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Article

The Role of AI in Enhancing Supply Chain Resilience: Insights from Industry Experts

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Abstract: This study investigates the role of artificial intelligence in enhancing supply chain resilience, drawing insights from industry experts to understand the transformative potential and challenges of AI adoption in supply chain management. In recent years, supply chains have faced unprecedented disruptions due to global crises, technological shifts, and evolving consumer demands, making resilience a critical focus. AI technologies, including machine learning, predictive analytics, and real-time data processing, have emerged as vital tools for maintaining continuity and improving decision-making under uncertainty. This research employs a qualitative methodology, engaging with 15 industry experts to gather in-depth perspectives on how AI is being integrated into supply chain practices and the tangible impacts observed. The thematic analysis of expert insights reveals that AI significantly contributes to risk mitigation, supply chain visibility, and adaptive planning. By harnessing real-time data, AI systems enable proactive responses to disruptions, enhancing operational agility. Moreover, AI-driven optimization techniques improve logistics efficiency, while predictive analytics support accurate demand forecasting and inventory management. Despite these advantages, the research identifies several barriers to successful AI implementation, including high initial costs, data integration challenges, and concerns regarding data privacy and workforce adaptation. Addressing these issues requires a strategic, phased approach to technology integration, fostering collaboration between AI developers, supply chain professionals, and policymakers to create sustainable and resilient systems. The study concludes that while AI offers substantial benefits for supply chain resilience, its successful implementation demands a balanced approach that considers technological, organizational, and ethical dimensions. Future research should focus on developing practical frameworks for AI adoption and assessing long-term impacts on supply chain sustainability and workforce dynamics.

Keywords: Artificial intelligence; supply chain resilience; machine learning; risk mitigation; logistics optimization; predictive analytics; industry insights

1. Introduction

The role of artificial intelligence (AI) in enhancing supply chain resilience has garnered significant attention in recent years as organizations strive to mitigate the effects of disruptions and improve operational agility. The integration of AI into supply chain management (SCM) represents a transformative leap in the ability to anticipate, respond to, and recover from unforeseen events such as natural disasters, economic crises, and geopolitical tensions (Ameen & Zaki, 2022; Baryannis et al., 2020). In an increasingly interconnected world, supply chains face escalating risks and uncertainties that demand innovative strategies for ensuring continuity and efficiency. AI has emerged as a promising solution, offering tools and technologies that enable real-time decision-making, predictive analytics, and process optimization (Gunasekaran & Ngai, 2020; Afolabi & Olojede, 2021). This research seeks to explore the role of AI in enhancing supply chain resilience by drawing insights from industry experts, with a focus on how AI tools and techniques can address contemporary challenges while offering new opportunities for building more robust, adaptive, and efficient supply chains. Supply chain resilience refers to the capacity of a supply chain to adapt to and recover from

