The role of Artificial Intelligence in Supply Chain Management: A systematic Literature Review

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Abstract

As the global business landscape continues to evolve, the integration of advanced technologies has become imperative for enhancing efficiency and competitiveness. This paper explores the multifaceted role of Artificial Intelligence (AI) in revolutionizing supply chain management (SCM). The traditional supply chain paradigm is being reshaped by AI-driven solutions, presenting opportunities for optimization, agility, and resilience. The author conducted a systematic literature review evaluation of the published literature from peer-reviewed journals in the major databases Scopus and Web of Science. The analysis of literature is a frequency analysis of the literature by considering the year of publications, the contribution of leading journals and publishers, and the methodology adopted and the content analysis of literature. The author's findings from the literature reveal that key AI applications in supply chain management, such as demand forecasting, inventory management, logistics optimization, and risk mitigation enable organizations to make informed decisions, reduce forecasting errors, and optimize inventory levels, ultimately improving overall supply chain efficiency.

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Introduction

Organizational success depends heavily on supply chains, and disruptions in these chains can have serious repercussions. Exogenous shocks have profound effects that go beyond our prior experiences and change the environment in which enterprises compete (Zamani et al., 2022). Disruptions can substantially influence business performance in today's supply chains since they operate in a more competitive and uncertain environment (Azadegan et al., 2020). Accidents (Stecke & Kumar, 2009), natural disasters as well as man-made ones (Elluru et al., 2019), such as the global financial crisis of 2008 and Brexit (Belhadi et al., 2022a), the loss of essential suppliers (Ponomarov & Holcomb, 2009), and many other situations can result in such disruptions.

Businesses typically create business continuity plans combined with risk management measures to mitigate against disruptions to handle such issues (Azadegan et al., 2020). For traditional businesses to compete in the age of the digital economy, company operations must be digitalized (Weill & Woerner, 2018). Technologies like Internet of Things (IoT), AI, blockchain, and data analytics have gained prominence in recent years. The adoption of IoT, blockchain, cloud computing, data analytics, and artificial intelligence (AI), along with the growth and maturity of pertinent digital skills and capabilities, are crucial in this regard for the digital transformation of businesses (Akter et al., 2022). Research has demonstrated that advanced technologies, such as artificial intelligence (AI) among others, are essential for ensuring business continuity, particularly in the event of external shocks (Papadopoulos et al., 2020). Today's supply chains are strengthened by sensors and actuators like RFIDs, GPS and POS, tags, and other smart devices, all of which constantly send and receive data (Fosso Wamba et al., 2018). As a result, AI can be used to develop proactive strategies for predicting the likelihood of risks occurring and their impact (Baryannis et al., 2019), and to reduce the negative effects and assist decision-makers in handling difficult situations.

Blockchain, AI, and IoT have emerged as efficient means to enhance the resilience of supply chains. Advanced technologies have revolutionized supply chain management by providing tools and solutions to enhance visibility, optimize operations, and mitigate risks. Investing in advanced technologies offers organizations a range of potential benefits for supply chain resilience. These benefits include increased visibility into supply chain operations, faster response times to disruptions, cost reductions through automation, and improved decision-making capabilities (Wagner & Bode, 2008). Quantifying the impact of technology on supply chain resilience is essential for organizations to assess the effectiveness of their investments. Key performance indicators and metrics, such as on-time delivery rates, inventory turnover, and demand forecast accuracy, can provide insights into the tangible benefits of technology adoption (Sarkis et al., 2020).

Application of Artificial Intelligence in the supply chain

AI is defined as "a system's ability to interpret external data correctly, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation" (Haenlein & Kaplan, 2019) in the context of data analysis. AI refers to a system's capacity to learn by examining the data from the external environment and using that knowledge to modify existing plans or create new ones in response to environmental changes (Grover et al., 2022). This comprises methods and algorithms that allow us to infer knowledge from input data, whether we know the outputs' final forms (Baryannis et al., 2019; Rodriguez-Espindola et al., 2020). In terms of concept and opportunity development, current AI systems are excellent at getting over the

information processing limitations of humans. Deep neural networks, which need and can analyse enormous amounts of data, are currently a major component of AI systems (Ng, 2017). With this capability, we see a veritable abundance of AI systems that can assist people in coming up with concepts, opportunities, and solution strategies by analysing a lot more data than a person can handle and identifying intriguing topics for research.

