VAASAN AMMATTIKORKEAKOULU
UNIVERSITY OF APPLIED SCIENCES

Abdullah Al Mamun, Md Shahidul Islam

The Impact of Artificial Intelligence on Global Supply Chains

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ABSTRACT

Author	Abdullah Al Mamun, Md Shahidul Islam
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The introduction reflects the dramatic change that has arisen from the integration of artificial intelligence (AI) into international supply chains, which has become necessary due to the increasing complexity and volatility of markets. The assessment of AI applications in global supply chains, evaluation of AI's influence on efficiency and optimization, AI's impact on resilience and risk management, and identification of integration opportunities and obstacles are among the main objectives of the research. To achieve these goals through thematic analysis and comparative research, methodologies reflect thorough assessments of academic literature, trade publications, and case studies a mixed approach that combines quantitative and qualitative techniques for collecting and analyzing data.

The data analysis and findings about the use of AI in global supply chains provide important new information on how AI is used in supply chain operations and that AI is important to planning, shipping, warehousing, procurement, and supplier selection. Prominent uses include supplier risk assessment, last-mile delivery, demand forecasting, and route optimization to enhance supply chain efficiency and optimization by improvements in demand forecasting accuracy, lower expenses for route optimization, and lower labor expenses for warehouse operations. AI-driven solutions also make it easier to improve procurement procedures, optimize space, and handle inventories, which in turn enhances resource allocation and smoothens operations.

Furthermore, by providing real-time monitoring, predictive analytics, and dynamic reaction planning, artificial intelligence (AI) considerably increases supply chain resilience and risk management by better plan for redundancy, proactively identifying and resolving risks, and maintaining business continuity even in the face of errors or emergencies. Even with the advantages that come with integrating AI, several challenges still need to be resolved, such as technological complexity, data quality control, regulatory compliance, and change resistance. The recommendations made to solve these issues include implementing strong data governance frameworks, ensuring compliance monitoring, ensuring successful change management strategies with support from the leadership and stakeholder collaboration, and investing in technological expertise through training and collaboration.

Keywords: Artificial intelligence, global supply chain, opportunities, challenges

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1 INTRODUCTION

An important change in how businesses conduct their operations and react to market conditions is the adoption of artificial intelligence (AI) into global supply chains (Belhadi et al., 2024). Supply chain management has historically planned and implemented several tasks using manual procedures, rigid models, and historical data. However, a more flexible, data-driven approach to supply chain management is required due to the rising complexity and volatility of global marketplaces (Pournader et al., 2021).

1.1 Background of the Study

The evolution of artificial intelligence (AI) technologies, including natural language processing, trend analytics, and machine learning, has created new potentials for risk management, supply chain management, and innovation (Dash et al., 2019). Big data analysis, pattern recognition, and real-time decision-making are all made possible by AI algorithms, which help businesses become more efficient, reduce expenses, and enhance customer satisfaction (Modgil et al., 2022).

Figure 1. AI technologies for Supply Chain (Srivastava, 2022)

Implementation of AI technologies in the supply chain in terms of data quality and availability, infrastructure and technology, and vendor choice and collaboration can be both beneficial and challenging (Fig. 2). This study context is based on the

growing acceptance of artificial intelligence (AI) as a revolutionary factor in supply chain management. Organizations are using AI-driven solutions to gain a competitive advantage, increase operational excellence, and enhance innovation across their supply chains as they work to adapt to the quickly changing market setting (Helo and Hao, 2022).

Furthermore, the COVID-19 pandemic has brought focus on how crucial supply chain agility and resilience are for managing unexpected interruptions. AI's capacity to detect possible sourcing solutions, maximize inventory output, and ensure potential insights has become critical for reducing the effects of disruptions and enhancing business continuity (Riahi et al., 2021).

Figure 2. Examples of AI used in Supply Chain (Urwin, 2022)

AI provides an enormous of uses in the supply chain. The supply chain and logistics domains are impacted in several ways, including operational procurement with the use of chatbots and intelligent data like IBM Watson Assistant and Coupa's AI analytics, supply chain planning to predict supply and demand like Blue Yonder and 09 Solutions, warehouse management to optimize stock like LIamasoft's

Inventory Optimization Solutions and Fetch Robotics, faster and more smooth shipping to decrease lead times and transportation costs like Rout4Me and Optimo Route, and the best supplier selection with real-time data like SAP Ariba (Benzidia et al., 2021).

The other examples of AI technologies are given in Figure 2. Globalization, the rise of e-commerce, and consumer demands for lower delivery times have all contributed to the rising need for AI-powered supply chain solutions. The need for businesses to deliver goods quickly, smoothly, and affordably is pressurizing them, which is why AI technologies are being integrated throughout the supply chain (Baryannis et al., 2019).

In light of this, this study aims to investigate the implications, difficulties, and opportunities related to the incorporation of AI into international supply chains. This research aims to provide important insights into the transformative opportunities of AI in transforming the future of supply chain management by using empirical data, real-world case studies, and expert insights.

1.2 Research Purpose, Objectives, and Methods Used

This study aims to assess how artificial intelligence (AI) is impacting global supply chains for businesses. The paper offers insights into the advantages, challenges, and opportunities related to the integration of AI in supply chain management through a comprehensive investigation. The specific research objectives are given as follows:

1. To identify the key applications of AI in global supply chains;

    - ***Methods Used:*** a comprehensive analysis will be conducted through published studies in scholarly journals, trade publications, and conference proceedings such as IEEE Xplore, ScienceDirect, and Google Scholar. It will

include research papers that identify particular AI technologies and how they are being applied to different activities of supply chain management, including planning, shipping, warehousing, procurement, and supplier selection. The identified uses of AI in supply chains will be analyzed using thematic analysis.

2. To evaluate the impact of AI on supply chain efficiency and optimization;

    - ***Methods Used:*** Assessment of scholarly articles and business publications regarding artificial intelligence's impact on supply chain efficiency and optimization, considering cost and lead time as key KPIs through case studies like Deloitte and McKinsey research. It will compare the results of business case studies and scholarly research to detect recurring themes and patterns in the ways that AI affects supply chain efficiency and optimization.

3. To assess the impact of AI on supply chain resilience and risk management;

    - ***Methods Used:*** Evaluation of industry reports, case studies, and scholarly publications to identify AI-driven tools and approaches for handling risks and practical examples of artificial intelligence (AI) being utilized in supply chain risk management, such as IBM and Flexport to reduce the risk of disruptions from occurrences like natural disasters. It will compare results from various sources to address the most effective approaches and best practices for using AI in supply chain resilience and risk management.

4. To assess the challenges and opportunities of AI integration in global supply chains;

- ***Methods Used:*** secondary data will be used by reviewing scholarly publications, industry publications, and professional viewpoints that emphasize the challenges and opportunities of integrating AI into supply chain management from Gartner and IDC to find out frequent challenges, best practices, and upcoming opportunities in the adoption of AI. It will use thematic analysis to pinpoint recurring challenges impeding the implementation of AI in supply chains, such as constraints in expertise, interoperability problems, and data quality issues.

5. To provide some recommendations to overcome the challenges of AI integration on global supply chains.

    - ***Methods Used:*** results from scholarly articles and case studies to offer practical suggestions for overcoming challenges in the integration of AI within the global supply chains.

1.3 Key Concepts and Frameworks

- ***Artificial Intelligence:*** Artificial intelligence (AI) is used to define the mechanical simulation of human intellectual processes, including robotics, machine learning, and natural language processing. Supply chain participants can automate operations, assess data, and make better decisions based on AI technologies (Attaran, 2020).

- ***Global Supply Chains:*** Global supply chains are the complex webs of interconnected companies that produce, distribute, and transport goods and services beyond national boundaries. Artificial Intelligence (AI) revolutionizes supply chains through process optimization, enhanced transparency, and increased stakeholder collaboration (Chopra, 2019).

- ***Optimization:*** Optimization is the process of maximizing resource use, reducing costs, and increasing overall performance to ensure supply chain operations are more effective and efficient. Organizations can gain an increased level of efficiency and responsiveness by using AI-driven optimization tools like prescriptive modeling and predictive analytics (Toorajipour et al., 2021). Initiatives for digital transformation can use AI technology to facilitate data-driven decision-making, optimize processes, and improve cooperation amongst supply chain stakeholders. Organizations may enhance visibility, efficiency, and process optimization through the adoption of AI into global supply chains (Dash et al., 2019).

- ***Resilience:*** The capacity of supply chains to withstand and return from shocks like natural disasters, international calamities, and supply chain failures. By offering real-time information, focusing on proactive risk management, and promoting quick reactions to disruptions, artificial intelligence (AI) increases resilience (Fatorachian and Kazemi, 2021). By addressing and reducing risks, AI-driven optimization technologies strengthen supply chain resilience and enhance overall performance and flexibility.

- ***Digital Transformation:*** This reflects the process of integrating digital technologies into every stage of supply chain management. The result is a revolutionary shift in the way businesses operate and provide value to their customers. Artificial Intelligence (AI) plays a pivotal role in ensuring the digital transformation of supply chains. It adopts technologies like intelligent automation, demand forecasting, and predictive analytics, all of which enhance efficiency, resilience, and customer happiness (Benzidia et al., 2021).

1.4 Justification of the Topic Selection

The evolution of artificial intelligence (AI) to enhance resilience, creativity, and efficiency makes it relevant and significant in global supply chains. Businesses may match changing customer needs, minimize risks, and simplify operations with AI integration, ensuring sustainability and competitiveness in a market that is becoming more and more dynamic. Investing in advanced AI technologies that enhance the efficiency and profitability of supply chains might be advantageous to investors. The adoption of AI in supply chains has regulatory implications for data security, privacy, and ethics. Regulatory agencies are crucial in establishing policies and procedures that ensure the ethical application of AI, accountability, and transparency across supply chain activities.

Customers can benefit from AI-driven supply chain management in the form of increased product availability, quicker delivery, and more personalized shopping experiences. Increased consumer satisfaction and trust are benefitted by AI-enabled supply chain viability and transparency. Understanding AI's influences is important for supply chain and logistics professionals to stay competitive and increase innovation.

Training, career promotion, and specialization in cutting-edge fields like supply chain optimization and forecasted analytics are all made possible by AI technologies. AI provides a revolutionary chance for companies involved in international supply chains to enhance efficiency, minimize risk, and encounter market possibilities. Adopting AI-driven supply chain solutions can increase revenue growth, cost savings, and efficiency, which will increase sustainability and competitiveness in the marketplace.

Artificial intelligence (AI) skills and knowledge are becoming more and more valuable for professionals in the field of supply chain management. For professional growth and career growth, it is important to stay updated with AI

trends, best practices, and implications in supply chain management. Policy-making is influenced by the incorporation of AI in supply chains on multiple levels. Legislators must formulate laws that support innovation while addressing issues with cybersecurity, data privacy, and the moral use of AI. To ensure economic growth and competitiveness, governments can also use subsidies, tax exemptions, and other supportive policies to encourage the adoption of AI.

The potential of AI to enhance operational efficiency and address economic trends like increasing labor costs makes it an important and relevant topic in global supply chains. Further pinpointing the applicability and significance of this research in managing future supply chain dynamics are the regulatory implications, which include difficulties and policies associated with the application of AI like as data privacy laws.

1.5 Problem Statement and Research Questions

Although the adoption of artificial intelligence (AI) into global supply chains is gaining focus, a thorough understanding of its practical implications, problems, and opportunities is still lacking. Organizations are unable to fully utilize AI's dedication to enhance supply chain resilience, efficiency, and cooperation due to this knowledge gap.