disruptions while maintaining its performance (Christopher & Peck, 2021). With the rapid advancement of AI, many organizations are turning to machine learning (ML), deep learning, and other AI-driven approaches to strengthen their supply chains. AI technologies allow companies to not only enhance operational efficiency but also improve risk management, enabling them to respond proactively to potential disruptions. By leveraging data-driven insights and automation, AI empowers organizations to optimize inventory management, reduce lead times, and anticipate market shifts (Kamble & Gunasekaran, 2021; Helo & Xu, 2020). In particular, AI applications in supply chain risk management have become central to addressing vulnerabilities that could arise due to supply and demand fluctuations, supplier failures, or logistical bottlenecks (Sahu & Das, 2021; Singh & Gupta, 2021). AI's contribution to supply chain resilience is multifaceted, encompassing several dimensions such as demand forecasting, risk assessment, real-time monitoring, and automated decision-making (Thakur & Soni, 2022; Raj & Zolghadri, 2022). By using AI-powered predictive models, organizations can forecast disruptions before they occur, allowing them to take preventive actions such as sourcing alternatives, adjusting production schedules, or reallocating resources (Lee, 2020; Pournader & Fathi, 2020). This proactive approach is essential in maintaining the flow of goods and services during crises, such as the COVID-19 pandemic, which exposed significant weaknesses in global supply chains (Ma & Zhang, 2022). AI technologies such as natural language processing (NLP) and neural networks can analyze vast amounts of data from multiple sources, identifying patterns and trends that would be impossible for human analysts to detect (Emon & Khan, 2025). This capability enhances decision-making and supports real-time responses to supply chain disruptions (Duflou & Kumar, 2020; Kumar & Yadav, 2020). The application of AI in supply chain management is not without challenges. While AI holds the potential to revolutionize supply chain resilience, its adoption and implementation require significant investment in technology, infrastructure, and human capital (Bhardwaj & Sharma, 2021; Gunes & Ustundag, 2021). Many organizations face difficulties in integrating AI with existing systems, especially in industries where legacy technologies dominate. Additionally, the complexity of AI algorithms and the need for large amounts of high-quality data pose barriers to entry for smaller firms or those with limited resources (Kumar & Yadav, 2020). Furthermore, AI-driven systems require continuous monitoring and adjustment to ensure their effectiveness in a dynamic environment, raising concerns about the long-term viability of such systems (Afolabi & Olojede, 2021; Houbini & Awad, 2022). Despite these challenges, the potential benefits of AI in enhancing supply chain resilience are undeniable, and organizations are increasingly investing in AI tools to overcome these hurdles and remain competitive. One of the key strengths of AI in the context of supply chain resilience is its ability to optimize supply chain operations in real-time. AI technologies, such as robotic process automation (RPA), IoT (Internet of Things), and blockchain, can provide continuous, up-to-the-minute visibility into the status of goods, shipments, and inventory (Gunes & Ustundag, 2021; Kamble & Gunasekaran, 2021). For example, AI-enabled supply chain monitoring systems can track the movement of products across global networks, detecting potential delays or disruptions and providing early warning signs to decision-makers (Emon & Khan, 2025). This enhanced visibility allows companies to make adjustments on the fly, minimizing the impact of disruptions and reducing the likelihood of stockouts or overstocking (Gunasekaran & Ngai, 2020; Helo & Xu, 2020). Furthermore, AI's ability to optimize routing, scheduling, and inventory management can help companies minimize costs, improve delivery times, and reduce waste, all of which contribute to a more resilient and sustainable supply chain (Thakur & Soni, 2022; Wu & Kwon, 2021). AI also plays a crucial role in risk management by identifying vulnerabilities within the supply chain network and recommending appropriate actions to mitigate potential disruptions (Sahu & Das, 2021; Houbini & Awad, 2022). AI algorithms can analyze historical data, supplier performance metrics, and external variables such as geopolitical events or environmental factors to assess the likelihood of disruptions. This predictive capability allows organizations to develop contingency plans and build flexible supply chain strategies that can quickly adapt to changing circumstances (Raj & Zolghadri, 2022; Ivanov & Dolgui, 2021). For instance, AI tools can suggest alternative suppliers, adjust production schedules, or recommend route

changes in the event of a disruption, thereby ensuring business continuity even in the face of unforeseen challenges (Jain & Soni, 2020; Tran & Phan, 2021). Moreover, the application of AI extends beyond traditional risk management to encompass strategic decision-making processes. AI-driven models, such as decision support systems (DSS), can assist supply chain managers in making more informed, data-driven decisions regarding inventory levels, sourcing strategies, and market expansion plans (Kamble & Gunasekaran, 2021; Ameen & Zaki, 2022). By simulating various scenarios and assessing the impact of different decisions, AI can provide insights into the most effective strategies for minimizing risk and maximizing resilience (Liu & Zhang, 2021; Anand & Mehta, 2020). This ability to model and predict various outcomes based on real-time data empowers organizations to stay ahead of potential disruptions and adjust their strategies accordingly. The integration of AI into supply chain management is not just about improving operational efficiency; it also has significant implications for sustainability and corporate responsibility. AI technologies can enable companies to reduce their environmental footprint by optimizing resource utilization, minimizing waste, and improving energy efficiency (Jarboui & Ben Rejeb, 2020; Sharma & Chatterjee, 2022). For example, AI algorithms can help optimize transportation routes to reduce fuel consumption, or they can suggest more sustainable sourcing options that align with the company's environmental goals (Maheswaran & Kaur, 2020). In addition, AI can assist in monitoring compliance with sustainability standards, ensuring that companies adhere to regulations and contribute to global sustainability efforts (Galvão & Monteiro, 2021; Gunasekaran & Ngai, 2020). As supply chain resilience continues to be a critical priority for organizations worldwide, the adoption of AI technologies will likely accelerate, driven by the increasing complexity and interconnectedness of global supply chains (Emon & Khan, 2024). Industry experts agree that the future of supply chain management lies in the integration of advanced technologies such as AI, machine learning, and data analytics, which will enable companies to anticipate disruptions, optimize their operations, and respond more effectively to change (Kumar & Yadav, 2020; Christopher & Peck, 2021). However, as organizations embark on their AI adoption journeys, they must also address the associated challenges, including data quality, integration with existing systems, and the need for skilled personnel to manage and interpret AI-driven insights (Manogaran & Jayaraman, 2021; Kamble & Gunasekaran, 2021). The evolution of AI in supply chain resilience is still unfolding, and ongoing research will continue to reveal new opportunities and challenges in this rapidly evolving field (Bhardwaj & Sharma, 2021; Tiwari & Agarwal, 2020).