AI is found to be the most impactful application in manufacturing in this century and typically leverages centralized computing and data storage infrastructure to study continuous data flows for real-time decision-making (Nasar et al., 2020). However, complex concerns, including data security and interoperability, adversarial attacks, morality, and ethics, are faced by AI systems (Awad et al., 2018). AI is viewed as a "black box" to a greater or lesser extent, and distrust surrounds the application of its analysis results to crucial decision-making. For the past 20 years, numerous firms have attempted to digitize their business operations, and more recently, the term "Industry 4.0" has become a business buzzword (Wollschlaeger et al., 2017). Since its inception, AI has been acknowledged as a key technology that facilitates communication between machines and devices (Guzman & Lewis, 2020). Due to the complexity of the jobs involved in the supply chain, AI can streamline operations by processing enormous volumes of data while also solving problems more quickly and accurately (Schniederjans et al., 2020). AI has the ability to help supply chain managers make quick, informed decisions that can help them foresee issues. Toorajipour et al. (2021) and Fosso Wamba et al. (2021) found that proactive AI systems improve service quality and please consumers by making on-time, undamaged deliveries. Every minute and every mile count in the supply chain, and AI employs algorithms that can save time and cost by optimizing routes and delivery (Wen et al., 2018).

The usage of AI for risk management as well as creating and maintaining resilience in supply chains, is currently of increasing interest (Baryannis et al., 2019; Modgil et al., 2022; Sanders, 2016). There are still several areas that lack understanding, despite this attention. While technology has been examined at a relatively abstract level, a recent major review of supply chain resilience concentrated on research conducted over the past 20 years, detailing the types of disruptions, their impact on the supply chain, and recovery strategies for mitigating these (Katsaliaki et al., 2022). Other researchers have concentrated on identifying and classifying the various AI risk management approaches (Baryannis et al., 2019; Hamdi et al., 2018) and evaluating the various supply chain resilience techniques (Belhadi et al., 2022a). In both instances, academics appear to be less interested in how AI impacts resilience and the various stages of risk management (readiness, response, recovery, and adaptability). Others have discovered that AI fosters the growth of dynamic skills, which can in turn help the company's supply chain resilience (Modgil et al., 2022).

When multidimensional data are engaged in dynamic scenarios like supply chain disruption, AI as a technology has the capacity to analyse and assess alternatives. As information becomes increasingly available throughout global supply chains, so do the expectations for AI's use of this information (Sanders et al., 2019). supply chains' efficiency and productivity are set to increase significantly due to the use of AI over the next decade. In the supply chain spectrum, the introduction of AI implementations adds value by facilitating supply network design and reconfiguration through vetting and classifying potential stakeholders (e.g., alternative suppliers), facilities, and technologies (Govindan et al., 2017); analysing big data for explaining and assessing risks thus promoting supply chain resilience (Papadopoulos et al., 2017); supporting near real-time, automated and optimal decision-making via analysing large amounts

of data from diverse sources (e.g., web, social media, information systems of involved supply chain actors) to address uncertainty and demand volatility (Baryannis et al., 2019); and enabling learning, reasoning and self-correction of supply chain operations whilst promoting validation of information for particular purposes such as contracting (Shen et al., 2019). The introduction of AI in supply chain management facilitates the orchestration and optimization of network operations via: revealing complex behavioural patterns through multifaceted analysis of data (e.g., classification, optimization, clustering); perceiving the surrounding environment to inform autonomous activities and proactively address emerging performance and quality issues; informing supply chain design, simulation and planning; and enabling negotiation-based collaborative modelling (Toorajipour et al., 2021).