1. What are the key applications of AI in specific global supply chain processes like inventory management, demand forecasting, and distribution?
2. What are the impacts of AI on supply chain efficiency and optimization in terms of lead times, inventory turnovers, and cost reductions?
3. What are the impacts of AI on supply chain resilience and risk management by applying AI-driven approaches like predictive analytics, real-time monitoring, and scenario planning and simulation to reduce disruptions?

4. What are the primary challenges and opportunities of AI integration in global supply chain processes like inventory management, demand forecasting, and distribution?
5. What are the recommendations to overcome the challenges of AI integration on global supply chains?

2 THEORETICAL FRAMEWORK AND LITERATURE REVIEW

The literature analysis addresses five major objectives while examining the crucial position of artificial intelligence (AI) in global supply chains. It accumulates useful insights from real-world applications with theoretical frameworks like the Technology Acceptance Model (TAM). It provides a thorough understanding of AI's disruptive nature in supply chain management by highlighting its applications, impact on resilience, efficiency, possibilities, and difficulties, and offering recommendations.

2.1 Applications of AI in Global Supply Chains

According to Calatayud et al. (2019), based on theoretical frameworks, the adoption of artificial intelligence (AI) in global supply chains presents many potential applications. The Technology Acceptance Model (TAM) is a well-known theoretical framework that suggests that users' perceptions about the utility and usability of a technology affect its acceptance. , posit that to be accepted by stakeholders in the supply chain context, AI applications must show tangible improvements in decision-making, operational efficiency, and customer satisfaction.

According to Hofmann et al. (2019), the Resource-Based View (RBV) framework also ensures the significance of internal resources and competencies in gaining a long-term competitive edge. AI technologies are strategic tools that help businesses increase resource efficiency, simplify the supply chain, and attain operational excellence. Ivanov et al. (2019) stated that organizations can experience new chances for value creation and competitive differentiation by using AI capabilities. There are some applications of supply chain used in every process like demand forecasting, inventory management, and distribution. The applications are given below:

- **Predictive analytics:** According to Rodríguez-Espíndola et al. (2020), using historical data and AI-driven algorithms, forecasted analytics predicts future demand trends, helping businesses manage inventory outputs, reduce stockouts, and increase customer experience. Dash et al. (2019) also added that it helps with demand forecasts and seasonal product inventory management in retail. Predicting equipment repair requirements simplifies production scheduling in the manufacturing industry. It enhances pharmaceutical supply chain visibility in the healthcare industry, ensuring on-time delivery and inventory control. Yang et al. (2021) added that predictive analytics is used, for example, by Amazon and Walmart to forecast customer demand and maximize inventory replenishment strategies, which ensures significant cost savings and higher sales.

- ***Autonomous Vehicles:*** According to Akbari and Hopkins (2022), AI-driven autonomous vehicles, such as self-driving trucks and drones, are dynamically changing supply chain logistics and transportation. These cars can increase delivery accuracy and speed, lower distribution costs, and automate delivery processes. Free and Hecimovic (2021) also stated that autonomous vehicles (AVs) are revolutionizing supply chains in several industries. AVs optimize operations, lower costs, and enhance efficiency in various industries, including manufacturing, agriculture, and e-commerce logistics. Their adaptability and revolutionary effect on supply chain management are specifically noteworthy. For example, drones may be used for last-mile delivery by businesses like UPS and DHL, which would support quicker and more efficient package deliveries in cities.

- **Robotic Process Automation:** According to Ghadge et al. (2020), order collecting, processing, invoicing, and warehouse automation are just a few examples of the repetitive activities and processes that robotic process

automation (RPA) technology automates in supply chain processes. Baryannis et al. (2019) posit organizations can enhance overall efficiency, reduce manual error rates, and simplify operations by implementing RPA bots. Coca-Cola, for example, used RPA bots in their order processing system, which minimized processing times by 30% and ensured order accuracy. Lund et al. (2019) posit that supply chain processes are simplified using robotic process automation (RPA) across various industries, including retail, healthcare, and automotive. RPA enhances inventory management in healthcare and automates order processing in retail. The automotive sectors reflect the versatility and adaptability of RPA by utilizing it to automate assembly lines.

- **Natural Language Processing (NLP):** According to Moosavi et al. (2022), by focusing on robots to understand and interpret human language, NLP technologies enhance communication and assist in supply chain management decision-making. NLP-driven chatbots can ensure real-time assistance to customers, vendors, and employees, enhancing communication and speeding up the resolution of problems. Sanders (2020) found that to increase user experience and enhance communication, businesses such as IBM and SAP use natural language processing (NLP)--based chatbots in their supply chain processes. Supply chain management across various industries is aided by natural language processing (NLP). Singh et al. (2021) added that NLP powers chatbots in retail to respond to customers, and it supports real-time communication between stakeholders in manufacturing. NLP is used in the healthcare industry to manage inventories, reflecting how versatile it is in enhancing operational effectiveness in several industries.

- **Supply Chain Optimisation:** According to Fonseca and Azevedo (2020), demand forecasting, inventory control, production scheduling, and

logistics optimization are just a few of the areas of the supply chain that AI algorithms focus on. AI-driven optimization models help businesses make wise decisions, reduce expenses, and increase supply chain performance by filtering through enormous volumes of data and finding trends. Dolgui and Ivanov (2022) also found that techniques for supply chain optimization vary throughout industries. While it focuses on production scheduling and logistics optimization in manufacturing, it simplifies inventory management and demand forecasting in retail. Supply chain optimization is used in the healthcare industry to increase patient care through improved distribution procedures and effective inventory management, reflecting its cross-sector implications. For example, businesses like Unilever and Procter & Gamble use AI-driven optimization technologies to reduce the cost of inventory holding and enhance product scheduling.

2.2 Impact of AI on Supply Chain Efficiency and Optimization

According to Ivanov (2020), through, the ability to enhance decision-making, maximize resource utilization, and simplify operations, artificial intelligence (AI) plays an important role in improving supply chain efficiency. Free and Hecimovic (2021) posit that large-scale historical data is assessed by AI-driven predictive analytics algorithms to forecast future supply chain risks, inventory levels, and demand trends.

These algorithms consider variables including lead times, resource constraints, and demand unpredictability to optimize inventory levels, minimize transportation costs, and optimize production schedules. Lezoche et al. (2020) posit that artificial intelligence (AI)-driven optimization models maximize the supply chain dynamically to cope with changing conditions, reduce costs, enhance service standards, and raise overall efficiency.

Inventory Optimization: Organizations can reduce excess inventory costs, maximize inventory levels, and reduce stockouts by effectively predicting market trends and changes in demand. Furthermore, Sharma et al. (2020) added that proactive decision-making is made possible by forecasted analytics, which ensures businesses to foresee possible disruptions and take primitive action to overcome risks.

Singh et al. (2021) agreed that picking, packing, and sorting are just a few of the warehouse activities that autonomous robots operate to speed up order fulfillment and reduce labor expenses. Artificial intelligence (AI) enhances supply chain efficiency by freeing up human resources to focus on more strategic responsibilities by automating routine processes. Ivanov et al. (2019) said that artificial intelligence (AI)-driven optimization algorithms examine intricate supply chain data to find areas where efficiency may be improved in several areas, such as production scheduling, transportation logistics, and inventory management.

Lower Errors and Lead Time: This enhances supply chain efficiency overall. Hopkins (2021) found that robotic process automation (RPA) and autonomous robots are two applications of AI-driven automation technologies that smoothen labor-intensive and repetitive processes in supply chain operations. RPA minimizes errors and processing times while enhancing operational efficiency by automating manual tasks including order collection, processing, invoicing management, and data entry.

According to Lund et al. (2019), artificial Intelligence assists the real-time tracking of supply chain activities and offers supply chain managers the ability to make wise decisions. Key performance indicators (KPIs) including inventory levels, order fulfillment rates, and delivery durations are continuously monitored by AI-powered analytics dashboards and forecasting models, which ensure management of any possible hindrance or departures from organizational goals.

Informed Decision-making: Hartley and Sawaya (2019) posit that Artificial Intelligence (AI) assists managers in enhancing supply chain efficiency and responsiveness by helping informed decision-making, maximizing resource allocation, and smoothly addressing bottlenecks. This is achieved by offering valuable insights and practical solutions.

According to Miroudot (2020), supply chain optimization is being completely transformed by artificial intelligence (AI), which ensures sophisticated tools for automation, decision-making, and data analysis. Demand forecasting algorithms driven by artificial intelligence (AI) utilize machine learning techniques to assess historical data, market trends, and external effects with unprecedented reliability and accuracy.

Demand Forecasting: Koh et al. (2019) stated that artificial intelligence (AI) systems provide more accurate demand forecasting by seeing patterns and correlations in large datasets. This helps businesses maximize inventory levels, reduce stockouts, and save money on excess inventory. Better planning and resource allocation are made possible by this reliable forecasting, which enhances supply chain optimization. Dolgui and Ivanov (2022) found that AI-driven inventory management systems focus on supply chain dynamics, demand fluctuations, and inventory levels in real time.

These systems cope with shifting situations and adjust inventory replenishment strategies through machine learning algorithms. Singh et al. (2021) agreed that AI enhances inventory management procedures by dynamically changing lead times, reorder points, and safety stock levels regarding supply chain disruptions and demand changes. This ensures ideal inventory levels while reducing carrying costs and stockouts. To find the most economical and effective routes, AI-driven

optimization algorithms assess complex transportation networks, route possibilities, and delivery schedules.

Cost Minimization: Wamba and Queiroz (2020) posit that artificial intelligence (AI) algorithms maximize logistics processes, reduce transportation costs, and enhance delivery dependability by considering variables including traffic conditions, weather forecasts, and delivery limits. Lee et al. (2022) stated that AI further enhances transportation efficiency and optimization by ensuring dynamic routing alterations regarding real-time incidents like traffic jams or vehicle failures.

Production capacity, resource availability, and demand forecasting are all balanced by AI-driven production planning and scheduling systems, which maximize manufacturing operations. Sharma et al. (2020) posit that AI identifies production bottlenecks, maximizes production sequences, and plans production operations to reduce idle time and increase output using forecasting analytics and optimization algorithms.

Supplier Management: According to Singh et al. (2021), AI ensures effective resource utilization, reduces lead times, and improves overall production efficiency by coordinating production schedules with demand forecasting and inventory levels. By assessing supplier performance data, market trends, and risk considerations, artificial intelligence (AI) assists in supplier relationship management.

Pournader et al. (2021) posit that artificial intelligence (AI)--driven supplier management solutions identify chances for supplier consolidation, accept good deals and proactively minimize supply chain risks. Artificial intelligence (AI) improves supply chain resilience, reduces procurement costs, and enhances overall supply chain optimization through maximizing supplier selection, sourcing strategies, and managing administration procedures.

2.3 Impact of AI on Supply Chain Resilience and Risk Management

According to Dash et al. (2019), supply chain resilience is greatly influenced by artificial intelligence (AI), which ensures businesses proactively identify risks, react quickly to disturbances, and develop adaptive capabilities. Artificial intelligence (AI) utilizes machine learning algorithms and predictive analytics to assess massive volumes of data from multiple sources, assisting in early risk detection in supply chains.

According to Rodríguez-Espíndola et al. (2020), supply chains need to balance carefully between proactive and reactive tactics to be resilient, and artificial intelligence is essential to achieving this balance. Using AI-driven analytics to predict possible disruptions based on past performance, industry shifts, and outside factors is known as a predictive strategy. Dolgui and Ivanov (2022) also added that artificial intelligence (AI) can foresee events like supplier failures, natural disasters, or geopolitical issues by assessing large datasets. This capability enables businesses to proactively apply risk mitigation initiatives.