2. Literature Review

Artificial intelligence (AI) has emerged as a transformative force in various sectors, particularly in the field of supply chain management (SCM). Supply chains, which involve a network of organizations, resources, and processes that are essential to producing and delivering goods, have been under increasing pressure to become more resilient, efficient, and adaptive to changing market conditions. AI, through its capabilities in automation, prediction, and optimization, has become an indispensable tool in the modern supply chain landscape, driving new opportunities for enhancing resilience, reducing risks, and improving overall performance (Helo & Xu, 2020). However, the integration of AI into supply chain operations is not without challenges, as it requires overcoming technological, organizational, and data-related barriers. The role of AI in enhancing supply chain resilience has become a focal point of academic and industry research, particularly as global supply chains continue to experience disruptions due to factors such as geopolitical instability, natural disasters, and global pandemics (Houbini & Awad, 2022). In this context, supply chain resilience refers to the ability of a supply chain to anticipate, respond to, and recover from disruptions, maintaining its performance despite external shocks. AI technologies, particularly machine learning (ML), deep learning, and data analytics, enable organizations to identify patterns, predict potential disruptions, and optimize their operations in ways that traditional approaches cannot (Ivanov & Dolgui, 2021). The ability of AI to process and analyze vast amounts of real-time data has made it a critical tool for organizations aiming to stay competitive in an increasingly volatile and uncertain

market environment. AI-powered tools and algorithms are being deployed across various stages of the supply chain, from procurement and inventory management to transportation and logistics (Jain & Soni, 2020). Machine learning, for instance, has been applied in predictive analytics to forecast demand more accurately, allowing companies to adjust their production schedules, manage inventory more effectively, and mitigate the risks associated with stockouts or overstocking (Kamble & Gunasekaran, 2021). Furthermore, AI has been instrumental in optimizing routes for transportation, improving delivery times, and reducing fuel consumption, which contributes not only to cost savings but also to environmental sustainability (Khan & Kang, 2020). The application of AI in logistics, particularly through the use of autonomous vehicles and drones, has the potential to further enhance the efficiency and resilience of supply chains (Tiwari & Agarwal, 2020). In addition to optimizing operational efficiency, AI also plays a significant role in enhancing the agility of supply chains (Khan & Emon, 2025). The dynamic nature of global markets demands that organizations not only respond quickly to changes but also anticipate potential disruptions before they occur. AI's ability to analyze historical and real-time data allows companies to identify emerging risks and develop proactive strategies to mitigate them (Kumar & Yadav, 2020). For example, AI-driven models can predict the likelihood of supply chain disruptions based on factors such as political instability, weather patterns, and changes in consumer behavior. These predictive capabilities enable companies to develop contingency plans, adjust sourcing strategies, and collaborate with suppliers to ensure continuity of supply in the face of unforeseen events (Lee, 2020). The integration of AI into risk management processes also enables organizations to monitor their supply chains continuously, providing them with real-time insights into potential vulnerabilities. AI's application in supply chain resilience is particularly relevant in the context of risk management. Supply chains are often exposed to various types of risks, including demand fluctuations, supplier failures, and disruptions in logistics networks. By leveraging AI, organizations can enhance their risk management capabilities by identifying potential threats early, assessing their impact, and developing mitigation strategies (Liu & Zhang, 2021). AI systems can also be used to evaluate the resilience of different supply chain configurations, helping organizations design more robust networks that are better able to withstand disruptions (Emon & Khan, 2024). The flexibility of AI-based systems, which can continuously learn and adapt to new data, makes them an invaluable tool for managing the ever-evolving risks faced by global supply chains (Manogaran & Jayaraman, 2021). Despite the numerous benefits, the adoption of AI in supply chain management comes with challenges that need to be addressed for successful implementation. One of the main hurdles is the integration of AI systems with existing supply chain infrastructures (Pournader & Fathi, 2020). Many organizations still rely on legacy systems that are not equipped to handle the large volumes of data generated by AI technologies. Additionally, AI implementation often requires significant investments in infrastructure, including data storage and processing capabilities, which can be a barrier for smaller organizations (Maheswaran & Kaur, 2020). Furthermore, the successful deployment of AI in supply chains requires collaboration between various stakeholders, including suppliers, logistics providers, and customers. The need for interoperability among different AI systems and the sharing of data across organizational boundaries presents additional challenges (Rai & Sahu, 2020). Data quality and availability also remain significant concerns in the application of AI in supply chains. AI algorithms rely heavily on large volumes of high-quality data to function effectively. However, data in supply chains is often fragmented, inconsistent, and incomplete, which can hinder the performance of AI models (Sahu & Das, 2021). Furthermore, the privacy and security of data are critical considerations, as sensitive information about suppliers, customers, and inventory is often exchanged and processed across multiple systems (Jarboui & Ben Rejeb, 2020). Organizations must implement robust data governance frameworks to ensure the integrity, security, and privacy of the data they use in AI-driven decision-making. The ethical implications of AI in supply chain management also require attention. As AI systems become more autonomous, there are concerns about their potential impact on employment, decision-making transparency, and accountability (Ramesh & Patel, 2021). AI-driven automation in logistics and manufacturing processes may lead to job displacement, particularly in roles that involve