Methodology

This paper will conduct a systematic literature review (SRL) on the role of AI in supply chain management. Supply chain management is increasingly crucial in today's dynamic business landscape. This paper explores how AI can be utilised to enhance supply chain management. We shed light on technology's pivotal role in ensuring supply chain robustness through SLR. The paper aims to examine how supply chain resilience can be increased by adopting AI. For this purpose, we defined SLR on increasing the resilience of the supply chain by adopting AI based on the following research questions:

RQ1: In what ways might the resilience of supply chain benefit from the adoption of AI?

RQ2: What are the challenges of implementing AI to increase supply chain resilience?

Topic fragmentation and connections to other fields grow as management research expands in volume and scope, and because of that, Tranfield et al. (2003) introduced the management field to a tool known as SLR. An SLR offers a transparent, unbiased, and comprehensive summary of the body of knowledge currently available in relation to a research question (Tsafnat et al., 2014), and serve as a beneficial instrument for management research (Pati & Lorusso, 2018; Siddaway et al., 2019).

Based on AI in the supply chain, we conducted the study using SLR to examine our research questions. We followed the steps prescribed by SLR processes, which are outlined by Govindan and Hasanagic (2018) and Mathiyazhagan et al. (2021). SLR focuses on the supply chain's current state and organizations' challenges in enhancing resilience. The paper explores the role of AI in improving inventory management, enhancing supply chain visibility, and improving risk assessment. Additionally, the review addresses the benefits and challenges of implementing AI in the supply chain.

Database

The initial stage of the bibliographic analysis is database creation. Databases are a useful tool for scientometric analysis, and the most comprehensive index of indexed journals was created using the Scopus and Web of Science (WoS) databases. WoS contains thousands of peer-reviewed social sciences, technology, and medicine publications, Scopus database was chosen as well since it provides thorough bibliographic data and high-quality, dependable coverage (Mongeon & Paul-Hus, 2016). After conducting a database search in June 2023, 277 articles from the WoS database and 804 articles from the Scopus database resulted in the preliminary results of the article search, conference papers were omitted. Different keywords were chosen as a search technique to discover similar articles because this study aims to undertake a bibliographic analysis of scientific articles. Two groups of wide keywords

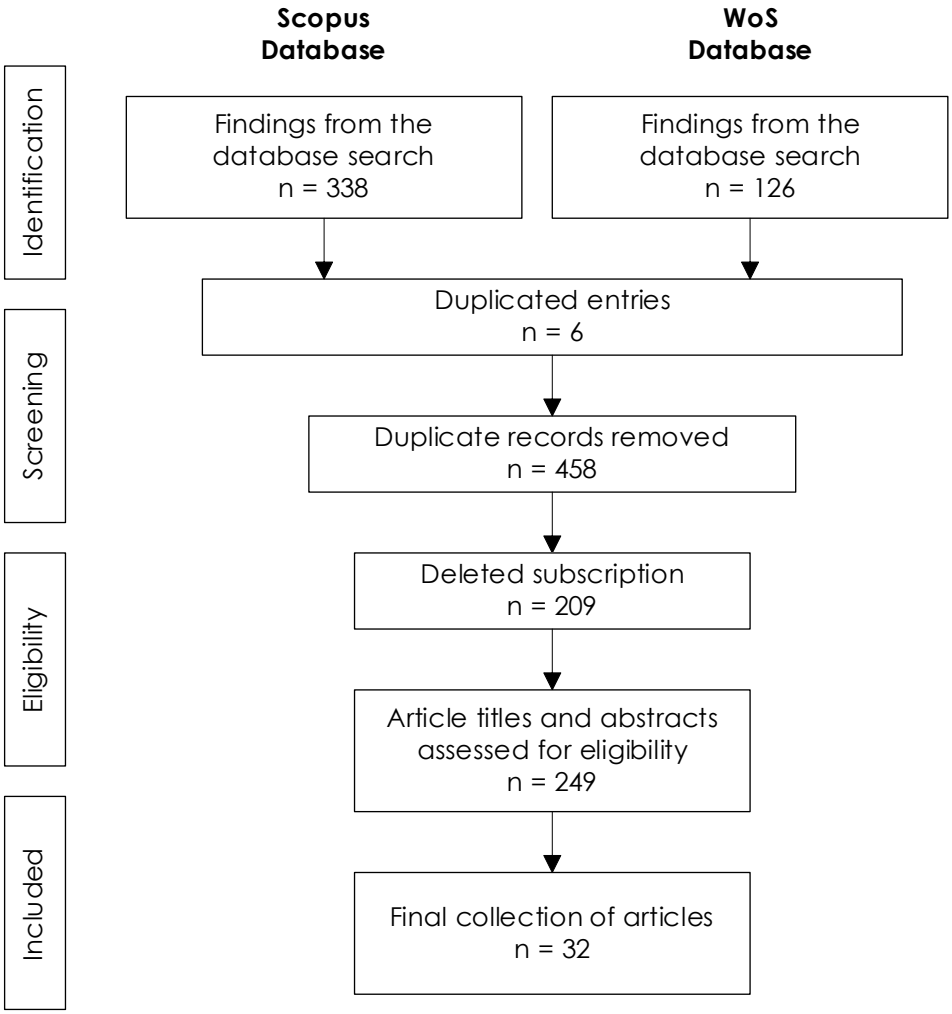
were established for this study to avoid restricting the desired papers while simultaneously removing undesired results (Cunha et al., 2019).:

