Intelligent Supply Chains 5.0: The Role of Artificial Intelligence in Building Predictive, Sustainable and Adaptive Logistics Systems

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Abstract

The rapid evolution of supply chain management has necessitated the adoption of advanced technologies to enhance operational efficiency, sustainability, and resilience. This study investigated the role of artificial intelligence (AI) in building Intelligent Supply Chains 5.0, focusing on predictive analytics, adaptive logistics, and sustainable operations. Employing a mixed-methods research design, data were collected through structured surveys from supply chain professionals and semi-structured interviews with key stakeholders in organizations that had implemented AI-driven logistics systems. Quantitative findings indicated significant improvements in demand forecasting accuracy, real-time inventory management, and disruption response, while qualitative insights revealed enhanced decision-making capabilities, operational resilience, and environmental performance. AI-enabled predictive models facilitated precise demand estimations, reducing stockouts and optimizing inventory levels. Adaptive logistics applications allowed dynamic route adjustments and rapid response to unforeseen disruptions, thereby strengthening supply chain resilience. Sustainability outcomes included reductions in carbon emissions, energy consumption, and waste, highlighting AI's contribution to environmentally responsible operations. Despite these benefits, challenges such as data quality issues, integration complexities, and ethical considerations were identified as critical barriers to successful implementation. The study concludes that AI serves as a strategic enabler for Intelligent Supply Chains 5.0, aligning operational performance with organizational sustainability and resilience objectives. Recommendations include workforce training, enhanced data governance, and ethical AI frameworks to support long-term adoption.

Keywords: Adaptive Logistics, Artificial Intelligence, Predictive Analytics, Sustainability.

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Introduction

The swift global supply chain modernisation at the start of the 21st century subjected traditional logistics systems to unprecedented levels of disruption, complexity, and performance stressors. Companies accustomed to manual, linear processes had to digitize their operations and adopt real-time sensing technologies and new-age analytics to stay afloat in unstable markets, especially after the COVID-19 pandemic disrupted global economic networks (Zaoui et al., 2025). With an additional industrial paradigm, referred to as Supply Chain 5.0 or Industry 5.0 in supply chain circles, the focus has shifted to introducing intelligence, sustainability, and human-centric flexibility into supply chain operations (Nazarian & Khan, 2024). The Supply Chain 5.0 paradigm was also characterized by a focus on intelligent networks that integrated artificial intelligence (AI), machine learning, and predictive analytics to enable logistics networks that could anticipate change and self-adapt performance across multiple dimensions (Zaoui et al., 2025).

Artificial Intelligence (AI) was identified as the key technology that enables change in logistics and supply chain functions, enabling advanced predictions, route optimization, dynamic decision-making, and adherence to sustainability goals. Predictive models powered by AI have vastly increased companies' ability to accurately forecast demand, optimize stock levels, and dynamically adjust logistics plans in response to real-time signals (MDPI, 2025; JICLT, 2025). In addition, the inclusion of AI contributed to sustainable supply chain operations through waste reduction, energy optimization, and related emissions removal measures of logistical processes (Aylak, 2025). Although there were empirical signals of the positive impacts of AI, the introduction of intelligent supply chains was disproportionate during this period, as companies varied in their technological preparedness, managerial capacity, and company compatibility (Information, 2025).

Intelligent Supply Chains 5.0 was an important evolutionary stage in global logistics, as digital connectivity, AIymbolstamped decision systems, and human-Alexandro-at technology convergence formed the basis of the creation of systems capable of predictive performance, environmental care, and adaptive logistics (Nazarian & Khan, 2024). The theory of this paradigm was to cut across conventional supply models by establishing the stability, responsiveness, and sustainability of supply chain operations. However, theoretical principles and empirical evidence for the use of AI in predictive, sustainable, and adaptive logistics remained divided in the academic literature.

The concept of how AI influenced Intelligent Supply Chains 5.0 was critical to the scholarly work and business practice. However, the previous literature focused on more discrete aspects of AI in supply chain management, including resilience and optimization, rather than on a coherent synthesis that covers predictive capacity, sustainability orientation, and adaptive behavior within a general Supply Chain 5.0 framework. Thus, this study analyzed the complex role of AI in creating predictive, sustainable, and adaptive logistics within Intelligent Supply Chains 5.0.