Reactive tactics, on the other hand, Baryannis et al. (2019) found that focus on quickly and successfully managing unplanned interruptions as they occur. AI makes it possible to assess supply chain activity in real-time, giving businesses the ability to see patterns that deviate from plans and adopt appropriate action. According to Chopra (2019), AI-powered sensors, for instance, may focus on production schedules, transportation routes, and inventory levels, informing relevant parties of any irregularities or delays.

Belhadi et al. (2024) added that to identify any hazards and disruptions in real-time, artificial intelligence (AI) systems continuously assess supply chain processes, supplier performance indicators, market changes, and external effects. AI systems can identify minimal changes and new threats, such as supplier

bankruptcies, natural disasters, or geopolitical events that could indicate potential disruptions through pattern recognition and anomaly detection.

Artificial Intelligence (AI) assists take proactive steps by organizations to overcome operational impacts and improve supply chain resilience by identifying possible hazards early on. Helo and Hao (2022) also added that in today's complex and dynamic supply chain circumstances, early risk detection enabled by artificial intelligence (AI) helps organizations predict and respond to disruptions more efficiently, reducing them and preserving business continuity.

According to Flexport (2023), AI-driven risk management technologies are used by Flexport, a freight forwarding and customs brokerage business, to reduce supply chain interruptions. Flexport identifies potential dangers and adopts preemptive steps to reroute goods and minimize delays by analyzing real-time data on weather, geopolitical events, and port congestion. According to Belhadi et al. (2024), artificial intelligence (AI) offers real-time insights and adaptable capabilities to manage changing risk landscapes, making it an important tool for dynamic risk assessment in supply chains. To dynamically identify risk levels, AI-driven algorithms continuously assess various data sources, such as internal operations, external market changes, and geopolitical factors.

Riahi et al. (2021) added that artificial intelligence (AI) systems can find new risks and hazards by utilizing machine learning tools to find patterns, correlations, and mismatches in the data. By the use of dynamic risk assessment, artificial intelligence (AI) helps the adaptation of risk reduction measures by organizations to dynamic conditions, thereby ensuring resilience and agility in the face of uncertainty. Benzidia et al. (2021) posit that these AI-driven solutions provide supply chain managers with practical insights into new risks, empowering them to allocate resources wisely and make well-informed decisions.

In today's unstable business environment, organizations may reduce the effect of interruptions, ensure operational continuity, and protect their competitive advantage by proactively recognizing and mitigating potential threats. Baryannis et al. (2019) stated that supply chain resilience is enhanced by proactive risk management and flexible decision-making in the face of uncertainty, which is made possible by AI-driven dynamic risk assessment.

According to La Face (2023), one of the biggest shipping businesses in the world, Maersk, uses AI-driven predictive analytics to efficiently mitigate supply chain risks. Maersk predicts possible disruptions like labor strikes or port closures by assessing past data on container movements. This helps them to manage port schedules and ensure simple operations. According to Chopra (2019), supply chain scenario planning and simulation are being changed by artificial intelligence (AI), which allows businesses to simulate and model various risk scenarios with previously unattainable risks and speed. Advanced analytics and machine learning tools are used by AI-driven simulation models to assess massive volumes of data and recreate complex supply chain conditions.

Attaran (2020) added that organizations can assess the possible impacts of various risk events, such as demand variations, natural disasters, or disruptions in suppliers, on supply chain performance due to these AI-driven solutions. Organizations can emphasize risk mitigation strategies, find weaknesses, and create alternative plans to ensure business continuity by modeling various conditions and assessing their outcomes. Toorajipour et al. (2021) stated that AI also makes it possible to develop scenarios dynamically by automatically updating simulation models regarding real-time data and changing market conditions.

According to Yusuf (2023), businesses can address and reduce supply chain risks with the aid of AI-driven risk management solutions from IBM Watson Supply Chain. Through the assessment of data from several sources, including supplier

performance measures, market shifts, and geopolitical events, IBM Watson offers reliable insights and suggestions aimed at reducing interruptions and ensuring supply chain resilience.

By considering an adaptable approach, organizations can smoothly address new challenges and change their policies to enhance the resilience and flexibility of their supply chains. All things considered, Fatorachian and Kazemi (2021) stated that the use of AI in scenario planning and simulation ensures businesses better manage risks, make better decisions, and develop resilient supply chain plans that can resist disruption and unpredictability in the ever-changing business world of today.

According to Calatayud et al. (2019), supply chain redundancy and flexibility are being changed by artificial intelligence (AI), which provides sophisticated capabilities for dynamically restructuring the supply chain, varying sourcing strategies, and maximizing inventory location. Artificial intelligence (AI)-driven algorithms assess enormous volumes of data from various sources, such as past sales data, market shifts, and supply chain interruptions, to identify ways to increase redundancy and flexibility.

According to Garland (2023), UPS utilizes artificial intelligence (AI) and machine learning algorithms to enhance risk management throughout its international supply chain. UPS can predict and prevent risks like inventory shortages and delivery delays by focusing on data related to cargo levels, weather issues, and delivery routes.

Hofmann et al. (2019) stated that supply chain redundancy can be enhanced by AI in part by optimizing inventory placement throughout the network. Artificial intelligence (AI) systems can identify the best inventory locations and levels depending on lead times, cost constraints, and demand fluctuations by using

forecasted analytics and machine learning. By doing this, Ivanov, Dolgui, and Sokolov (2019) stated that businesses may ensure that critical locations have sufficient amounts of safety stock on hand to minimize the effects of disruptions and minimize stockouts.

To minimize reliance on a single source, AI also helps businesses to diversify their sourcing strategies and find alternate suppliers or supply chain paths. Yang et al. (2021) posit that AI can assess supplier performance, find possible risks, and offer real-time suggestions for alternative sourcing paths using predictive analytics and risk assessment. This allows businesses to ensure supply continuity and proactively minimize supply chain risks. Furthermore, according to Akbari and Hopkins (2022), by ensuring real-time decision-making and adaptive reaction to changing situations, artificial intelligence (AI) improves the dynamic restructuring of supply chains.

Artificial intelligence (AI)-driven optimization algorithms focus on supply chain performance indicators, identify bottlenecks and interruptions, and recommend changes to supply chain configurations like rescheduling shipments or reallocating resources. Ghadge et al. (2020) stated that Organizations can adapt smoothly to unpredicted occurrences and ensure operational continuity in dynamic and uncertain contexts because of this adaptability and flexibility.

According to John (2023), leading aerospace producer Airbus ensures supply chain resilience using AI-driven risk management technologies. Airbus can predict potential risks like component shortages or manufacturing bottlenecks and adopt primitive measures to ensure continuous operations and interruptions are reduced by assessing data from suppliers, production processes, and market trends.

2.4 Challenges and Opportunities of AI in Global Supply Chains

According to Baryannis et al. (2019), organizations must overcome several challenges when integrating artificial intelligence (AI) into global supply chains to maximize AI's advantages while reducing associated risks. For AI to make accurate decisions, high-quality data is important. Nonetheless, a lot of businesses face issues with inconsistent data, poor data quality, and data gaps in their supply chain operations.

Moosavi, Fathollahi-Fard and Dulebenets (2022) stated that establishing data standards, managing data governance issues, and ensuring data accessibility throughout the supply chain process are all necessary for integrating AI. Global supply chains ensure many different systems, processes, and stakeholders, making them intrinsically complex. Interoperability, data integration, and system reliability are issues that arise when integrating AI across various platforms and systems.

Sanders (2020) posits that investments in frameworks and technologies that ensure smooth integration and interoperability between AI systems and present infrastructure are important for organizations. Supply chain AI implementation offers specific knowledge of data science, machine learning, and AI technology. On the other hand, the supply chain industry lacks reliable experts with AI experience. Fonseca and Azevedo (2020) argued that to develop AI capabilities and expertise inside their workforce, organizations must invest in training initiatives, reskilling programs, and talent acquisition techniques.

AI technology implementation requires a large initial investment in personnel, software, and infrastructure. According to Ivanov (2020), it could be challenging for organizations to ensure a short-term return on investment (ROI) and to justify the expense of integrating AI. To ensure long-term sustainability and value generation, it is crucial to create concise business cases, set numeric KPIs, and

collaborate on AI projects with strategic goals. According to Free and Hecimovic (2021), AI raises moral questions about accountability, bias, transparency, and data privacy. Organizations must ensure that AI systems provide industry best practices, ethical standards, and legal requirements.

Moreover, managing international supply chains' data protection and cross-border limitations complicates hampers to integration of AI. Sharma et al. (2020) posit that organizational and cultural change is necessary for AI integration. Integration and implementation efforts may be limited by low trust in AI technologies, losing one's job, and resistance to change. Increasing an innovative and collaborative culture requires effective change management strategies, stakeholder engagement, and communication.

Hopkins (2021) added that the incorporation of AI ensures new cybersecurity and privacy risks. AI systems are vulnerable to hostile manipulation, cyberattacks, and data breakdowns. Encryption methods, data protection procedures, and strong cybersecurity initiatives must be implemented by organizations. According to Ivanov et al. (2019), by incorporating artificial intelligence (AI) into global supply chains, businesses can enhance their competitiveness, resilience, and efficiency in several ways. More precise demand forecasting is made possible by AI-driven analytics, which assesses enormous volumes of data, including past sales information, industry shifts, and externalities.

Lezoche et al. (2020) stated that businesses can enhance customer happiness and profitability by maximizing inventory levels, reducing extra inventory expenses, and minimizing stockouts through enhanced demand forecasts. AI-driven inventory management systems dynamically cope with inventory levels to consider lead times, cost factors, and variations in demand. Lund et al. (2019) argued that organizations may reduce obsolescence, enhance inventory turnover

rates, and reduce carrying costs by using machine learning and predictive analytics.

This offers cost savings and better cash flow. AI enables the optimization of logistics and transportation processes by facilitating load, vehicle, and route concerns. According to Hartley and Sawaya (2019), to identify the most effective routes and delivery schedules, AI-driven algorithms examine variables including traffic patterns, weather predictions, and delivery limitations. This leads to transportation cost reductions, more reliable deliveries, and better customer service.

AI makes it easier to automate supplier selection, contract management, and procurement processes. Miroudot (2020) stated that AI-driven procurement systems can assess market trends, find cost-saving strategies, and assess supplier performance data. Furthermore, AI offers proactive risk management by focusing on supplier risks and identifying substitute sourcing choices to ensure supply chain continuity.

According to Koh et al. (2019), real-time insights into inventory levels, order collection, and shipment tracking throughout the supply chain processes are offered by AI-driven supply chain visibility platforms. Better decision-making, proactive problem-solving, and increased cooperation amongst supply chain actors are made possible by this visibility. Artificial Intelligence (AI) encourages responsiveness and flexibility in global supply chains by improving transparency and communication.

Dolgui and Ivanov (2022) stated that AI uses predictive analytics and condition monitoring to offer maintenance of machinery and equipment. AI systems can predict equipment failures before they happen, ensuring preventive maintenance and minimizing downtime, by assessing sensor data and machine performance

factors. This minimizes maintenance costs, enhances asset reliability, and increases equipment lifecycle.

According to Chopra (2019), a thorough examination must identify the moral issues of integrating AI into global supply systems. Case law examples can determine the practical implications of insufficient ethical concerns. Examples of such cases include AI bias cases and privacy breaches. Furthermore, Lee et al. (2022) stated that regulatory trends like AI governance frameworks or data protection laws, provide insight into how the legal system and business ethics are changing.