- Group 1: AI-related documents to be selected: "artificial intelligence (AI)".
- Group 2: supply chain management-related documents to be selected: "supply chain", "logistics".
- After extracting the articles from the two databases, WoS and Scopus, the search was limited to peer-reviewed articles in English. The publication period was not limited and ensured a comprehensive search; duplicate articles were removed. By reviewing the titles and abstracts, 2412 were selected and archived for further analysis. Articles were then reviewed to ensure they matched the keyword search, abstracts were assessed based on the research objective, and duplicates were removed. The total number of articles was reduced to 1241 to be analysed in the next stage.

We conducted a structured Boolean-type keyword search in the WoS and Scopus databases (Aivazidou et al., 2016). The Boolean keyword search was conducted using the following combination in the "Article title, Abstract, Keywords" field: (artificial intelligence) AND (supply chain OR logistics). The search was further limited to journal articles written in English. The time horizon of publications was left unrestricted.

Figure 1

Summary of the Steps of SLR of AI in the Supply Chain



Source: Author's illustration

Figure 1 summarizes the steps in this section using the preferential reported items for systematic reviews and meta-analysis (PRISMA) provided by Moher et al. (2009). By searching for these terms in the paper's title, keywords, and abstract using the databases' search feature, 464 papers were retrieved from the two databases. This keyword search work was done on July 9, 2023, and considered the full paper publication year up to 2023. In the second stage, inclusion and exclusion criteria were applied to get the most relevant papers according to our review theme shown as the screening stage in Figure 1. Based on the language of the paper, the exclusion of duplicates, the inclusion of peer-reviewed journal articles alone, open access, and the inclusion of publications based on the subject in two databases (Scopus and WoS), we obtained 249 papers. In the third step, we assessed if the complete article focuses on how AI impacts supply chain management. After the 249 papers were analysed, 32 articles were selected for the final study.

Content analysis

A research technique based on observations called content analysis is used to objectively assess the content of written materials. By identifying the main theme of a text's contents and organizing, categorizing, and comparing texts, content analysis is a technique that can aid in the evaluation of large amounts of data in a structured and systematic manner (Kazemi et al., 2019). This technique also results in the inference of an overall result (Özyurt & Özyurt, 2015).

This paper considers the applications of AI in the supply chain. It aims to provide a more accurate and integrated understanding of AI and its effects on supply chain management.

Results

Benefits of the adoption of AI to Supply Chain Management

The main benefits of adopting AI to supply chain management are enhanced supply chain visibility, better risk assessment, faster response times, cost reductions, and improved decision-making capabilities.

Grounded in organizational information processing theory, Belhadi et al. (2021a) found that during disruptive and unexpected events, the supply chain could maintain or even enhance the supply chain performance through information processing and adaptation capabilities provided by AI techniques. When the supply chain is disrupted for an extended period, technology like AI can be used by firms to improve supply chain resilience by synchronizing manufacturing and inventory planning. AI can play a critical role in balancing demand and supply to minimize the effects of disruption under extremely uncertain conditions. (Modgil et al., 2022).