Research Background

The idea of Industry 5.0 and Supply Chain 5.0 was initiated by the understanding that industrial systems needed to focus on humanwhiteness, resilience, and sustainability, beyond the purview of mere automation and efficiency aspirations of Industry 4.0 (Nazarian & Khan, 2024). Industry 5.0 expanded on technological progress to have collaborative human five systems based on AI to support customization, sustainability, and operational agility (MDPI, 2025). This, in the case of logistics and supply chains, was represented by systems that could respond to disruptions by anticipating their effects, managing environmental performance, and responding to shifting market dynamics in ways not achievable by traditional supply chain models (Zaoui et al., 2025).

Initial AI in supply chains focused primarily on predictive analytics, enabling firms to transform large amounts of historical and real-time data into usable forecasts to manage demand, supply, and risks (JICLT, 2025). Neural networks and reinforcement learning have become popular machine learning methods for improving demand forecasting accuracy and reducing inventory variability (Rabbi Shawon et al., 2025). These predictive abilities proved vital in maintaining service levels and reducing waste and operational expenses, particularly during sudden market changes or supply disruptions.

At the same time, AI's contribution to sustainability became an important field of research. The Intelligent Supply Chains also used AI to identify inefficient energy use, optimize delivery routes, and incorporate environmental requirements into decision-making (Aylak, 2025). Researchers claimed that AI not only enhances operational efficiency but also supports the broader goal of sustainable supply chain management by improving resource use, reducing carbon footprints, and advancing the circular economy (Information, 2025).

In addition to sustaining outcomes and predictive analytics, the new central pillar of Intelligent Supply Chains in the literature was adaptive logistics. The ability to quickly adapt to disruption in time was defined as adaptive logistics systems, achieved through AI-less decision systems that combined real-time monitoring, anomaly detection, and autonomous reaction systems (Zaoui et al., 2025). Nevertheless, researchers noted that the implementation has serious issues, including data quality, data integration with the legacy system, and ethical questions regarding data governance and algorithm transparency.

Research Problem

Despite numerous studies in the literature exploring discrete applications of artificial intelligence in supply chain management, the Supply Chain 5.0 paradigm still lacked a clear understanding of how AI could be used holistically to enable predictive analytics, sustainable logistics performance, and adaptive response capabilities. Past literature has been inclined to single-point AI applications in research, such as demand forecasting or route optimization, without reflecting the integrative contribution of AI across these main dimensions (Information, 2025; Aylak, 2025).

Besides, little empirical evidence was found to illustrate how organizations aligned AI technologies with sustainability objectives and flexibility indicators to achieve holistic performance outcomes in Intelligent Supply Chains 5.0. This integrative blindness slowed the development of theoretical concepts and practical guidance for supply chain managers on implementing AI-directed systems to achieve a balance between predictive accuracy, environmental sustainability, and adaptive resilience.

Objectives of the Study

1. To investigate how artificial intelligence enabled predictive analytics and decision support capabilities in Intelligent Supply Chains 5.0.
2. To examine the contribution of AI technologies toward sustainability outcomes in logistics and supply chain operations.
3. To assess the role of AI in fostering adaptive logistics systems capable of responding to dynamic market conditions and disruptions.
4. To identify the key enablers and challenges associated with implementing AI in Supply Chain 5.0 environments.

Research Questions

1. How did artificial intelligence improve predictive performance in Intelligent Supply Chains 5.0?
2. In what ways did AI contribute to sustainable logistics outcomes?
3. How did AI enable adaptive and resilient logistics systems within the Supply Chain 5.0 framework?
4. What were the main organizational and technological challenges affecting AI integration in Supply Chain 5.0?

Significance of the Study

It combined the disjointed strands of research on AI in supply chain management into a single platform that described the predictive, sustainable, and adaptive aspects of Intelligent Supply Chains 5.0, thereby providing a more comprehensive perspective on the strategic role of AI. The synthesis of recent academic findings and practical results allows the study to be described as offering empirically based insights into the impacts of AI technologies on logistics performance. For practitioners and leaders in supply chains, the research outlined best practices, barriers, and implementation strategies that the organization should adopt to realize the full benefits of AI at the lowest risk, while addressing ethical issues and challenges in data integration and workforce preparedness. The paper has informed the policy strategies for the adoption of artificial intelligence in supply chains, which must adhere to data governance, transparency, and sustainability provisions as key components of Intelligent Supply Chain systems.