repetitive and manual tasks. Moreover, the use of AI in decision-making raises questions about transparency and accountability, especially when AI systems are used to determine critical decisions, such as supplier selection or inventory management (Singh & Gupta, 2021). Organizations must address these ethical concerns to ensure that AI is deployed responsibly and that its benefits are distributed equitably across society. Despite these challenges, the potential of AI to enhance supply chain resilience is immense. The integration of AI in supply chain management can lead to more agile, efficient, and responsive supply chains that are better able to adapt to disruptions. By harnessing the power of AI, organizations can improve their ability to predict and respond to risks, optimize operations, and enhance overall supply chain performance (Wang & Sun, 2020). Moreover, the continued advancements in AI technologies, such as the development of more sophisticated machine learning algorithms and the increased availability of big data, will likely drive further innovations in supply chain resilience (Wu & Kwon, 2021). As AI becomes more integrated into supply chain operations, it will play an increasingly central role in helping organizations navigate the complexities of global supply chains and maintain a competitive edge in the face of uncertainty. The future of AI in supply chain management is characterized by increasing sophistication and integration. AI-driven supply chains will be able to process and analyze data in real-time, making it possible to respond to disruptions almost instantaneously. Furthermore, the use of AI-powered predictive models will allow organizations to anticipate potential risks and disruptions before they occur, providing them with a competitive advantage in managing uncertainties. The potential for AI to enhance supply chain resilience will continue to evolve as new technologies and methods emerge, offering organizations new ways to optimize their operations and stay ahead in an increasingly complex and competitive global market (Thakur & Soni, 2022).

3. Method

The research was conducted to explore the impact of artificial intelligence (AI) on supply chain resilience, with a particular focus on understanding the applications, challenges, and future directions of AI in this field. A qualitative research approach was chosen to gather in-depth insights into the experiences and perspectives of professionals in the supply chain and logistics industry. A sample size of 15 participants was selected for the study, with the inclusion of experts and practitioners who had significant experience in supply chain management and AI-related technologies. These participants were chosen using a purposive sampling technique, ensuring that individuals with relevant expertise and knowledge of AI applications in supply chains were included. The selection criteria focused on individuals with hands-on experience in implementing AI-based systems or those who had a deep understanding of the theoretical and practical implications of AI for supply chain resilience. Data collection was carried out through semi-structured interviews, allowing for a flexible yet focused approach to exploring the key themes of the study. The interviews were conducted either face-to-face or through virtual platforms, depending on the participants' availability and preferences. The interview questions were designed to gather information on the role of AI in supply chain resilience, the challenges faced during its adoption, and the potential for future advancements. Additionally, participants were asked about their experiences with AI technologies in various aspects of supply chain management, such as inventory optimization, risk management, logistics, and demand forecasting. The semi-structured nature of the interviews allowed for follow-up questions and deeper exploration of specific topics, ensuring that the responses provided rich, detailed data. The interviews were recorded with the consent of the participants, and the audio data was transcribed for analysis. The transcripts were analyzed using thematic analysis, a method that involves identifying patterns and themes within the data. Thematic analysis was chosen because of its ability to handle qualitative data effectively and its flexibility in identifying both explicit and implicit meanings within interview responses. The analysis process involved several stages, including familiarization with the data, generating initial codes, searching for themes, reviewing themes, and finalizing the interpretation of the data. The findings were categorized into key themes related to the use of AI in enhancing supply chain resilience, the barriers to AI adoption, and the

potential for future research and development in this area. To ensure the validity and reliability of the research, triangulation was employed by comparing the findings from different participants to identify consistent patterns and discrepancies. Additionally, member checking was used, where a summary of the interview findings was shared with participants to verify the accuracy of the interpretations and ensure that their perspectives were accurately represented. Ethical considerations were also taken into account, with participants being informed about the study's objectives and assured of the confidentiality and anonymity of their responses. The small sample size of 15 was chosen to allow for in-depth analysis of each participant's experience and expertise. Although the sample size may limit the generalizability of the findings, the focus was on gaining a deeper understanding of the specific experiences and perspectives of those directly involved with AI applications in supply chain resilience. The research methodology aimed to provide valuable insights into the role of AI in the context of supply chain management and to identify key challenges and opportunities for future development in this rapidly evolving field.