AI offers the chance for supply chains to achieve greater levels of trust and transparency, which is the key driver for making a supply chain resilient enough to handle and thrive in uncertain events; as internet penetration rises and AI is used, supply chains are becoming intelligent with little supervision required and in addition, a supply chain with AI capabilities can aid with speedy decision-making as well as planning for the supply chain's continuity under a range of different conditions (Singh et al., 2023).

With their empirical study of 318 companies, Wang & Pan (2022) confirmed that the adoption of AI technology positively impacts the elasticity and performance of the supply chain, also confirming that implementing new technology can give businesses a long-term competitive advantage, as well as supplying fresh perspectives and a foundation for further study on implementing AI.

Challenges of implementing AI in Supply Chain Management

AI has proven effective tool to reduce information asymmetry and increase transparency across supply chains (Bumblauskas et al., 2020; Ebinger & Omondi, 2020). However, multiple, and diversified data archetypes often exist in end-to-end supply chains. Key challenges in implementing these technologies are often related to limited processing capabilities of unstructured, incomplete, and sometimes inaccurate data (Choi et al., 2020). The challenges for AI implementation comprise technical, ethical, legal, managerial, and socio-economic considerations.

A major technical challenge for adopting AI in business operations relates to the availability and use of data. Data available to firms is often unstructured and difficult to share between the supply chain members. Structuring this data can be very costly. Furthermore, the data used for a specific case might not be generalizable (Cubric, 2020). For example, problems can arise by (small) datasets, which do not accurately reflect reality, or by overfitting the AI algorithm to the training data set. On the other end, a lack of training data may lead to reduced performance of the elaborated AI algorithms (Cubric, 2020). In addition, a lack of standardization of information can lead to difficulties in choosing the right AI solution. There is a trend toward individualizing companies' digital solutions via internal data architecture (Ebinger & Omondi, 2020).

Another challenge arising from the use of data for AI is the possibility of privacy rights infringement (Leone, 2017). Furthermore, project datasets often contain confidential information, leading to significant technical barriers to adopting AI-driven solutions in industrial applications. Additionally, the application of AI may impose social problems with ethnical and racial profiling, thus raising privacy concerns (Dauvergne, 2020). Furthermore, due to the early development and application stage, many AI-based solutions are demonstrated only in pilot/trial demonstrators and offer limited practical solutions (Ebinger & Omondi, 2020). Accordingly, there is often a lack of managerial awareness about the implementation benefits of AI in corporations (Cubric, 2020).

Lastly, despite the benefits stemming from the implementation of AI in an industrial context, a range of significant social risks is involved (Di Vaio et al., 2020). As technologies like autonomous driving are developing fast, unemployment issues for professional truck drivers might arise in the long term (Sanders et al., 2019). The possibility of AI-driven solutions replacing human labour will exacerbate social and technical engineering tensions (Camaréna, 2020).

Conclusion

This paper explores the vital role of AI in enhancing supply chain management. In an increasingly complex and volatile global landscape, supply chains face various disruptions that can significantly impact business operations. To mitigate these challenges, organizations are turning to advanced technologies to bolster their supply chain resilience.

This paper provides an in-depth analysis of the benefits and challenges related to adopting advanced technologies in supply chain management. The paper highlights the role of AI in enhancing supply chain management, comprehensively reviews the existing literature on the topic, and identifies the challenges and opportunities associated with implementing these technologies. We explain how the technology works, its relevance to supply chain operations, and the potential benefits it can offer in terms of enhancing resilience.

The main benefits of AI to supply chain management are enhanced supply chain visibility, better risk assessment, faster response times, cost reductions, and improved decision-making capabilities. Implementing AI can be challenging for organizations, as it requires significant investment, expertise, and a willingness to change. This paper highlights the organizational, technical, operational, and ethical challenges connected with the adoption of advanced technologies.

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