For example, according to Akbari and Hopkins (2022), businesses all around the world are impacted by the General Data Protection Regulation (GDPR) of the European Union, which places strong restrictions on data processing and AI algorithm transparency. Sharma et al. (2020) added that the significance of using AI ethically is further emphasized by recent court cases, such as the lawsuit brought against a large tech company for discriminatory AI employment practices. These instances show how unethical use of AI can result in legal issues, harm to one's reputation, and cause financial penalties.

Singh et al. (2021) posit that artificial intelligence (AI) is utilized in analytics and optimization technologies to offer insights into supply chain performance metrics, highlight problem areas, and suggest solutions. This ensures businesses constantly develop and improve supply chain processes, driving operational excellence and competitive advantages.

2.5 Recommendations to Overcome the Challenges of AI Integration on Global Supply Chains

According to Wamba and Queiroz (2020), a comprehensive approach that considers organizational, cultural, and technical issues is needed to tackle the challenges associated with AI integration in global supply chains. To ensure data security, quality, and accessibility, businesses can develop strong governance structures and data management techniques. To compile and integrate data from various sources, businesses may use platforms and technologies for data integration.

Lee et al. (2022) stated that to increase the quality and dependability of data, they may invest in tools for data normalization, filtering, sorting, and enrichment. To increase the organization's use of AI, investments in talent acquisition tactics, upskilling programs, and training courses may be another way to overcome challenges. According to Wamba and Queiroz (2020), providing workers the opportunity to improve their AI knowledge and abilities to enhance a culture of learning and creativity and obtaining AI talent and experience, working with academic institutions, industrial partners, and professional groups can be beneficial to overcome challenges.

Sharma et al. (2020) posit that when selecting AI technology and solutions, companies may provide compatibility and interoperability as top priority. Selecting AI tools and platforms that operate well with the infrastructure and processes that are already in place, promoting adoption and interoperability, and assessing vendor solutions according to their support systems for open standards, APIs, and data exchange protocols can be ways to minimize challenges.

According to Rodríguez-Espíndola et al. (2020), creating precise cases and business justifications for integrating AI and placing a focus on numeric business value and quantitative return on investment can be the mitigating strategies. Conducting

proofs-of-concept and pilot studies to ensure that AI technologies are a good fit for overcoming particular supply chain issues and informing important stakeholders, such as business partners, investors, and senior leadership about the possible advantages of integrating AI can be the strategies as well.

Akbari and Hopkins (2022) stated that developing the moral standards and guiding concepts for the creation, use, and application of AI within the company and assuring dedication to ethical guidelines, data privacy laws, and industry best practices when adopting AI can reduce challenges. Establishing fairness, accountability, and transparency initiatives to reduce moral dilemmas and enhance public confidence in AI systems can be the strategies to reduce challenges.

Baryannis et al. (2019) stated that using effective change management and communication techniques to connect stakeholders from all areas of the company in the AI integration process and encouraging cooperation between supply chain parties, IT departments, and business units to overcome issues, collaborate goals, and encourage adoption. Encouraging the collaboration of cross-functional teams on AI projects by using their varied backgrounds and perceptions can be the strategy to reduce supply chain challenges.

Ivanov (2020) argued that to secure AI systems and data from security threats, businesses may implement strong cybersecurity protections, encryption protocols, and access controls. To find weaknesses and reduce risks, they might ensure frequent security audits, penetration testing, and evaluations. To stay up to date on new threats and best practices, businesses may coordinate with government agencies, industry colleagues, and cybersecurity specialists.

According to Free and Hecimovic (2021), encouraging the development of an innovative and experimental culture that rewards risk-taking, creativity, and

continuous development, employees should be given incentives and rewards to experiment with new concepts and technologies. To encourage creativity and resilience within the company, recognizing accomplishments, and drawing lessons from failures may help in succeeding in potential challenges in supply chains.

According to Akbari and Hopkins (2022), this implementation process includes several crucial steps. To begin with, businesses must thoroughly assess the parts of their supply chain operations that are ready for AI adoption. They should then compare several AI technologies to determine which one best fits their requirements. Dolgui and Ivanov (2022) again stated that evaluating these solutions in specific supply chain activities through pilot testing makes it possible to identify their efficacy and highlight any problems. It is crucial to ensure that the appropriate data infrastructure, comprising strong data acquisition, storage, and processing capabilities, is in place to enable AI applications.

Furthermore, Sharma et al. (2020) found that providing staff with skill development and training programs makes it easier for them to use AI technologies properly. Throughout the implementation stage, collaborating with technology providers and industry experts can ensure invaluable resources and experience. Wamba and Queiroz (2020) stated that AI applications must be continuously monitored, optimized, and assessed as well as adjusted regularly to ensure continuous improvement and consistency with corporate goals. This methodical strategy optimizes benefits while reducing risks as it directs businesses through the challenges of adopting AI.

2.6 Literature Gap

A gap in the literature that may arise from the secondary study is the limitation of in-depth studies that look at the particular opportunities and challenges of integrating AI in global supply chains across various industries and geographical locations. Previous studies frequently focused on broad patterns and best

practices; however, a more comprehensive analysis is required, considering the distinct circumstances and complexities encountered by different industries and regions. Closing this gap will help policymakers, practitioners, and researchers formulate particular plans and solutions for the integration of AI in various supply chain conditions.

2.7 Theoretical Framework

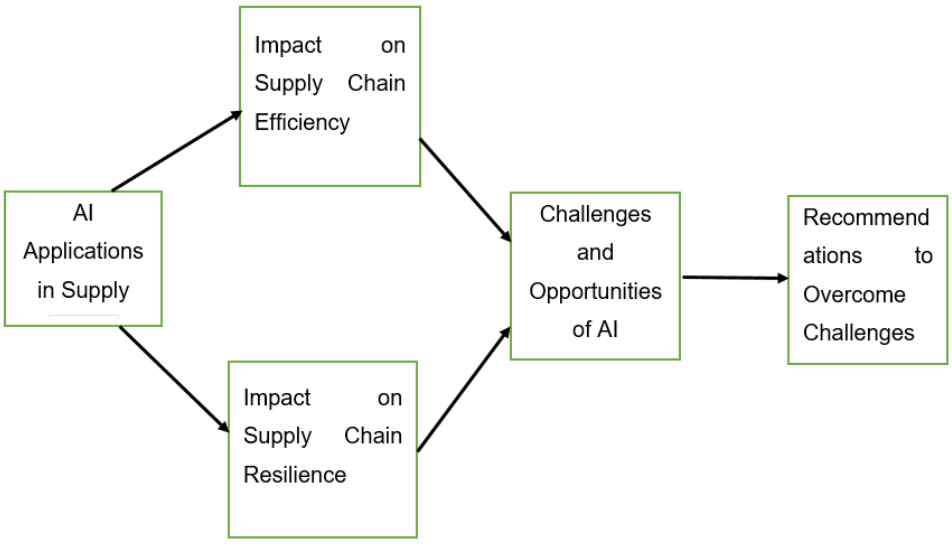

Figure 3. Theoretical Framework

Fig. 3 provides a visual representation of the relationships between the research questions and how they influence the theoretical knowledge of AI adoption in global supply chains. The complex relationships between the primary concepts generated from the study questions are illustrated by the arrows, which direct the flow of influence between various factors. With arrows pointing in the direction of each other objective, Objective 1 forms the foundation of the framework. The determination of important AI applications influences Objective 2. The arrow suggests that analyzing AI applications' effects on efficiency and optimization comes after understanding their uses.

Similarly, the identification of AI applications influences objective 2. The arrow implies that evaluating AI's effects on resilience and risk management is influenced by knowledge of how supply chains adopt the technology. The identification of AI applications and the assessment of their effects on resilience and efficiency are related to Objective 4. By evaluating its uses and effects, one can attain a deeper understanding of the opportunities and challenges associated with integrating AI. Lastly, recommendations for conquering challenges are based on all previous objectives.

2.8 Conclusion

The extensive examination of the literature on the uses, effects, difficulties, and prospects of integrating AI into global supply chains emphasizes how revolutionary AI technology can be. Through an analysis of theoretical frameworks and empirical cases, the paper highlights the significance of artificial intelligence (AI) in augmenting supply chain resilience, efficiency, and optimization. Nonetheless, some obstacles must be overcome, including problems with data quality, integration, and ethics. Organizations can surmount these obstacles and fully utilize artificial intelligence (AI) to stimulate creativity and competitiveness in international supply chains.

Future studies may focus on assessing the long-term consequences of integrating AI into supply chains, assessing newly developed AI technologies, and examining how AI might be used to solve ethical issues. The study's conclusions offer insightful information about how supply chains might utilize AI to improve resilience, efficiency, and risk management. Industry sectors can strategically utilize AI-driven solutions to improve operations, reduce disruptions, and manage competitiveness in a market that is becoming more and more dynamic by being aware of these results.

3 METHODOLOGY

Research methodology is a plan that reflects how the research will be conducted. The research design ensures that the study has been conducted in a way that considers the type of data to be utilized, the source and method of data collection, the tools needed for data collection, organizing, coding, and analysis of the data to address the research questions, as well as the presentation and interpretation of the results to assist the audience in realizing and appreciating the significance of the research findings (Costley et al. 2010). My research methodology is based on the "research onion" model proposed by Saunders. This section has contributed the research philosophy, research approach, research strategy, research method, time horizon, data collection and analysis, Gantt chart, and ethical issues to answer the research questions indicated above through the application of the research onion model.

3.1 Research Onion Model

Research Onion implies that the researchers adopt an accurate research methodology. According to Saunders et al. (2019), it reflects that there are some actions the researcher needs to perform to ensure a valid and reliable approach that will help in answering the study questions.

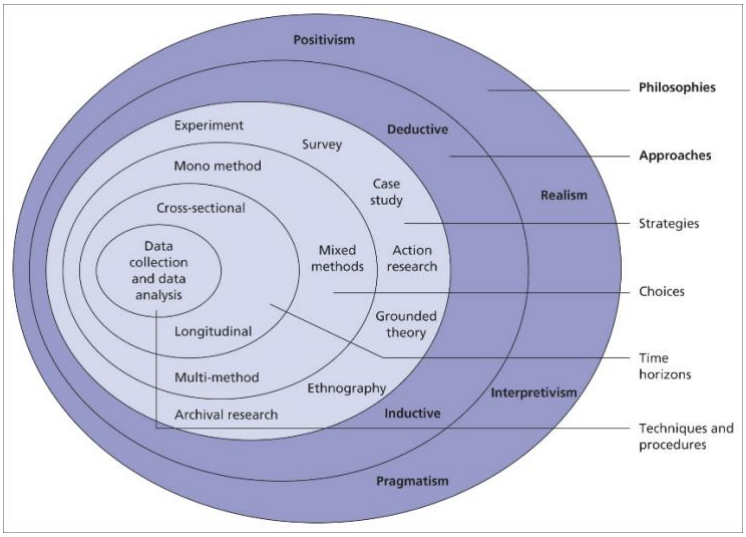

Figure 4. Research Onion Model (Saunders et al., 2019)

It first helps the researcher to choose which philosophy (positivism, interpretivism, pragmatism, or realism) is the most appropriate for the research aim. This helps the researcher select which research strategy (survey, case study, archival research, experiment, or grounded theory), which research methods (mono, mixed, or multi-methods), which research time-horizon (cross-sectional or longitudinal), and which tools and instruments to gather and assess data. The study has shown this process in the ways listed below (Flick, 2011).