4. Results

The results and findings of the study were derived from the semi-structured interviews conducted with the 15 participants. The analysis revealed several key insights regarding the role of artificial intelligence (AI) in enhancing supply chain resilience. Throughout the interviews, participants discussed various aspects of AI adoption, challenges faced during implementation, and the potential for future advancements in the field. The findings were categorized into several overarching themes, which were centered on the practical applications of AI in supply chain management, the barriers to its successful integration, and the evolving nature of AI technologies within this context. One of the most notable findings was the significant impact AI had on supply chain visibility and decision-making. Many participants highlighted how AI-powered tools, such as predictive analytics and machine learning algorithms, were instrumental in enhancing the ability to forecast demand, optimize inventory management, and improve overall supply chain operations. AI-driven solutions allowed organizations to move from reactive to proactive management, enabling them to anticipate disruptions before they occurred. The ability to analyze large volumes of data in real time allowed for better decision-making and the optimization of supply chain processes, which contributed to improved resilience, especially during disruptions. AI also enabled more accurate risk assessments and facilitated the identification of potential vulnerabilities within the supply chain network. By continuously monitoring key metrics and performance indicators, AI systems were able to identify areas that needed attention, allowing companies to respond quickly and mitigate the impact of disruptions. Another important finding was the significant role AI played in enhancing logistics operations. AI-based systems were found to be particularly effective in route optimization, transportation management, and warehouse automation. Participants noted that AI-powered logistics platforms helped organizations optimize delivery routes, reducing transportation costs and improving delivery efficiency. By leveraging real-time traffic data and weather patterns, AI systems were able to dynamically adjust delivery schedules and reroute vehicles, thereby reducing delays and enhancing overall supply chain responsiveness. AI also played a pivotal role in warehouse automation, with many organizations adopting robotics and machine learning algorithms to streamline operations and improve inventory control. The use of AI in warehousing not only reduced human error but also increased efficiency, allowing for faster and more accurate order fulfillment. These advancements in logistics contributed to a more resilient supply chain, as companies were better able to adapt to changes in demand and disruptions in transportation networks. Despite the promising potential of AI in supply chain resilience, several barriers to successful implementation were identified. One of the primary challenges was the high cost of AI adoption. Many participants expressed concerns about the initial investment required to implement AI technologies, particularly for small and medium-sized enterprises (SMEs). Although the long-term benefits of AI adoption, such as cost savings and improved efficiency, were acknowledged, the upfront financial commitment posed a significant hurdle. Additionally, there were concerns about the complexity of integrating AI

systems with existing supply chain infrastructure. Participants emphasized the importance of having the right technological infrastructure in place to support AI applications. The integration of AI into legacy systems required careful planning and coordination, and in some cases, organizations needed to completely overhaul their existing systems to fully leverage AI capabilities. Another significant barrier identified was the lack of skilled personnel to operate and maintain AI systems. Several participants noted that the implementation of AI in supply chain management required a highly specialized skill set, and the demand for qualified professionals often exceeded the available supply. Organizations faced difficulties in finding individuals with the necessary expertise in machine learning, data analysis, and AI programming. This skills gap posed a challenge not only during the initial implementation phase but also in ensuring the long-term sustainability of AI-powered systems. Some participants also highlighted the importance of ongoing training and development for their workforce to ensure that employees could effectively manage and utilize AI tools. The need for continuous upskilling was viewed as essential to maintaining a competitive edge in the rapidly evolving field of AI. Data quality and availability were also identified as significant challenges in the successful implementation of AI in supply chain management. Many participants reported that AI systems require high-quality, accurate, and up-to-date data to function effectively. Inconsistent or incomplete data posed a significant barrier to the successful deployment of AI technologies. Participants emphasized that data collection and management practices needed to be robust and well-organized to ensure that AI systems could generate reliable and actionable insights. This was particularly important in the context of supply chain resilience, as AI systems relied heavily on accurate data to identify potential disruptions and risks. The challenge of ensuring data accuracy and completeness was further complicated by the vast amounts of data generated across the supply chain, which required advanced data management and integration systems to process and analyze effectively. Additionally, some participants expressed concerns about the ethical implications of AI in supply chain management. While AI was recognized as a powerful tool for improving efficiency and resilience, there were concerns about the potential for bias in AI algorithms and the impact of automation on employment. Several participants noted that AI systems might unintentionally perpetuate biases in decision-making processes, particularly if the underlying data used to train AI models was biased or incomplete. These concerns raised questions about the transparency and accountability of AI systems, especially in situations where decisions could significantly impact workers or customers. There was also a broader concern about the societal implications of widespread automation, particularly in terms of job displacement and the future of work in the supply chain sector. Despite these challenges, the participants were generally optimistic about the future of AI in supply chain resilience. Many believed that AI technologies would continue to evolve and become more accessible, helping organizations overcome some of the current barriers to implementation. Participants identified several key trends that they believed would shape the future of AI in supply chain management. One of these trends was the increasing integration of AI with other emerging technologies, such as the Internet of Things (IoT), blockchain, and robotics. The combination of these technologies was seen as a powerful driver of innovation, enabling more seamless data sharing, improved traceability, and enhanced decision-making across the supply chain. AI-powered IoT devices, for example, could provide real-time monitoring of goods in transit, allowing companies to respond more quickly to potential disruptions and improve overall supply chain visibility. Another trend identified by participants was the growing emphasis on sustainability in supply chain management. Many participants noted that AI could play a critical role in helping organizations achieve more sustainable supply chains by optimizing resource use, reducing waste, and improving energy efficiency. AI-based solutions could help companies track and analyze environmental impacts across their supply chains, enabling them to make more informed decisions about sourcing, production, and distribution. This growing focus on sustainability was seen as an important factor in driving the adoption of AI, as companies sought to align their operations with environmental and social responsibility goals. Finally, the participants emphasized the need for greater collaboration between industry stakeholders, including supply chain professionals,

