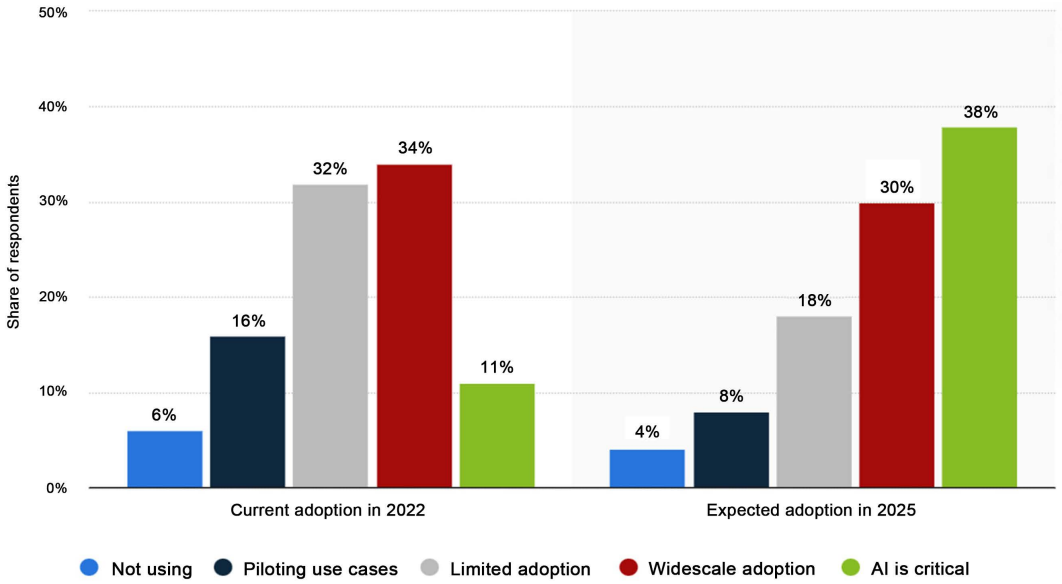

Figure 1. Global AI adoption rate in supply chain and manufacturing businesses (2022 and 2025), source: Statista (2022).

to respond quickly to changes in demand, reduce waste, and improve collaboration and customer satisfaction.

According to Barták et al. (2010), the term "artificial intelligence (AI) planning and scheduling in supply chain management" refers to a set of methods for making intelligent system decisions within the context of restrictions (such as the availability of resources in a manufacturing facility). Planning, in contrast to scheduling, which is concerned with the assignment of activities to resources in a specific amount of time, is concerned with making decisions to optimize the sequence in which activities take place (Kreipl & Pinedo, 2004). Recent advancements in artificial intelligence have made it possible for managers to detect and predict disruptions that may impair normal system operations (such as fraud detection, predictive maintenance, and system failures), and they have also assisted with system recovery in a more responsive and data-driven approach. These advancements have made it possible for managers to detect and predict disruptions that may impair normal system operations (Abedinnia et al., 2017).

4. Analysis of Literature

The quantitative analysis and the qualitative analysis were going to be used to analyze the literature review. The quantitative element of the report would comprise the industries related to supply chain management in which the techniques and technology of artificial intelligence are implemented (El Jaouhari et al., 2022). In addition to that, the perceiving, interacting, and deciding processes will all be a part of it. The analysis of the report conducted by the organization will be taken into consideration during the decision-making process of the organization. The purchasing operation, logistics, resource management, and information workflow would also be a part of the quantitative literature evaluation as

described by Rostami et al. (2022).

On the other hand, the qualitative literature evaluation considers the scientific gaps about the effects of AI on the performance of supply chain management. More directly to the topic at hand, the survey found that the influence of AI in supply chain management scored second and third in terms of the share of respondents indicating the potential for cost reduction and revenue rise across all eight business functions investigated (Tirkolaee et al., 2022). 63% of respondents reported increased revenues, while 61% reported decreased expenses. The most likely applications that prompted these modifications were found in sales and demand forecasting, expenditure analytics, and network optimization, all of which are part of supply chain management. McKinsey & Company (2019) summarized the prospective effects of AI on supply chain management. Unfortunately, it appears that it will be some time before widespread acceptance in the actual world matches that promise. The Internet of Things (IoT), robotics, and prescriptive analytics are all ahead of artificial intelligence (AI), which is presently ranked seventh. The good news is that almost a quarter of those who took part in the survey anticipate having adopted AI within the next two years.

Scopus database was employed to retrieve and evaluate the status of AI applications in SCM and its impact on its performance. Good information can be obtained from the Scopus database that can give an instinct into the research community, history, countries, affiliations, authors, published articles, abstracts, and several citations that can be exported and analyzed. The database includes a huge number of peer-reviewed literature: scientific journals, book chapters, and conference proceedings.