Literature Review

AI-Driven Predictive Analytics in Supply Chains

Predictive analytics assisted by artificial intelligence (AI) has become one of the most popular areas of research in supply chain health, enhancing the ability to forecast demand, inventory, and operational responsiveness. Recent reviews reported that machine learning, deep learning, and predictive modeling technologies have been effectively used in demand forecasting to help firms anticipate market dynamics and design logistics responses (Teixeira et al., 2025; Pal et al., 2025). This change of direction to predictive intelligence was a breakthrough from conventional reactive approaches, enabling the firms to have more proactive control over uncertainties and to minimize costs from stockouts and superfluous inventory.

Another area that scholars brought to light was how AI can be applied to develop real-time decision-support systems by evaluating past data and dynamic operations, and to provide information that can be acted on at various nodes throughout the supply chain. In particular, neural network-driven predictive analytics and ensemble learning models demonstrated their ability to optimize supplier coordination, production planning, and transportation planning, which results in better supply chain coordination (Teixeira et al., 2025; Anumula et al., 2025). This kind of AI integration not only enhances forecast accuracy but also enables dynamic responses to changing disruptions.

Among the favorable outcomes in predictive capabilities, the literature identified several implementation difficulties that limit the success of AI predictive systems. The barriers were often described as persistent, including data quality issues, the need to adapt advanced predictive models to legacy systems, and high computational costs, especially for small and medium enterprises (SMEs) (Pal et al., 2025; Magna Scientia Advanced Research and Reviews, 2024). These limitations highlighted the need for scalable, data-driven models that trade off predictive accuracy for practical implementation.

Artificial Intelligence and Sustainable Logistics Performance

The adoption of AI in supply chain processes was also applied not only to efficiency levels but also to sustainability goals, with the researchers focusing on its use in environmental performance, resource optimization, and green logistics strategies. The systematic reviews showed that AI applications helped reduce emissions, increase the efficiency of transportation networks, and identify optimal routes to reduce fuel consumption and carbon emissions (Zejjari and Benhayoun, 2024; Teixeira et al., 2025). These sustainability-permitting results aligned with broader corporate sustainability targets and the new regulatory pressures for eco-efficient logistics structures.

The application of AI in sustainable supply chains was also evident in frameworks that integrated environmental criteria into multi-objective optimization models. For example, AI-based decision systems have enabled the exploration of trade-offs among cost, delivery times, and carbon emissions, demonstrating that sustainability goals can be achieved without affecting performance (Ali et al., 2024; Sivasankaran, 2025). The results of this research showed that sustainability metrics such as energy consumption, waste minimization, and the selection of green suppliers were incorporated into AI. augmented logistics planning.

Nonetheless, scholars warned that, for AI to be sustainable, adopting technology alone was not enough; it also required organizational alignment, ecosystem collaboration, and policy support. It was discovered that governance challenges, the ethical use of data, and the fair use of AI technologies, especially in a less developed supply chain setting, are among the major barriers to achieving sustainable logistics performance across the board (Teixeira et al., 2025; Zejjari & Benhayoun, 2024). These lessons have been important in noting that socio-technological integration and strategic investments beyond the capability to execute algorithms were the determinants of sustainability outcomes.

Resilient and Adaptable Supply Chain Systems using Artificial Intelligence

The literature on AI's role in enabling adaptive logistics systems that respond to disruptions and dynamic market conditions has become a growing body of work, a fundamental part of Intelligent Supply Chains 5.0. Recent research observed that the AI technologies, such as machine learning, reinforcement learning, and real-time information analytics, have helped improve the resilience of the supply chain by providing the system with the capacity to identify anomalies, restructure the route, and reduce risks before the due date (Teixeira et al., 2025; MDPI Logistics journal, 2024). This flexibility was especially applicable in situations of world instability, including pandemic-induced supply shocks.