3.2 Research Philosophy

The type of study a researcher conducts is reflected in their research philosophy. Furthermore, it usually ensures the current stage of the investigation of the researcher. It suggests the appropriate method for collecting and assessing data for a particular study based on the questions and research aim. Furthermore, positivism, pragmatism, interpretivism, and realism are the four key philosophies that can be used to do research correctly (Grey, 2009).

The researcher can adopt any of these, depending on how they want to conduct the investigation. The positivist perspective implies that to truly realize the world, it must be observed and assessed for what it is (Pandey & Pandey, 2021). Positivist ideas prioritize an "objective" assessment of reality, based on their beliefs on numeric and observable instances, such as international organizations and states of affairs. As a result, positivism prioritizes the factual analysis of data. Since the researchers' questions are neutral, they individually offer objective results based on their analysis and conclusions. This type of study is well-organized and generally accepted (Newman and Gough, 2020).

The work of pragmatic researchers is distinct by its newness and vibrancy as they make practical decisions based on "what will work best" to solve the research questions. Research philosophy also includes interpretivism as a philosophical

strategy. This concept reflects that because humans can assign significance to natural incidents, they are different from those events (Nayak & Singh, 2021).

Interpretivism ensures that the social world is too complex to be investigated in the same manner as the physical world. The purpose of interpretive research is to provide fresh and different perspectives on the natural world. Last but not least, the realism philosophy of research is predicated on the idea that reality occurs apart from human interaction. This worldview reflects the potential and importance of scientific acquisition of new knowledge. The two types of realism are critical and direct realism (Thomas, 2021).

The positivist philosophy has been selected for this research project, which ensures that secondary sources were used to acquire data for the study, accept practical results, and interpret those results in light of the body of existing research and reliable judgment. For instance, statistics from secondary results have been correctly assessed about how AI technologies are impacting the global supply chain.

3.3 Research Approach

After deciding on the research philosophy, the researcher must select a research strategy that considers the implications of a finding based on many research phases. Based on the research approach, more activities connected to the methodology are decided. Deductive and inductive reasoning are the two approaches used in research. To develop research hypotheses, models, concepts, theories, etc. for a particular research problem that has never been solved before, the study adopts an inductive approach (Dubey & Kothari, 2022).

Therefore, inductive research starts with observations of reality to build theories, models, and presumptions; it ends with a judgment based on subjectivity and

observation. On the other hand, deductive research implies the application of prior theories and hypotheses that have been formulated for a particular topic and are then utilized to answer the research question (Haydam & Steenkamp, 2020). As a result, the process ensures identifying relevant or required prior theories and models, developing hypotheses, collecting data, analyzing that data, and testing the hypotheses. Consequently, inductive research typically provides new theories, whereas deductive research confirms concepts to solve practical research issues (Sekaran & Bougie, 2016).

The literature review section of the research draws on several results and findings about AI technology's impact on supply chains like what AI technologies are used in the supply chain, how they help to achieve operational efficiency and resilience, their opportunities, challenges, and various recommendations to solve the challenges that highlight the study is based on an inductive research approach. Using such findings, the study topic is to ascertain how AI impacts the global supply chains as they are implemented in practice among different stakeholders.

3.4 Research Strategy

The study will be conducted in a structured manner is mostly dependent on the research strategy. The five types of research methodologies are action research, correlational, experimental, case study, and archival research. An experimental study design reflects that some variables will be changed to manipulate the outcomes to answer the research topic (Hair et al., 2019). Correlational design is based on developing a relationship between the variables that were found to solve the study problem. According to action research, there are several approaches to overcoming a particular issue, but the best solution needs to be selected to deal with it as soon as possible (Easterby-Smith et al., 2021).

In addition, the case study ensures the need for the researcher to carefully assess the research problem methodically without biasing any data. Lastly, research

conducted with the archival technique ensures that the data will be generated from existing sources or materials, or that it is by reviewing published data before the new investigation (Melnikovas, 2018). Since the data for this study will be acquired through an organized review of current sources reflecting the research purpose, an archival research strategy has been chosen.

3.5 Research Method

After the research strategy has been chosen, a research method that best fits the methodology, philosophy, and research strategy must be selected to solve the research questions. A research method reflects the information collection, final assessment, and sample size calculation. Research methodologies come in three types: mixed, qualitative, and quantitative. One can gather this kind of information from primary as well as secondary sources. Based on sample size, study participants are selected and data is gained from them when primary data is needed (Bougie & Sekaran, 2019).

Websites, journals, papers, books, and other sources are the sources of data that are used when secondary data is needed. While qualitative data is collected in a described format, quantitative data is collected in a numerical format. The qualitative data is subsequently evaluated and interpreted using qualitative techniques such as content analysis, semantic analysis, case studies, and grounded theory (Bell et al., 2022). Several statistical techniques, such as Z-test, t-test, exploratory factor analysis (EFA), regression analysis, correlation analysis, and confirmatory factor analysis (CFA), are used to assess the quantitative data.

A scientific method like this helps to the generation of more significant and reliable research findings that are appropriate for population-wide generalization. The sample size becomes larger when to ensure it is more representative of the target audience. Lastly, the mixed approach reflects that the researcher can

simultaneously use qualitative and quantitative methodologies to offer more dependable results and implications (Basias & Pollalis, 2018).

Because both qualitative and quantitative data were collected from secondary sources, such as books, articles, master's theses, journals, websites, conference proceedings, and other materials based on the impact of AI technologies on global supply chains and their effects on various stakeholders, the mixed research method was selected for this study.

3.6 Research Time Horizon

The aim and objectives of the study will consider several data collection points that are described in the research time horizon. The time horizon can be of two types: longitudinal data, which implies data of a specific problem will be collected for different points of time and is used in studies based on changes and developments, and cross-sectional data, which is data collected for any single point in time to understand the present state of the problem (Antwi & Hamza, 2015).

A longitudinal time horizon was used to collect data on the impact of AI on the global supply chain for various periods and their effects on the company's overall efficiency and resilience, as the research is focused on identifying Al integration difficulties and their influence on operations and stakeholders.

3.7 Data Collection and Analysis

Data can be acquired from two types of sources: primary and secondary sources. The term "primary source" implies the process of collecting data from research subjects or study participants, who will supply objective and reliable raw data (Thomas, 2021). A secondary source is a tool used to acquire and organize data from sources other than research participants. Though there is frequently a chance of data fabrication, secondary sources need to be reliable and have a high

impact rating. Secondary sources include books, websites, journals, newspapers, news portals, magazines, and existing published articles (Newman and Gough, 2020).

Additionally, data comes in two forms: qualitative and quantitative. While qualitative data is collected in a descriptive form that may provide in-depth insight into the problem, quantitative data is obtained in a numerical style that is very easy to assess and provide reliable results with statistical evidence (Nayak & Singh, 2021). Data were generated from secondary sources in both qualitative and quantitative formats for this research project from several sources, including books, journals, papers, industry websites, news channels, and websites. All of the sources used in this study were reliable and might provide up-to-date and precise information.

High-impact journals such as the Journal of Supply Chain Management, Journal of Operations Management, Journal of Logistics, and the Harvard Business Review, academic publishers such as IEEE Xplore, Google Scholar, Science Direct, Scopus, etc., news articles, and industry reports like Gartner, Forrester, Accenture, etc. may be included in this. Additionally, media coverage of AI applications on supply chains in Forbes, Bloomberg, Supply Chain Dive, CNBC, etc. as well as stakeholder reports and customer feedback and reviews from the corporate websites, and Technology-based reports like International Data Corporation, IBM Institute for Business Value, etc.

The search terms used to get information on sources included "AI in supply chain management," "AI in logistics," "AI-enabled supply chain resilience," “AI in supply chain and risk mitigation”, “AI in supply chain and operational efficiency,” and "challenges and opportunities of AI integration in supply chain management”. Lastly, the data inquiry was based on information that was published during the previous 6 years, from 2018 to 2024.

3.8 Ethical Considerations

Ethical considerations in research include some norms of behavior that researchers should balance their rights to develop research methodologies and maintain reliable relationships with participants. Several ethical guidelines should be considered when performing research, both for qualitative and quantitative investigations (Haydam & Steenkamp, 2020). The study's mixed-method design, which accumulates quantitative and qualitative research, raises ethical questions. This study complies with the rules against plagiarism: all data used is appropriately referenced, cited, and quoted, and none has been gathered without permission from other sources (Dubey & Kothari, 2022).

Since the study is related to AI implications on supply chains, no information may be considered to neglect the revolution of AI, and no private information of various companies has been disclosed at any point. No information may be used to disregard the firms because the study is connected to supply chain and logistic companies, and no private information has ever been made public. In addition, proper transparency is followed so that the intended audience knows which reference list the data was collected from.

4. DATA ANALYSIS AND FINDINGS

This section reflects the data analysis and findings derived from the study objectives concerning the uses, consequences, difficulties, opportunities, and recommendations of artificial intelligence integration in international supply chains. It examines the major uses of AI in particular supply chain operations, assesses how it affects productivity, adaptability, and risk control, and highlights the main obstacles and opportunities. Moreover, it offers recommendations to solve these issues and ensure AI integration in international supply chains.

4.1 Key applications of AI in specific global supply chain processes

Table 1. Analysis 1

Key Themes	Sub-themes	Description
Planning	Demand Forecasting	Demand forecasting is the process of predicting future demand patterns using machine learning algorithms. Coca-Cola forecasts product demand using machine learning algorithms that consider seasonality, previous sales data, and external variables like weather forecasts (Coca-Cola, 2021).
	Route Optimization	Delivery routes are optimized via AI-driven algorithms that utilize real-time traffic data together with other factors. To minimize fuel costs and delivery times, Amazon utilizes AI-driven algorithms to optimize delivery routes for its transition to delivery vehicles (Law, 2022).
	Inventory Optimization	Inventory optimization is gained by AI-powered systems that examine demand by reviewing present and past data to identify

		the ideal inventory levels. To manage ideal inventory levels while decreasing surplus inventory, Walmart uses AI-powered algorithms to assess sales data and change inventory levels in real-time (Writer, 2023).
Shipping	Last-mile Delivery	Drones and autonomous vehicles for last-mile delivery can reduce costs and delivery times. To improve delivery efficiency and decrease delivery costs, FedEx has used autonomous delivery trucks for last-mile deliveries in some specific areas of its logistics network (FedEx, 2021).
	Preventive Maintenance	AI-powered predictive maintenance helps to foresee equipment failures and reduces delays in shipping operations. The international shipping giant Maersk uses AI algorithms to forecast equipment failures on its ships, enabling preventive maintenance to reduce delays in shipping activities (Wong et al., 2023).
	Real-time Tracking	Real-time shipment tracking and tracing are ensured with RFID technology and sensors driven by artificial intelligence (AI). UPS tracks and traces shipments in real time utilizing RFID technology and AI-powered sensors to provide customers with reliable, accurate, and updated information on the status of their products ordered (Tan & Sidhu, 2022).