Scopus provides a useful and powerful search engine that allows different search parameters such as "Document search", "Author search", "Affiliation search", and "Advanced search" for many fields such as "Article Title, Abstract, Keywords", "Source Title", "Year of Publication", etc. The keywords used in this study are simply "Artificial Intelligence" and "Artificial Intelligence in Supply Chain Management Performance" in document search. Results were refined to include publications in those fields of research during the period 2012-2023. The retrieved data was used to obtain the following facts: a) Type of document, b) Subject area, c) Source type, d) and number of publications per country or region. Search was limited only to peer-reviewed scholarly articles.

When using the keywords "Artificial Intelligence" and "Artificial Intelligence in Supply Chain Management Performance", Scopus. **Figures 2-6** represent the obtained facts. **Figure 2** indicates that articles are the most popular type of document, followed by conference reviews and conference papers. **Figure 3** shows that computer science has the highest frequent subject area followed by engineering and business, management, and accounting.

It is indicated in **Figure 4** that the distribution of source type among journals, book series, conference proceedings, and books came at 55.47%, 32.27%, 23.20%, and 7.6%, respectively.

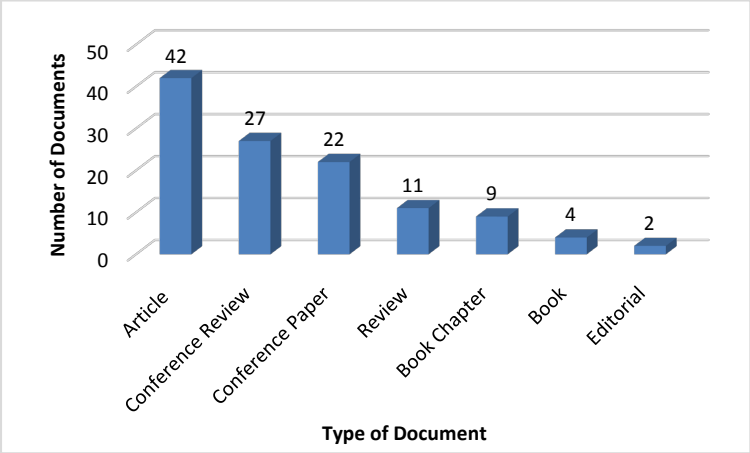

Figure 2. Type of document.

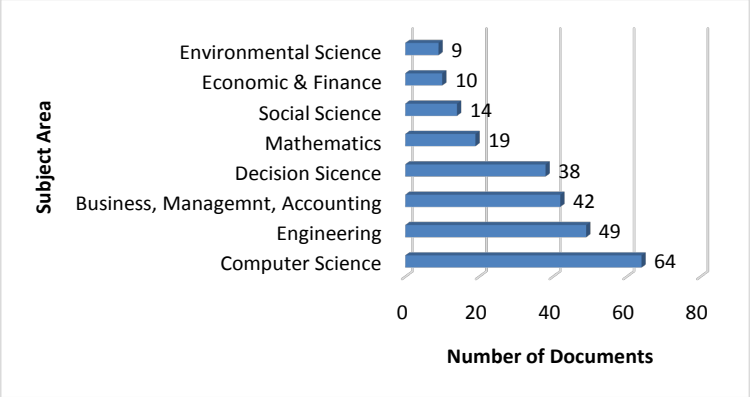

Figure 3. Subject area.

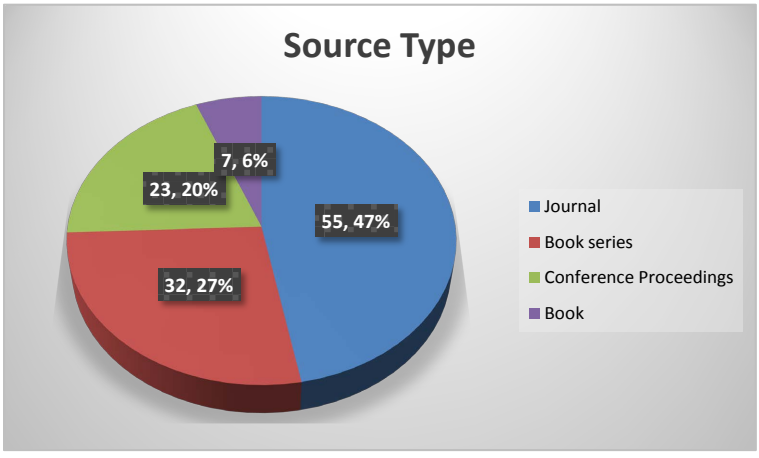

Figure 4. Source type.

Figure 5 shows the number of SCOPUS documents on the topic of AI in Supply Chain Management with contributions per country of origin. India tops the list, followed by the UK, USA, France, China, and Australia with 20, 16, 9, 9, 8, and 8 respectively.