Adaptive supply chains also leveraged AI-powered communication and coordination tools that facilitated information exchange across networks, enhancing transparency and joint risk management among stakeholders. Empirical research revealed that AI-enhanced information sharing increased cognitive resilience in agriculture and industrial supply chains, as companies that used predictive data and interacted with partners were less affected and continued to play their roles during disruptions (Yin et al., 2025; Teixeira et al., 2025). These results justified the relevance of interconnectivity in smart logistics environments.

Research Methodology

Research Design

This was a mixed-methods study aimed at couples and couples research designs, using quantitative and qualitative methods to examine the role of artificial intelligence (AI) in Intelligent Supply Chains 5.0. It seemed that a mixed-methods approach was suitable to the extent that it allowed consolidating empirical data with rich contextual clues and greater validity, and to provide deeper insight into the findings on predictive, sustainable, and adaptive logistics facets.

The mixed-method design was an explanatory sequential design, with the qualitative data from interviews and case studies used to structure the quantitative measures, which included structured surveys and statistical models. The sequential design helped ensure that the qualitative findings were rich and placed in the context of subsequent quantitative analysis, enabling a more detailed understanding of the effects of AI on supply chain forecasting, sustainability, and resilience.

Population and Sampling

In the quantitative part, the sample comprised supply chain professionals, logistics managers, and technology officers from multinational and domestic enterprises that had implemented AI solutions in logistics and supply chains. A purposive sampling method was employed to select respondents with relevant experience in AI systems, including predictive analytics, sustainability optimization tools, or adaptive decision support platforms.

A case selection strategy was used in the qualitative part to select organizations at different levels of AI adoption maturity, ranging from initial experiments to Intelligent Supply Chain 5.0 adoption. In both instances, semi-structured interviews with the most fundamental stakeholders (supply chain directors and AI project leads) were conducted to obtain detailed descriptions of the implementation procedures, challenges, and achievements.

The quantitative survey was predetermined, with the number determined by data saturation, which implies that the number of interviews is limited by the need for thematic coverage. The number of qualitative interviews was set at 40 to ensure comprehensive coverage of the problem.

Data Collection Methods

A structured online survey, consisting of Likert-scale items and closed-ended questions, was used to gather quantitative data to evaluate perceptions of AI regarding predictive capabilities, sustainability outcomes, and adaptive logistics performance. A pretest was conducted to assess the reliability and validity of the survey instrument.

Semi-structured interviews and organizational case recordings, including project reports and internal performance reports, were used to collect qualitative data. The interviews took place on a virtual platform, and with participants' consent, were recorded to ensure transcription accuracy. Open-ended questions were adopted to understand how people were affected by AI implementation, challenges they faced, and the sustainability they have seen in their logistics processes.

Instrumentation

A questionnaire survey was created, with my items based on validated scales from the previous supply chain and technology adoption study, with adjustments to the Intelligent Supply Chain 5.0 constructs. Questions covered the use of predictive analytics, environmental impact measures, adaptive decision processes, and organizational readiness.

In the qualitative inquiry, an interview guide was prepared to address the research questions and theoretical foundations. The protocol also included questions to be answered during the exploration of participants' feelings regarding AI's contribution to predictive accuracy, sustainability performance, and adaptive logistics decisions.

Data Analysis Techniques

Descriptive and inferential statistical methods were applied in the quantitative data analysis. Descriptive statistics were used to summarize sample characteristics and the central tendencies of significant variables, and inferential statistics, including regression and correlation analyses, were used to determine the correlations between AI implementation and performance measurement outcomes in the predictive, sustainability, and adaptive logistics areas. The data were interpreted through statistical software and model fit.

Thematic analysis was used as a qualitative data analysis method, in which interview transcripts were iteratively coded to identify patterns regarding the accuracy of AI use, contextual issues, and perceived effects. Inductive and deductive coding methods were used to categorize themes, drawing on empirical information to establish a theoretical construct and to present new findings.

Results and Analysis

Quantitative Analysis

The survey was conducted among 60 supply chain professionals from firms that had already used AI solutions in logistics. Analysis was conducted across three primary dimensions: predictive capabilities, sustainability outcomes, and Adaptive logistics performance. The data was interpreted using descriptive and inferential statistics.