technology providers, and policymakers, to unlock the full potential of AI in enhancing supply chain resilience. Many participants believed that the successful implementation of AI would require a collective effort to address the challenges of data sharing, interoperability, and workforce development. Collaboration was seen as essential to creating a shared understanding of AI's potential and developing standards and best practices for its use in supply chain management.

Table 1. AI Applications in Supply Chain Resilience.

Theme	Description
Predictive Analytics	Use of AI to forecast demand, anticipate disruptions, and optimize processes.
Risk Management	AI's role in identifying risks, assessing vulnerabilities, and recommending solutions.
Inventory Optimization	AI-driven tools that optimize inventory levels and improve stock management.
Logistics & Routing Optimization	AI's application in route planning and transportation optimization.
Automation of Warehousing	The use of AI to streamline operations and reduce manual labor in warehouses.

The analysis of the AI applications in supply chain resilience revealed that organizations are utilizing AI to enhance various aspects of their operations. The application of predictive analytics stands out as one of the most significant benefits, enabling businesses to forecast future demands and detect potential disruptions before they occur. AI-driven tools are also being leveraged for risk management, where they help in identifying risks, vulnerabilities, and generating recommendations to mitigate these issues. Inventory optimization is another critical area where AI has been implemented, allowing for real-time stock management, reducing excess inventory, and improving order fulfillment. Additionally, AI has transformed logistics and routing, where it is applied to optimize transportation routes and schedules, improving efficiency and reducing transportation costs. In warehousing, AI has helped automate repetitive tasks, improving efficiency, reducing errors, and lowering operational costs.

Table 2. Barriers to AI Adoption in Supply Chain Management.

Theme	Description
High Implementation Costs	The significant financial investment required for AI adoption.

Integration Challenges	Difficulty in integrating AI with existing supply chain infrastructure.
Lack of Skilled Workforce	The shortage of professionals with the necessary AI expertise.
Data Management Issues	Challenges with data quality, accuracy, and availability for AI systems.
Ethical Concerns	Concerns about AI's potential biases and its impact on jobs and decision-making.

The barriers to AI adoption in supply chain management reveal several key challenges organizations face when implementing AI technologies. High implementation costs were identified as a significant hurdle, particularly for small and medium-sized enterprises (SMEs), which may lack the financial resources to invest in AI systems. Many companies also encountered integration challenges, as existing systems and infrastructure were not always compatible with new AI technologies. This required costly and time-consuming adjustments. Another key barrier was the shortage of a skilled workforce. The demand for AI experts often exceeds supply, leading to difficulties in recruiting and retaining employees with the necessary expertise in data analysis, machine learning, and AI programming. Data management issues were another common concern, with AI systems requiring large amounts of high-quality, accurate, and up-to-date data. Inadequate data posed a significant challenge, affecting the performance and reliability of AI tools. Ethical concerns also emerged, particularly regarding AI's potential to perpetuate biases and its long-term implications on employment, as automation could replace certain jobs, raising broader societal questions.

Table 3. Future Trends in AI for Supply Chain Management.

Theme	Description
Integration with IoT and Blockchain	AI's increasing integration with IoT and blockchain for enhanced supply chain visibility.
Sustainable Supply Chains	AI's role in promoting sustainability by optimizing resource use and reducing waste.
AI-driven Automation	Expansion of AI in automating more complex processes in supply chain operations.
Collaborative AI Systems	AI-powered collaboration tools for cross-functional decision-making.
Advanced AI Algorithms	The development of more sophisticated AI models for better forecasting and risk management.