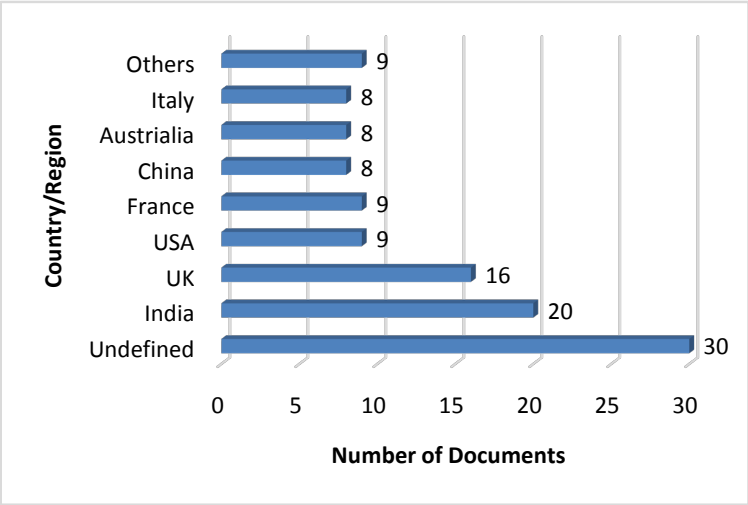

Figure 5. Country/region.

Figure 6 depicts the number of documents published per year during the period 2012 to 2023. There is a growing trend in the number of publications since 2012, which this year was marked AI's inception. This period witnessed growing research and scholarly activities on AI applications in SCM as well as other business areas.

5. Impact of AI on SCM Performance

Measuring performance is important because it helps businesses learn how to serve their customers better and achieve their long-term objectives. In reaching the desired level of customer satisfaction, it is crucial to evaluate the extent to which needs are satisfied, and resources are used effectively. Rather than 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). These standards are created in-house; thus, they do not consider the full scope of the supply chain.

Figure 7 depicts a framework for the digitalization of supply chain management. AI is one of the technologies that can be utilized in supply chain management as indicated in the reviewed literature. AI-powered solutions have the potential to revolutionize stock management due to their capacity to handle massive amounts of data. These intelligent systems can rapidly analyze and interpret huge datasets, delivering real-time actionable insights for demand and supply planning (Ben-Daya et al., 2019). These AIs provide accurate forecasts of future trends in consumer behavior and seasonality thanks to their complex algorithms.

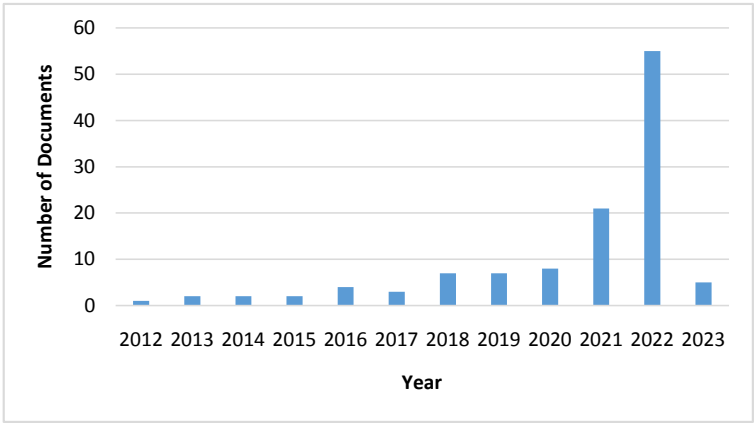

Figure 6. Number of documents per year.

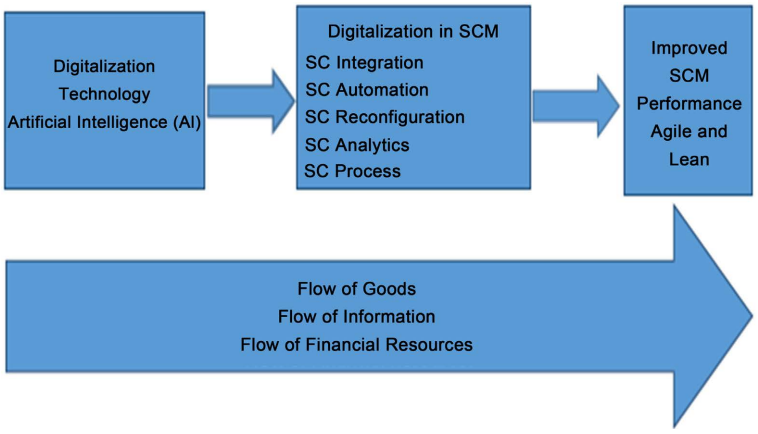

Figure 7. Digitalization of supply chain management.