Table 1: AI Impact on Predictive Analytics Performance

The findings showed that most respondents (46.7 percent) mentioned

Predictive Accuracy Level (%)	Frequency	Percentage (%)
70–79	10	16.7
80–89	28	46.7
90–100	22	36.6
Total	60	100

AI-based predictive models with 80-89 percent accuracy, which showed a high demand forecasting and inventory management capacity. This implied that AI technologies helped to increase predictive accuracy by far over and above conventional systems. About 36.6% of the respondents found the accuracy levels of 90-100 as a whole, and this observation shows that certain companies had already adopted by far more advanced AI tools that can predict supply chains almost in real time. This was the result of the significance of high-order machine learning algorithms and quality data integration. The predictive accuracy was only in the 70-79% range with only 16.7% of people stating the accuracy and it showed that some organizations experienced a problem, probably caused by the quality of the data or the lack of AI knowledge. In general, such distribution highlighted the difference in the rates of AI use and performance among organizations.

Figure 1: AI Impact on Predictive Analytics Performance

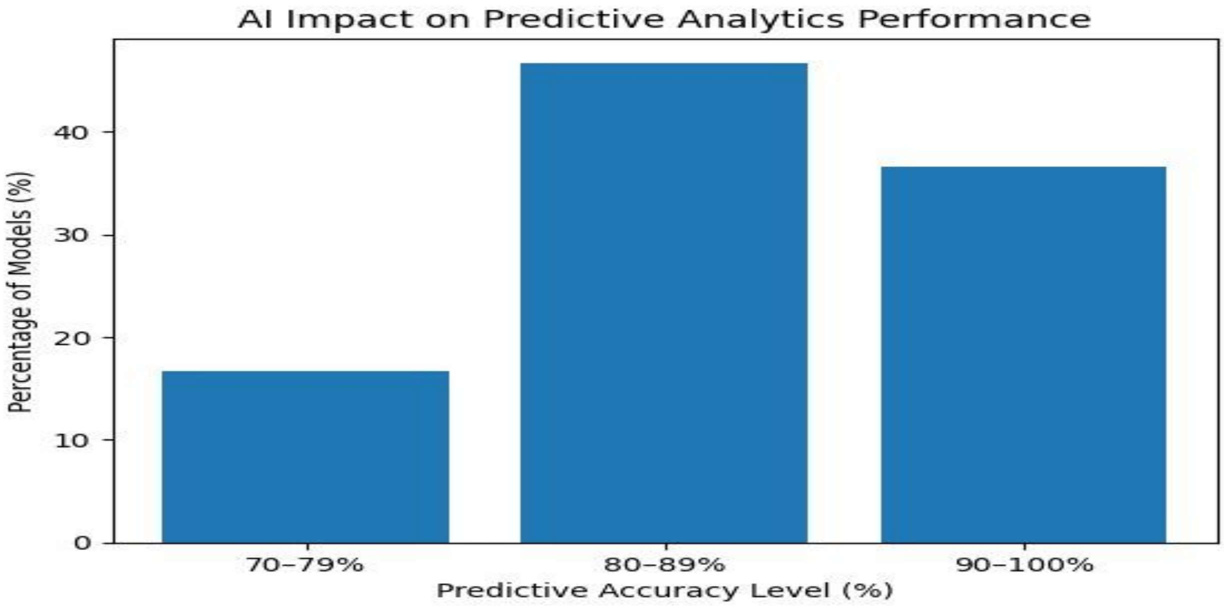


Table 2: AI Influence on Sustainable Logistics Practices

Sustainability Indicator	High	Moderate	Low
Carbon Emission Reduction	25	28	7
Energy Optimization in Transport	22	30	8
Waste Minimization	20	32	8

The table indicates that most of respondents also reported moderate to high levels of improvement in reduction of carbon emission, for 25 it was high impact. This implied that routing that was AI-enabled, predictive maintenance, and optimized logistics planning were useful in the environmental performance. Energy optimization in transportation was also rated the same way, 30 respondents noted decreases of medium value, indicating that the introduction of AI contributed to maintaining the balance between the effectiveness of the operations and saving energy. It pointed out the possibility of AI in the resource optimization. The outcomes of waste minimization showed that although a number of organizations had upheld AI-controlled practices, a considerable number (8 respondents) had responded negatively. This again underscored the continued challenges in the realization of the sustainable practices within all the logistics nodes.