Warehousing	Picking, Packaging, and Sorting	AI-driven automated material handling systems to improve picking, packaging, and sorting productivity. Robotic systems driven by artificial intelligence (AI) are adopted in Alibaba's warehouses to automate picking, packing, and sorting processes. This reduces labor costs and enhances warehouse productivity (Here, 2020).
	Space allocation	Using predictive analytics in inventory management can help reduce stockouts and ensure ideal stock levels. Predictive analytics is utilized by DHL to predict inventory demand and distribute warehouse space optimally, making demanding offerings conveniently available and minimizing storage expenses (DHL Supply Chain, 2020).
	Counting and Replenishment	Robots are used to increase speed and accuracy in duties related to replenishment and inventory counting. Robotic systems are utilized by Amazon Fulfilment Centres to ensure accuracy and efficiency in warehouse activities by counting inventory and replenishing stock (Sphere WMS, 2023).
Procurement	Order Processing	Chatbots with artificial intelligence (AI) can be used to automate repetitive procurement activities like processing purchase orders and supplier queries. IBM simplifies the procurement process and enhances productivity by using AI-driven

		chatbots to manage typical procurement tasks like processing purchase orders and responding to supplier questions (Time Doctor, 2024).
	Managing Risks	Predictive analytics can be used to proactively manage supplier risks and address possible disruptions in the supply chain. To avoid any disruptions and ensure supply chain continuity, Procter & Gamble utilizes predictive analytics to predict supply chain disturbances and proactively handle supplier risks (DeNittis, 2024).
	Assessing Contracts	Contracts and agreements can be assessed using natural language processing (NLP) to identify areas for cost savings and minimize hazards. Unilever utilizes natural language processing (NLP) technology to evaluate contracts and agreements with suppliers to identify ways to minimize costs and mitigate risks related to supplier contracts (Krigsman & Herrick, 2021).
Supplier Selection	Assessing Supplier Performance Data	To identify high-performing suppliers and optimize supplier portfolios, data analytics, and machine learning are used to evaluate supplier performance data. Toyota utilizes machine learning and data analytics to assess supplier performance information and highlight high-performing suppliers. This helps the business to optimize its portfolio of suppliers and enhance

		continuous supply chain improvement (Liu, 2022).
	Assessing Supplier Reliability	Algorithms powered by AI assess supplier capabilities and factors including cost, reliability, and quality. General Electric utilizes data-driven choices for supplier selection and relationship management by using AI-driven algorithms to assess supplier capabilities and factors including quality, cost, and reliability (GE.com, 2022).
	Assessing Supplier Risks	AI-powered risk assessment models are being used to address supplier-related risks and develop mitigation plans. Apple evaluates supplier-related risks, such as supply chain disruptions and geopolitical instability, using AI-powered risk assessment models. This helps the business to develop mitigation plans and ensure the continuity of its supply chain (Apple, 2022).

Various creative solutions that address various stages of the supply chain lifecycle are exposed by evaluating the major applications of AI in certain global supply chain activities. AI assists with inventory management, route optimization, and demand forecasting in planning. AI enhances preventive maintenance and last-mile delivery in shipping operations. AI-driven technologies in warehousing simplify the picking, packing, and sorting activities. AI enhances risk management, simplifies order processing, and examines contracts in the procurement process. All things considered, the widespread use of AI in global supply chains reflects how revolutionary it can be regarding changing conventional knowledge, smoothing

procedures, enhancing operational effectiveness, and ultimately helping better decision-making in various supply chain management domains.

4.2 Impact of AI on supply chain efficiency and optimization

Table 2. Analysis 2

Key Themes	Sub-themes	Description
Demand Forecasting	Accuracy and Precision	The Deloitte case study on retail forecasts reflects how the company used AI-driven predictive analytics to help a retail client enhance the accuracy and precision of demand forecasts. The client could more accurately forecast customer demand by using sophisticated algorithms, which would result in ideal inventory levels and minimal stockouts (Deloitte, 2023).
	Automation and Scalability	The demand prediction case study from McKinsey reflects how supply chain activities for a client were revolutionized by AI-powered demand forecast algorithms. The client increased forecasting accuracy and scalability, allowing for more effective inventory optimization, by automating the demand forecasting process and developing predictive analytics capabilities (Jackson, 2024).
Route Optimization	Cost Reduction	The transportation case study from Deloitte reflects how a client's transportation costs were dramatically reduced by AI-driven route optimization techniques. Through extensive dataset analysis and real-time

		delivery route optimization, the client significantly minimized fuel costs and improved the efficiency and effectiveness of transportation as a whole ((Deloitte Digital, 2023).
	Time Efficiency	The use of AI technology to enhance logistics management for a client is reflected in McKinsey's Case Study on Logistics Management. Through the utilization of AI-driven algorithms to optimize route planning and scheduling, the client could significantly enhance operational performance and time efficiency throughout its logistics network (McKinsey & Company, 2023).
Inventory Management	Reduction of Stockouts	An example of how AI-powered analytics helped a client reduce overstock and save inventory holding costs may be exposed in Deloitte's Case Study on Inventory Optimization. The client maximized inventory levels through data-driven insights and predictive analytics, which increased working capital management and reduced waste (Khan et al., 2022).
	Reduction of Overstock	An example of how AI-driven solutions helped a client simplify inventory management processes can be shown in McKinsey's Case Study on Inventory Management. The client could reduce overstock and increase inventory

		optimization by using AI algorithms to assess demand patterns and automate inventory replenishment (Taghizadeh & Taghizadeh, 2021).
Warehouse Efficiency	Labor Cost Savings	The Warehouse Automation Case Study from Deloitte reflects how the company helped a client automate warehouse operations with robotics and automation technology driven by artificial intelligence. Through the utilization of AI-driven picking, packaging, and sorting technologies, the client minimized labor costs and enhanced warehouse efficiency (Sardar et al., 2024).
	Space Optimization	The warehouse management case study from McKinsey reflects how a client's space allocation and operational efficiency were optimized by AI-driven technologies. The client increased storage capacity and quickened warehouse operations by adopting AI algorithms to optimize warehouse layouts and space distribution (Lamarre et al., 2023).
Procurement Process	Simplifying Order Processing	The order processing case study by McKinsey reflects how supply chain processes can be made more efficient and automated through the utilization of AI-driven technologies. The use of AI technologies like machine learning algorithms and natural language processing (NLP) to digitize and simplify the order

		processing workflow might be covered in detail in this case study. This would reduce errors and manual labor, and quicken order fulfillment cycles (Taghizadeh & Taghizadeh, 2021).
	Increased Supplier Collaboration	McKinsey's Supplier Integration Case Study might focus on how deeper supplier collaboration and integration are made possible by AI-driven technologies. This can entail assessing supplier performance, maximizing supplier portfolios, and identifying opportunities for strategic sourcing with AI-powered analytics. It might also focus on how AI improves supplier-buyer interaction and information exchange, which enhances overall supply chain performance and assists in more effective procurement processes (CLN WorldWide, 2024).

Multiple important themes emerge from the analysis of AI's effects on supply chain optimization and efficiency. These include increased automation and precision in demand forecasting, which enhance inventory control and reduce stockouts. AI-driven route optimization decreases costs and increases time efficiency, while labor cost savings and space allocation enhance warehouse productivity. Additionally, AI simplifies order processing, improves supplier integration and collaboration, and smoothens procurement procedures. All things considered, supply chain activities are significantly developed by AI-driven technologies, which also enhance efficiency and optimize operations.

4.3 Impact of AI on supply chain resilience and risk management

Table 3. Analysis 3

Key Themes	Sub-themes	Description
Real-time Monitoring	Proactive Risk Management	IBM's case study reflects how supply chain data is continuously assessed by AI-driven real-time monitoring to ensure proactive risk management. By reducing the effects of risks and ensuring continuous operations, this strategy improves supply chains' resilience by addressing possible interruptions and suggesting preventive interventions (Zagorin, 2023).
	Predictive Analytics	The Flexport case study reflects how supply chain stakeholders can predict possible disruptions, such as natural calamities or geopolitical events, with the help of predictive analytics driven by AI. This capacity strengthens supply chain networks' resistance to potential constraints by ensuring the application of proactive risk mitigation approaches (Telling, 2023).
Resilience Building	Redundancy Planning	AI's contribution to resilience-building through redundancy planning is focused on IBM's case study. In the event of a supply chain breakdown, it prioritizes the need to address and activate backup suppliers and routes. By decreasing downtime and reducing the impact of interruptions, this proactive strategy ensures operational continuity and, in the end, improves supply

		chains' resistance to unpredicted events (Time Doctor, 2024).
	Supply Chain Visibility	The case study by Flexport reflects how AI may enhance supply chain resilience by increasing visibility. Visibility is increased when stakeholders can quickly identify and resolve interruptions through real-time information in the flow of offerings. AI-driven visibility technologies improve supply chains' resilience to potential challenges and reduce the effect of disruptions by accepting proactive decision-making and response initiatives (Inspectorio, 2023).
Risk Identification	Supplier Risk Assessment	AI's use in supplier risk management is reflected in IBM's case study. AI systems can identify risks such as poor quality or delayed deliveries by assessing supplier performance data. This ensures the proactive implementation of mitigation strategies. By taking a proactive measure, supplier-related risks are less likely to influence operations, managing supply chain continuity and efficiency. IBM safeguards its supply chain from detrimental events by strengthening its resilience against potential interruptions through AI-driven supplier evaluations (Sharma, 2023).

	Demand Fluctuations	The case study of Flexport exemplifies the AI's ability to control demand volatility issues. Artificial Intelligence (AI) detects possible fluctuations by assessing market trends and demand patterns. This enables stakeholders to make proactive modifications to their production and inventory strategy. By taking a proactive measure, supply chain operations are minimally impacted by demand volatility, resulting in better resource efficiency and enhanced resilience to market fluctuations (Shobhana, 2024).
Crisis Response	Dynamic Response Planning	The IBM case study shows how AI can help with quick reaction planning in emergencies. Supply chain participants may quickly adjust production schedules, reroute shipments, and reallocate resources to efficiently handle disruption impacts by using AI capabilities. By permitting proactive modifications to potential events, ensuring continuity of operations, and reducing interruptions' negative effects on supply chain performance, this dynamic reaction mechanism enhances resilience (Attaran, 2020).
	Communication	The case study of Flexport reflects how AI may assist supply chain partners in communicating effectively in times of crisis. Operational continuity is ensured by

		stakeholders coordinating response activities through collaborative platforms and real-time information sharing. Enhanced communication facilitates flexibility and reactivity, allowing for quick modifications to changing conditions and efficient disturbance handling. In the end, it enhances resilience by appreciating a consistent crisis management strategy throughout the supply chain network (Lehmacher, 2021).
Business Continuity	Continuity Planning	AI ensures business continuity planning by addressing critical processes and resources, as found in IBM and Flexport cases. Organizations used to create strong backup plans with AI-driven analysis, ensuring quick recovery from disruptions. By protecting operations, this proactive strategy reduces the impact of unpredicted occurrences on supply chains. Businesses enhance their ability to adapt to changing environments and manage company continuity by utilizing AI technologies to predict and reduce risks (Khan et al., 2023).

Several important themes evolve from the evaluation of AI-driven supply chain resilience and risk management strategies. Proactive risk management and the prediction of potential disruption become possible by real-time monitoring and predictive analytics. Redundancy planning and supply chain visibility ensure resilience building, which enhances operational continuity and reduces downtime.

AI makes risk identification easier, enabling proactive mitigation strategies such as handling demand fluctuations and supplier risk assessment.

Resilience is enhanced during times of crisis when collective reaction efforts and rapid adaptation become possible through dynamic response planning and effective communication. Business continuity planning also ensures that important resources and processes are protected, which ensures quick recovery from interruptions. All things considered, supply chain resilience is enhanced by AI-driven technologies that proactively detect, mitigate, and resolve risks, ensuring operational continuity and flexibility in the face of unpredicted occurrences.