The future trends in AI for supply chain management emphasize the growing sophistication and integration of AI technologies. AI's increasing convergence with the Internet of Things (IoT) and

blockchain is expected to create more transparent, connected, and traceable supply chains. This integration will provide real-time insights into supply chain performance and enable faster responses to disruptions. Sustainability is another area where AI is poised to make a significant impact, helping organizations optimize resource use, minimize waste, and track environmental impacts more effectively. Automation will also continue to evolve, with AI expected to automate increasingly complex tasks, reducing human error and improving efficiency. AI-powered collaboration tools will further enhance decision-making by enabling real-time, cross-functional collaboration, which is critical for improving resilience during disruptions. Finally, the development of more advanced AI algorithms will lead to improved forecasting capabilities, enhanced risk management, and more intelligent decision-making across supply chains.

Table 4. Ethical and Social Implications of AI in Supply Chain Management.

Theme	Description
AI Bias and Fairness	The potential for AI algorithms to perpetuate bias in decision-making.
Job Displacement	Concerns over automation leading to job losses in supply chain roles.
Transparency and Accountability	The need for transparency in AI decision-making processes.
Privacy and Data Security	The implications of AI systems on data privacy and security in supply chains.
Social Responsibility	The role of companies in ensuring AI’s ethical use in supply chains.

Ethical and social implications of AI in supply chain management have raised several critical concerns. The potential for AI bias in decision-making processes is a major issue, as algorithms may reflect biases present in the training data, leading to unfair or discriminatory outcomes. Job displacement is another prominent concern, with automation increasingly taking over tasks previously performed by human workers, potentially leading to job losses. The transparency and accountability of AI systems have become a key topic, with stakeholders calling for clearer explanations of how AI decisions are made, especially in critical areas such as inventory management and risk assessment. Data privacy and security are also growing concerns, as AI systems handle vast amounts of sensitive information, and breaches could have serious consequences. Finally, there is a growing focus on corporate social responsibility, with organizations being urged to ensure the ethical use of AI and mitigate any negative societal impacts, such as exacerbating inequality or displacing workers without adequate retraining opportunities.

Table 5. Organizational Strategies for Successful AI Adoption.

Theme	Description
Clear Strategic Vision	The importance of a clear, well-defined strategy for AI adoption.

Incremental Implementation	Gradual adoption of AI technologies, starting with smaller, manageable projects.
Investment in Workforce Development	Commitment to training and upskilling employees to manage AI technologies.
Collaboration with External Partners	Partnering with AI technology providers and experts for smoother implementation.
Data Governance Framework	Establishing robust data management systems and policies for AI success.

The organizational strategies for successful AI adoption highlighted several best practices that contributed to the effective integration of AI technologies into supply chains. A clear strategic vision was emphasized as essential for guiding AI adoption, ensuring that AI initiatives aligned with broader business objectives. Many organizations took an incremental approach to AI adoption, beginning with smaller projects and gradually scaling up as they gained experience and confidence. This approach allowed them to manage risk and learn from early implementations. Investment in workforce development was another critical strategy, with organizations focusing on upskilling employees to operate and manage AI systems effectively. Collaboration with external partners, including AI technology providers and industry experts, was seen as key to navigating the complexities of AI implementation. Finally, a robust data governance framework was considered necessary for AI success, as it ensures data quality, integrity, and security, which are critical for AI systems to perform accurately and reliably. These strategies were seen as vital in overcoming the challenges associated with AI adoption and maximizing its potential to enhance supply chain resilience.

The findings from the thematic analysis of AI applications in supply chain management reveal significant advancements and challenges in integrating artificial intelligence to enhance supply chain resilience. AI is being increasingly used for predictive analytics, helping organizations forecast demand and potential disruptions, while also optimizing inventory management and logistics. However, the adoption of AI is not without its barriers, including high implementation costs, integration difficulties with existing systems, and a shortage of skilled professionals. Despite these challenges, the future trends indicate a promising integration of AI with technologies such as IoT and blockchain, which will further enhance supply chain visibility and efficiency. AI's potential to drive sustainability in supply chains by optimizing resource use and reducing waste was also highlighted. However, ethical concerns regarding AI's bias, its impact on jobs, and the need for transparency in decision-making processes must be carefully addressed. The analysis also pointed to the importance of a strategic approach to AI adoption, including clear vision, gradual implementation, workforce training, and strong data governance frameworks. These strategies, alongside external collaborations with technology providers, are critical for overcoming adoption challenges and ensuring that AI can be leveraged effectively to improve supply chain resilience.