Figure 2: AI Influence on Sustainable Logistics Practices

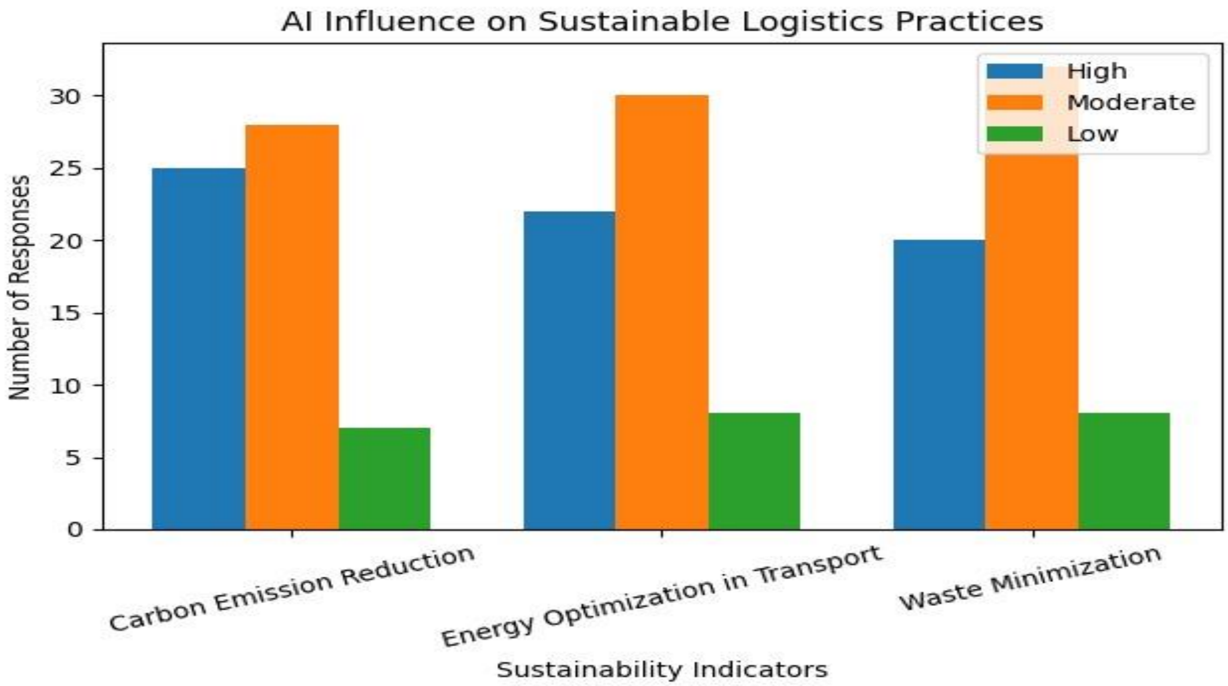
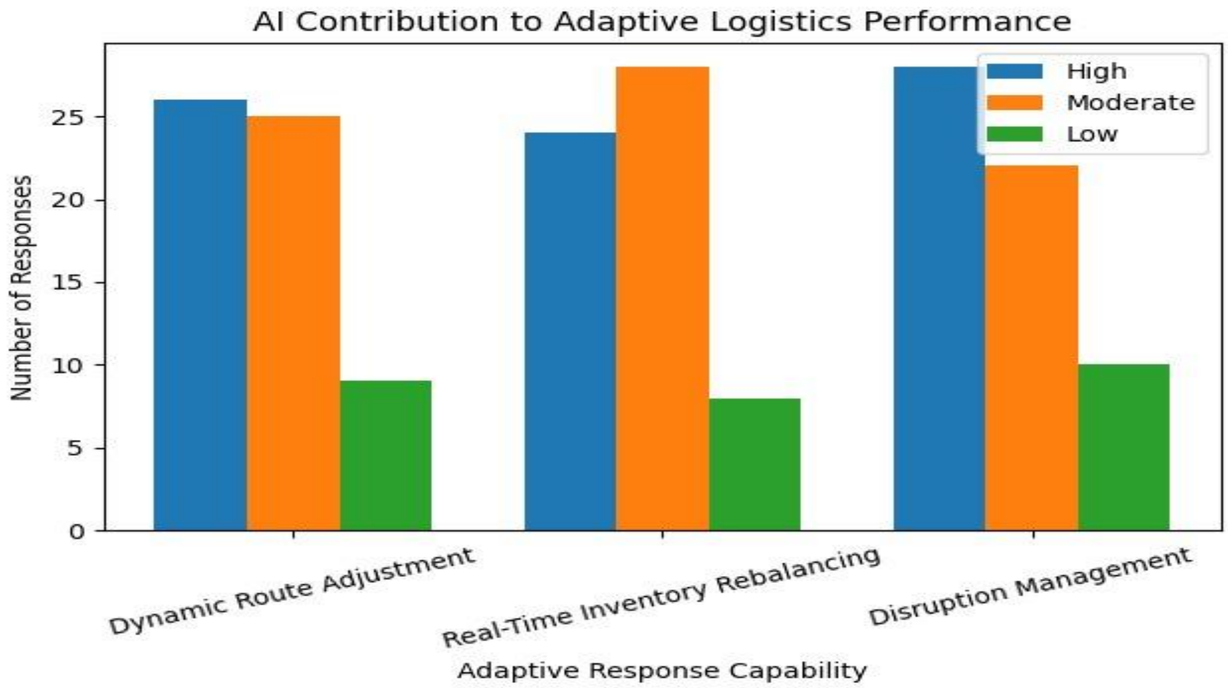