4.4 Challenges and opportunities of AI integration in global supply chain

Table 4. Analysis 4

Key Themes		Description
Challenges	Technological Complexity	The technological complexity of integrating AI is reflected in Gartner's case study, which also detects issues with data integration, interoperability, and system compatibility. These issues may make it complex for supply chain operations to smoothly implement AI technologies, necessitating a large infrastructure and skill investment to overcome (Gartner, 2024).
	Data Quality	The difficulty of ensuring data quality for supply chain AI-driven systems is emphasized in the IDC case study. Problems like erroneous or inadequate data can decrease the efficacy of AI systems, resulting in poor decision-making and inefficient

		operations. Proper data governance structures and investments in data cleansing and validation procedures are necessary to resolve problems with data quality (Al-Banna et al., 2022).
	Resistance to Change	The significance of change management in AI integration is focused on both case studies. Employee resistance to change, a lack of training, and cultural differences can all make it complex for supply chain operations to adopt AI technologies. To help organizations become ready for and appreciate AI-driven solutions, effective change management techniques such as stakeholder collaboration, training arrangements, and communication campaigns are required (Siderska et al., 2024).
	Regulatory Compliance	When utilizing AI in the supply chain, it can be difficult to manage regulatory complexities and maintain compliance with data privacy and security standards. This is emphasized in Gartner's case study. Different locations and industries have different regulatory requirements, thus to minimize the risk of non-compliance, organizations must develop legal knowledge and compliance standards (Marko, 2023).
	Cost and ROI	The two case studies emphasize the substantial financial outlay needed for AI

		integration in the supply chain, including costs for employing new employees, upgrading infrastructure, and adopting new technologies. To justify the expenditure, organizations must carefully evaluate the return on investment (ROI) of AI initiatives, considering elements like cost reductions, operational efficiencies, and competitive edge (Marko, 2023).
Opportunities	Process Optimization	The supply chain provides the potential for process optimization through AI integration, as reflected by the case study of Gartner. Predictive analytics, optimization algorithms, and autonomous systems are examples of AI-driven technologies that help businesses enhance productivity and minimize costs by simplifying operations, distributing resources more effectively, and making better decisions (Wessel et al., 2023).
	Innovation and Agility	The case study by IDC emphasizes how supply chain management may benefit from AI's ability to improve creativity and agility. Organizations may explore new opportunities for growth and differentiation, gain real-time insights, and adapt to changing market conditions by using AI technologies. AI-enabled innovation enhances agility, enabling businesses to respond quickly to changing market

		conditions and customer preferences (Ellis et al., 2020).
	Enhanced Customer Experience	The two case studies reflect how artificial intelligence (AI) can enhance supply chain operations' customer experience. Organizations may meet customer demands for speed, convenience, and reliability by implementing AI-driven personalization, demand forecasting, and delivery optimization. Businesses may enhance customer happiness, loyalty, and retention by offering exceptional customer experiences. This will ensure them a competitive edge in the marketplace (Wessel et al., 2023).
	Supply Chain Resilience	The case study from Gartner reflects how AI may enhance supply chain resilience by ensuring proactive risk reduction and management. Predictive analytics, scenario planning, and dynamic optimization are a few examples of AI technologies that assist businesses in predicting and resolving disturbances, minimizing downtime, and ensuring business continuity. AI-driven resilience minimizes vulnerabilities and improves adaptive capacity to improve supply chains against unpredictable events (Siderska et al., 2024).

	Strategic Decision-Making	The case study by IDC reflects how artificial intelligence (AI) may assist in strategic supply chain decision-making. Organizations may determine market trends, anticipate demand patterns, and optimize resource allocation with the use of AI-driven analytics and insights, which support strategic planning and wise decision-making. Organizations may gain a competitive edge, influence corporate expansion, and explore new market opportunities by integrating AI-driven intelligence (Cui et al., 2023).

Several difficulties are found in the thematic analysis of AI integration in global supply chains, including data quality assurance, technological complexity, regulatory compliance, and change management. Opportunities abound despite these challenges, such as enhanced decision-making, process optimization, and innovation. AI provides businesses the ability to improve productivity, optimize processes, and adapt to changing market conditions, all of which ensure that they become more resilient and competitive.

AI also finds proactive risk management easier, allowing businesses to predict interruptions and improve supply chain resilience. Further improving strategic positioning is increased customer experiences via AI-driven personalization and optimization. All things considered, even with potential challenges like organizational resistance and data integration, AI integration helps businesses with strong opportunities to innovate, smoothen supply chain operations, and achieve a competitive advantage in the global economy.

4.5 Recommendations to overcome the challenges of AI integration on global supply chains

Table 5. Analysis 5

Key Themes	Sub-themes	Description
Technological Expertise	Training and Development	Scholarly articles emphasize the value of funding training initiatives to enhance staff members' technical proficiency with AI technologies. Organizations can tackle the challenge of technological expertise by ensuring that their workforce is skilled in using AI technologies. This can be ensured by offering thorough training (Jabbar et al., 2021).
	Collaboration with Tech Firms	Working together with IT companies can help in closing the knowledge gap in technology. Through collaboration with AI technology providers, organizations can better overcome the challenges of AI adoption by using external resources and experience. By working together, companies may get access to specialized knowledge areas and expand the adoption of AI technologies into their supply chains (De Vass et al., 2021).
Data Quality Assurance	Data Governance	In AI-driven supply chain processes, developing strong data governance frameworks is important to ensure data integrity and quality. Scholarly publications advise standardizing data collecting, storage,

		and utilization strategies by implementing explicit data governance policies and processes. Organizations can minimize the risks related to low-quality data and enhance the reliability of AI-driven insights by implementing data governance guidelines (Ivanov, 2021).
	Data Cleaning and Pre-processing	To increase data quality, academic literature focuses on the value of spending money on data cleaning and preprocessing approaches. Through the detection and resolution of data inconsistencies, errors, and outliers, companies can increase the precision and reliability of artificial intelligence models. Organizations may optimize AI performance and enhance the data preparation process by implementing updated data-cleaning algorithms and technologies (Núñez-Merino et al., 2020).
Regulatory Compliance	Compliance Monitoring	Academic studies recommend the implementation of comprehensive compliance monitoring strategies as a means of resolving regulatory problems related to AI integration. Organizations may ensure compliance with applicable rules and regulations for their AI-driven supply chain activities by regularly reviewing regulatory developments and assessing compliance needs. The risk of financial fines and harm to

		one's reputation is minimized by proactive compliance monitoring (Yang et al., 2021).
	Legal and Ethical Frameworks	To minimize legal risks and ethical issues, it is important to develop explicit legal and ethical guidelines for the use of AI. The body of academic research reflects how important it is for companies to ensure rules and regulations around the use of AI, data privacy, responsibility, and transparency. Organizations can enhance responsible AI usage in supply chain activities and gain stakeholders' trust by following legal and ethical criteria (Wamba & Queiroz, 2020).
Change Management	Stakeholder Engagement	To effectively handle change, stakeholders at all organizational levels must collaborate. Scholarly articles reflect how crucial it is to develop an environment of transparency, cooperation, and communication to easily adopt AI. Organizations may overcome resistance to change and achieve successful implementation of AI initiatives by getting buy-in and commitment from stakeholders by considering their opinions in the decision-making process (Ageron et al., 2020).
	Leadership Support	Driving AI integration initiatives and overcoming change resistance need strong leadership support. Scholarly research reflects how important it is for senior executives to implement AI projects, allocate funds, and develop strategic priorities.

		Leaders may develop a positive and motivated working environment that supports the successful adoption of AI in global supply chains by exposing their commitment to AI adoption and providing strategic guidance (Kamble et al., 2022).

To overcome challenges in AI integration, the analysis table reflects the significance of investing in technological know-how, ensuring data quality, compliance monitoring, and efficient change management strategies. Strong data governance, cooperation with tech companies, and the creation of moral and legal frameworks are all found as the recommendations. Stakeholder involvement and leadership support are also prioritized as important factors that lead to the proper implementation of AI. All things considered, these results emphasize the need for a comprehensive strategy that considers organizational, cultural, technological, and legal factors to fully use AI in global supply chains.

5. DISCUSSION ON FINDINGS

The study assessed each of the five research questions (RQs) respectively as it discusses the themes that follow from the research findings in this chapter. It addresses the major uses of AI in global supply chains, how it affects resilience and risk management, efficiency and optimization, and integration challenges, opportunities, and recommendations. Stakeholders of the research findings, such as supply chain managers, legislators, business professionals, and researchers, can gain from them. This study provides stakeholders with the necessary information to help them make decisions, enhance supply chain performance, and navigate the changing nature of AI integration in global supply chains by highlighting the potential of AI, pinpointing challenges, and making recommendations.

5.1 Discussion on Key applications of AI in specific global supply chain processes

Key applications of AI in specific global supply chain processes, reflects the primary uses of AI in global supply chains, the analysis assesses many literature and empirical data to ensure a comprehensive understanding of AI's significant role. The results are consistent with the existing literature currently, which emphasizes the widespread types and diverse uses of AI across various supply chain activities. The use of AI to enhance supply chain planning, shipping, warehousing, procurement, and supplier selection is well-focused in the sources (Wamba & Queiroz, 2020).

The analysis ensures these claims by providing specific cases from academic research and case studies that showed AI's important impact on supply chain operations optimization. For example, demand forecasting algorithms driven by AI are important to better inventory management because they help businesses anticipate demand patterns with precision and easily. Artificial intelligence (AI)-driven route optimization algorithms ensure shipping operations by detecting the

most cost-effective delivery routes and enhancing delivery dependability and speed (Ivanov, 2021).

Furthermore, by automating material handling processes like picking, packing, and sorting, AI technologies reshape warehousing activities. AI-driven robotic systems enhance order accuracy, lower labor costs, and improve warehouse productivity. Furthermore, by automating tasks and enhancing supplier communication, AI-driven procurement tools, chatbots, and predictive analytics reshape conventional procurement activities (De Vass et al., 2021). RQ1 confirms the body of literature by assessing data on the practical utilization of AI in global supply chains. Organizations can achieve new opportunities for creativity, efficiency, and competitiveness by integrating AI technologies. All things considered, the analysis shows how AI can drastically shape how global supply chains will bloom in the future.

5.2 Discussion on Impact of AI on supply chain efficiency and optimization

The impact of AI on supply chain optimization and efficiency, the analysis uses knowledge of two case studies and literature to reflect on the findings of various sources. The findings of the analysis mainly support the literature, measuring AI's revolutionary impact on enhancing supply chain optimization and efficiency. Academic studies and corporate case studies continually focus on how integrating AI may increase critical performance metrics including lead times, inventory turns, and cost savings (Jabbar et al., 2021).

Organizations can achieve significant improvements in supply chain performance, operational efficiency, and resource utilization by adopting AI-driven technology. For example, firms can more accurately anticipate future demand through AI-driven demand forecasting algorithms, which reduces the cost of holding inventory on hand and minimizes the probability of stockouts (Cui et al., 2023). Similarly, transportation routes are optimized by AI-driven route optimization

algorithms, which reduce costs and quicken delivery. Furthermore, supply chain efficiency is enhanced via AI-enabled predictive maintenance, which minimizes downtime and enhances equipment reliability (Ellis et al., 2020).

The analysis shows the practical effects of AI on supply chain efficiency and optimization, coming from case studies and academic research to give factual support for these findings. Organizations can explore new opportunities for enhancing customer happiness, reducing expenses, and smoothing operations by adopting AI technologies (Al-Banna et al., 2022). However it's important to identify the challenges and limitations that arise from implementing AI in supply chains, like issues with data security, a lack of expertise, and implementation difficulties (Siderska et al., 2024). To successfully integrate AI into supply chain processes and understand the overall potential benefits of this technology, these difficulties must be addressed.