5. Discussion

The discussion of the findings highlights the transformative potential of artificial intelligence in enhancing supply chain resilience while also acknowledging the complexities involved in its implementation. The integration of AI into supply chains is increasingly seen as a strategic necessity

rather than just a technological enhancement. The ability of AI to predict disruptions, optimize decision-making, and enhance operational efficiency positions it as a critical tool for modern supply chain management. By leveraging machine learning algorithms and advanced data analytics, organizations can respond more swiftly to uncertainties, reducing the impact of unforeseen events on supply chain operations. The thematic analysis underscored how AI-driven predictive analytics significantly improves demand forecasting and inventory management. By analyzing vast amounts of data from various sources, AI systems can identify patterns and predict potential challenges before they materialize. This proactive approach helps companies mitigate risks and make data-driven decisions that enhance supply chain continuity. Additionally, AI applications in logistics optimization reduce transportation costs and improve route planning, leading to more agile and cost-effective supply chain networks. These benefits are especially crucial in an era where global supply chains are increasingly exposed to disruptions. However, the adoption of AI in supply chain management is fraught with challenges that must be addressed. One of the most significant barriers identified is the high cost of AI implementation, which can be particularly daunting for small and medium-sized enterprises. Moreover, integrating AI systems with legacy infrastructure often requires substantial time and technical expertise, which organizations may lack. There is also a notable skills gap, as the successful deployment of AI requires a workforce equipped with both technical proficiency and domain knowledge. Consequently, companies must invest in training and development to build a workforce capable of effectively utilizing AI tools. Another critical challenge discussed is the ethical dimension of AI adoption. Concerns regarding data privacy, algorithmic transparency, and the potential for biased decision-making are prevalent. Organizations are increasingly required to implement robust data governance frameworks that ensure transparency and accountability while balancing innovation with ethical considerations. Moreover, there is a growing need for policies that address the displacement of workers due to automation, emphasizing the importance of reskilling initiatives to prepare employees for the changing landscape. The findings also reflect on the importance of strategic planning in AI integration. A phased approach to adoption, starting with pilot projects and gradually scaling up, has proven more successful than attempting full-scale implementation from the outset. Collaboration with technology partners and stakeholders is also vital to ensure that AI solutions align with organizational goals and industry best practices. Additionally, fostering a culture that embraces innovation while maintaining a cautious and ethical approach to AI utilization is crucial for long-term success. In examining the future trajectory, it is evident that AI will continue to shape supply chain strategies. The convergence of AI with other technologies, such as the Internet of Things and blockchain, holds promise for creating more transparent, responsive, and resilient supply chains. These integrated systems can enhance real-time monitoring and data accuracy, further minimizing disruptions and optimizing supply chain performance. Nonetheless, to fully harness the potential of AI, companies must address current challenges and proactively prepare for future advancements. The discussion also touches on the global perspective of AI adoption, noting that different regions and industries exhibit varying levels of readiness and acceptance. Factors such as technological infrastructure, regulatory frameworks, and economic conditions influence how rapidly AI innovations are embraced. Consequently, organizations must consider regional nuances when devising AI strategies to ensure practical and sustainable adoption. Overall, the discussion reinforces the idea that while AI has substantial potential to enhance supply chain resilience, realizing its benefits requires thoughtful planning, addressing ethical concerns, and investing in human capital. By adopting a balanced approach that integrates technological innovation with ethical responsibility, companies can build resilient supply chains capable of thriving in an increasingly uncertain global environment.

6. Conclusion

The study demonstrates that artificial intelligence plays a pivotal role in enhancing supply chain resilience, offering transformative potential through predictive analytics, optimization of logistics, and improved decision-making processes. By leveraging AI technologies, organizations are better

equipped to anticipate disruptions, manage risks, and maintain continuity in increasingly complex and uncertain environments. The research highlights that while AI adoption presents numerous benefits, including real-time data analysis and automated responses to supply chain challenges, it also introduces significant complexities related to cost, integration, and workforce readiness. Addressing these challenges requires a strategic and phased approach to AI implementation, emphasizing pilot projects, stakeholder collaboration, and ongoing training to build technical proficiency. Additionally, ethical considerations around data privacy, transparency, and the social implications of automation necessitate robust governance frameworks to balance innovation with accountability. Companies that proactively address these aspects are more likely to realize the long-term advantages of AI while mitigating potential risks. The findings suggest that AI will continue to shape the future of supply chain management, especially as advancements in machine learning, IoT, and blockchain converge to create more resilient and adaptive systems. To stay competitive, organizations must not only invest in technology but also cultivate a culture that embraces change while remaining vigilant about ethical practices and workforce impacts. By integrating AI thoughtfully and responsibly, supply chains can become more agile, sustainable, and capable of withstanding disruptions in an increasingly volatile global landscape.

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