An artificial intelligence program may assist reduce wasteful inventory expenses by anticipating your customers' needs. Automation can greatly improve warehouse efficiency, which is essential to effectively running the supply chain. It would allow for the quick recovery of commodities from warehouses and their delivery to customers with little effort. Using AI in warehouses may increase productivity in several ways, including the rate at which issues are handled, the ease with which routine jobs can be completed, and the number of times workers can focus on more important daily activities planning (Ben-Daya et al., 2019). 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. It was reported by Xie et al. (2020) that digitalization and industry 4.0 central objective is

the transformation of the supply chain into an intelligent supply chain, which will lead to the elimination of asymmetric information in supply chain. The performance of intelligent supply chain management can be analyzed from visibility, personalization, information governance, warning, sustainability, innovation and learning, agile and lean (leagility) perspectives. Leagility is the combination of lean, which operates with minimal waste, loss, and total cost optimization, and agility which focuses on flexibility and receptiveness. It was stated by Xie et al. (2020) that lean and agile are not mutually exclusive in the intelligent supply chain. In addition, he concluded that AI can effectively improve the performance of supply chain management. It was reported by Mohsen (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. Mohsen (2022) demonstrated that Big Data plays an important role in various areas of supply chain management, such as procurement planning, logistics, inventory, innovation and product design, operations efficiency and maintenance, product and market strategy development, and network design.

Stoyanov (2021) presented a general overview of the integration of AI in supply chain management. He reported that AI provides companies with an autonomous supply chain that can transform into a self-aware, self-managed, and self-defining system.

Toorajipour et al. (2021) reported several subfields of supply chain management that have been improved by using AI. These include distribution and transportation, logistics hub management, sales, marketing, planning, production, and forecasting of supply chain demand.

McKinsey & 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.

Gülen (2023) found that 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.

Research has also shown that AI can improve collaboration between different stakeholders in the supply chain, such as suppliers, manufacturers, and retailers. By facilitating communication and sharing of information, AI can help companies to work together more effectively, leading to improved performance.

AI-powered chatbots and virtual assistants have been found to improve cus-

tomer service by providing instant and accurate responses to customer inquiries, leading to higher levels of customer satisfaction. This can help companies to retain customers, increase sales, and improve their performance.

The impact of digital technology, AI, and IoT on supply chain efficiency in the manufacturing industry was addressed by Wang et al. (2022). They indicated that several AI technologies have been used in supply chain management including Artificial Neural Networks (ANN), Genetic Algorithms (GA), Virtual Reality (VR), and Artificial Immune Systems (AIS). It was reported that AI has a positive impact on making predictions and planning in supply chain management, it results in minimization of the resources waste and business risk.

Artificial Intelligence (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. It 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, supply shortages, and political instability. 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, such as data entry, freeing up employees to focus on higher-value work, and it can be used to improve communication and collaboration between different stakeholders in the supply chain, such as suppliers, manufacturers, and retailers.

Overall, AI can help companies to improve their supply chain performance by increasing efficiency, reducing costs, and improving the quality of products and services.

6. Discussion and Conclusion

The aim of the paper is to examine the use of AI in supply chain management and its impact on its performance. The application of AI in supply chain management is growing. The role of AI in supply chain management is admirable and has a positive impact on different subfields of supply chain management, which include demand forecasting, distribution and transportation, logistics hub management, sales, marketing, planning, production, and inventory. AI has the potential to improve performance in supply chain management from an Agile and Lean perspective by increasing responsiveness and flexibility, reducing waste, and improving collaboration and customer satisfaction. Despite the potential benefits, it's important to note that 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. Therefore, companies should carefully consider the feasibility and risks before implementing AI in their supply chain management.

Based on the literature review, there is a research gap in AI's impact on supply chain management performance that includes: 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. Lack of concrete data and methods to measure the return on investment (ROI) of AI in supply chain management makes it challenging for organizations to determine the value of their AI investments. There is a challenge in integrating AI systems with existing supply chain management systems, which can lead to limitations in data availability and accuracy. 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. Most of the current AI-driven supply chain management solutions focus on optimizing processes and cost-saving, without considering the human factor and the need for workforce training and development.

The future of AI in supply chain management is likely to see several trends. AI is expected to become more widely adopted in supply chain management as organizations recognize its potential to improve efficiency and reduce costs. AI systems are expected to become more seamlessly integrated with existing supply chain management systems, allowing for more accurate data analysis and decision-making. As AI becomes more widely used in supply chain management, there will be a growing emphasis on ethical and privacy concerns, such as ensuring that AI systems are free from bias and protecting sensitive data. 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. AI will play an increasingly important role in predictive analytics, enabling organizations to anticipate and respond to supply chain disruptions and manage risk more effectively. AI and blockchain technology are expected to become increasingly integrated, providing a more secure and transparent supply chain management solution.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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