5.3 Discussion on Impact of AI on supply chain resilience and risk management

The effect of artificial intelligence (AI) reflects on supply chain resilience and risk management. The analysis assesses two case studies and literature to examine the reliability of existing findings. The results of the investigation are mostly consistent with the literature, reflecting the important role artificial intelligence (AI) ensures in improving supply chain resilience and risk management skills. Academic studies and case studies from businesses constantly show the revolutionary impact of AI-driven strategies in minimizing supply chain risks and increasing resilience (Wessel et al., 2023).

AI technologies provide organizations the ability to proactively determine and manage possible disturbances by providing real-time monitoring, predictive analytics, and dynamic reaction planning (Marko, 2023). Predictive analytics driven by artificial intelligence, for example, assists businesses in predicting and

minimizing risks related to shifts in demand, interruptions in the supply chain, and external effects like natural disasters or world events. AI algorithms are utilized by real-time monitoring systems to analyze supply chain data continually, considering proactive risk management and quick reaction to new risks (Shobhana, 2024).

AI also assists in resilience-building by helping supplier risk assessment, crisis response initiatives, and redundancy planning. Organizations can achieve continuity in the face of disruptions by detecting important activities, assuring backup suppliers, and dynamically changing operations by leveraging AI capabilities (Lehmacher, 2021). This analysis indicates the real benefits of AI integration in enhancing supply chain resilience and risk management by using actual data from case studies and academic research to ensure the reliability of these findings. Organizations can enhance their capacity to predict, mitigate, and resolve disruptions by employing AI-driven strategies. This will safeguard supply chain operations and ensure business continuity (Khan et al., 2023).

5.4 Discussion on Challenges and opportunities of AI integration in global supply chain

To find out the main challenges and opportunities related to the adoption of AI in global supply chain activities. The goal of this analysis is to assess the degree to which findings about these opportunities and challenges are consistent with actual data from case studies and the body of existing literature. Supply chain management could face a substantial change due to artificial intelligence (AI), however, there are several challenges with its deployment. Problems with data quality, interoperability, a lack of talent, and opposition to change are major challenges. These challenges may make the supply chain operations more difficult and complex to successfully adopt and apply AI technology, which would undermine the advantages that these technologies may provide to businesses (Attaran, 2020).

As focused on case studies and empirical research, this study ensures the existence of these challenges in practical situations. Gaining high-quality data, connecting different systems, and training staff to utilize AI tools successfully are challenges that organizations most often face. AI adoption initiatives can also be undermined by cultural differences and resistance to change, which can reduce implementation timelines and minimize organizational buy-in (Lamarre et al., 2023). This investigation finds major opportunities related to AI integration in global supply chains, alongside these constraints. Cost reductions, process improvements, better decision-making skills, and more supply chain visibility are some of these opportunities. Organizations may enhance resource allocation, expand operations, and better cope with changing market trends by using AI-driven technologies (Taghizadeh & Taghizadeh, 2021).

AI also makes predictive analytics, demand forecasting, and inventory optimization possible, providing businesses the ability to anticipate client needs and change supply chain activities accordingly. Organizations may enhance the resilience and agility of their supply chains by proactively determining and reducing risks through data-driven insights and real-time monitoring (Sardar et al., 2024). All things considered, despite certain challenges, integrating AI into global supply chains provides more benefits than demerits.

In today's quickly shifting business environment, organizations can gain a competitive edge and gain tremendous value by properly employing AI technology and resolving major challenges. The significance of people development investments, organizational readiness, and strategic planning to maximize the advantages of AI integration in supply chain management is focused on by this investigation (Khan et al., 2022).

5.5 Discussion on Recommendations to overcome the challenges of AI integration on global supply chains

The analysis is consistent with the suggestions of existing literature for resolving the challenges related to integrating AI into global supply chains. The recommendations that have been found, like investing in the development of talent and developing an innovative culture, align with industry publications and the best practices revealed from scholarly research. These recommendations are consistent with the demands on organizations to close talent gaps, develop a positive workplace culture, and provide strategic investments in AI infrastructure and technology as the priority (Liu, 2022).

This analysis reflects the ideas' relevance and practicality by validating them with empirical data from published scholarly articles. These strategies can be used by organizations to develop workable plans for addressing AI integration-related issues and maximizing the possible advantages of AI technology for supply chain management (Tan & Sidhu, 2022). The analysis is consistent with empirical findings and further emphasizes the importance of taking proactive steps to resolve the challenges related to adopting AI. Businesses that follow these suggested strategies will be in a better position to manage the challenges of implementation and exploit the supply chain management opportunities raised by AI-driven innovation (Wong et al., 2023).

To sum up, the analysis verifies the suggestions made by the literature for overcoming the challenges related to adopting AI into global supply chains. Our findings add to the body of knowledge on successful strategies for using AI technology to enhance supply chain performance and resilience by providing empirical validation and useful insights.

6. CONCLUSION AND RECOMMENDATIONS

This chapter summarizes the overall findings of the study and offers suggestions for overcoming challenges and exploiting opportunities for the integration of AI in global supply chains. Organizations can successfully utilize the potential of AI to optimize supply chain operations by making investments in talent development, developing an innovative culture, collaborating with partners, conducting trial projects, providing data quality first priority, effectively managing change, and monitoring performance.

6.1 Conclusion

Research Questions come up with findings that offer insight into the complex impact of integrating AI into global supply chain management. Several significant insights are revealed by a comprehensive examination of the most important technologies, impact on effectiveness and optimization, resilience and risk management, opportunities and challenges, and suggestions for overcoming the challenges. First, the investigation uncovered a wide range of important uses for AI in the supply chain in different areas, such as supplier selection, planning, shipping, warehousing, and procurement. These areas use artificial intelligence (AI) technologies including automation, natural language processing, and predictive analytics to improve decision-making, smoothen workflows, and enhance productivity.

Second, the study indicated that supply chain optimization and efficiency are significantly affected by AI. Businesses may enhance customer satisfaction, reduce expenses, and increase operational performance by using AI-driven strategies like demand forecasting, inventory management, and route optimization. Thirdly, supply chain resilience and risk management are significantly affected by AI. By using predictive analytics, dynamic response planning, and real-time monitoring, organizations may predict and resolve risks proactively, protecting their activities and reducing the effects of interruptions.

Fourthly, supply chain performance can be increased by AI integration, but there are several challenges to overcome. These challenges include problems with data quality, organizational resistance to change, and the limitation of qualified personnel. However, companies may overcome these challenges and properly utilize AI in supply chain operations by implementing strategies like investing in personnel development and developing an innovative culture.

The results indicate how this revolutionary artificial intelligence (AI) has the potential to be in the field of global supply chain management. Employing proactive methods and deploying AI-driven technology can help organizations gain a competitive edge in today's fast-paced business environment by enhancing efficiency, resilience, and agility. But for organizations to completely profit from AI integration, they must properly manage implementation issues and make use of suggested strategies. In general, the research provides significant perspectives for professionals and scholars that aim to manage the complexities of incorporating artificial intelligence into supply chain management and exploit opportunities for expansion and creativity.

6.2 Recommendations

To overcome the challenges and exploit the potential opportunities raised by AI deployment in global supply chains, some recommendations are given as follows:

- Investing in AI talent development is important for organizations that want to stay competitive in today's quickly changing business landscape. Through the prioritization of training and upskilling efforts, organizations may offer their staff the necessary knowledge and skills to fully use AI technologies (Chopra, 2019). Employees with experience implementing and utilizing AI may exemplify innovation, smoothen operations, and exploit new opportunities for the company to expand and become more efficient. In addition, developing an

environment that values continuous learning and development ensures that companies remain ahead of the trend in the ever-changing field of artificial intelligence (Baryannis et al., 2019).

- Organizations need to improve an innovative culture that values experimentation and creativity if they want to develop in the highly competitive environment of today. By encouraging employee exploration of AI-driven technologies and processes, companies can exploit new ways of supply chain growth and improvement (Fonseca and Azevedo, 2020). Developing a culture that values innovation, asks groups to question the established standards, identify inefficiencies, and raise ground-breaking solutions for challenging supply chain problems. Additionally, creating an innovative culture enhances cooperation and knowledge sharing, which ensures continuous development and ensures that businesses remain flexible and responsive to changing market conditions (Ivanov et al., 2019).

- Successful AI integration in supply chains needs cooperation with industrial partners. Through the deployment of technology vendors' experience, research institutions' expertise, and other relevant stakeholders' resources, organizations can gain invaluable insights, best practices, and resources to efficiently handle the complex landscape of AI implementation (Dash et al., 2019). Businesses can raise creative solutions, resolve implementation issues more quickly, and enhance their AI adoption journey through strategic collaborations and knowledge-sharing initiatives. Collaboration also enhances a feeling of community and group learning, which helps organizations stay updated on the newest developments in AI technology while ensuring a network of support for continuous growth and collaboration (Hofmann et al., 2019).

- An intelligent strategy for integrating AI into supply chain operations is to conduct trial projects. Before implementing AI-driven technologies widely, companies can assess their efficacy, identify possible problems, and develop their strategies by starting small and testing them in controlled settings. Continuous learning is made possible by pilot projects, which allow teams to enhance workflows, get insightful knowledge, and acquire confidence in AI technologies (Rodríguez-Espíndola et al., 2020). Moreover, effective trial projects operate as evidence of concept, attracting stakeholders and enabling more simple transfers to wider implementation. Pilot projects, in general, provide an organized framework for learning and experimenting, minimizing risks and maximizing the possibility of effective AI integration in global supply chains (Akbari and Hopkins, 2022).

- Prioritizing data quality is essential for supply chains to successfully deploy AI. Robust data standards, governance frameworks, and clear strategies are necessary to ensure the reliability and precision of AI-driven insights and suggestions. Organizations can enhance decision-making procedures, improve the efficacy of AI algorithms, and minimize the possibility of biases or errors in automated operations by utilizing high-quality data (Attaran, 2020). Furthermore, trustworthy data ensures businesses to draw insightful conclusions, identify patterns, and precisely predict demand, all of which enhance supply chain management and gain better economic results. Thus, investing in data quality initiatives is necessary to fully use AI's efforts for supply chain optimization on a worldwide scale (Riahi et al., 2021).

- Resolving change management is crucial to the supply chain's successful AI integration. Offering sufficient training and assistance, actively involving stakeholders, and identifying the advantages of adopting AI can all help minimize organizational resistance to change. Organizations may enhance buy-in and commitment to AI efforts by developing a culture of collaboration

and ownership among stakeholders and considering their concerns during the process (Modgil et al., 2022). Additionally, companies can enable staff members to cope with new processes and technology by providing comprehensive training and assistance, which will ease transitions and maximize the efficiency of AI-driven technologies. In the end, proper change management strategies help in the acceptance and application of AI in global supply chains (Dash et al., 2019).

- To optimize the impact of AI-driven initiatives on supply chain activities and ensure their efficacy, it is crucial to monitor and assess their performance. Organizations can assess the success of AI solutions against existing benchmarks and properly follow their results by developing preset metrics and key performance indicators (KPIs) (Pournader et al., 2021). Organizations can make data-driven decisions to increase the performance of AI-driven technologies by detecting areas for improvement and refinement through continuous assessment. Organizations may ensure that their AI initiatives are consistent with strategic goals, gain measurable results, and influence continuous innovation and enhancement in global supply chains by conducting routine monitoring and assessments (Belhadi et al., 2024).

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