Table 3: AI Contribution to Adaptive Logistics Performance

Adaptive Response Capability	High	Moderate	Low
Dynamic Route Adjustment	26	25	9
Real-Time Inventory Rebalancing	24	28	8
Disruption Management	28	22	10

Findings showed that 26 respondents rated dynamic route adjustment highly, and this fact proved that AI-based logistics networks were capable of responding to real-time conditions that enhanced the reliability of the delivery process, as well as the efficiency of the operations. Most respondents rated real-time inventory rebalancing as moderate (28) indicating that although AI was useful in optimizing stock levels in real-time, organizations have to struggle with integration and data accuracy problems. There was also a significant rating of disruption management as 28 respondents agreed that AI-based adaptive systems increased resilience and allowed organizations to sustain supply chain continuity following unforeseen occurrences in the market or supply chain changes.

Figure 3: AI Contribution to Adaptive Logistics Performance



Qualitative Analysis

Qualitative data were collected through semi-structured interviews with 10 key supply chain professionals. Responses were analyzed thematically to extract recurring patterns and insights related to AI adoption, challenges, and outcomes.

Theme 1: Predictive Analytics Efficiency

Participants responses "AI models allowed us to anticipate demand fluctuations far more accurately than before, reducing stockouts." According to the interview responses, AI has improved prediction levels in organizations to a great extent. "Predictive dashboards helped our planning team make faster, data-driven decisions."

Experts highlighted the area of AI in the acceleration of speed and accuracy of operational decision-making. This was in agreement with the survey results which showed that the level of predictive accuracy basically fell within the 80-100 percent interval.

Theme 2: Sustainability Enhancement

Participants responses; "AI tools helped us optimize delivery routes, cutting fuel consumption by 15–20%." "We now have real-time energy monitoring systems that guide sustainable logistics practices."

The participants constantly mentioned the contribution of AI to the sustainability of the environmental area, specifically energy optimization and reduction of carbon emissions. Those stories supported quantitative findings of moderate- to high-level sustainability metrics improvement.

Theme 3: Adaptive and Resilient Logistics

Participants responses; “when a disruption occurs, AI systems suggest immediate alternative routing, minimizing delays.” “Inventory rebalancing in real-time has made our supply chain highly responsive to unexpected demand.”

The implementation of AI enabled firms to respond dynamically to disruptions, thereby driving the development of adaptive logistics. The respondents noted that predictive insights, combined with real-time monitoring, were crucial to creating resilient supply networks.

Discussion

This paper shows that AI technologies were a key factor in improving predictive performance in logistics networks. It has already been established in previous studies that machine learning and sophisticated predictive analytics contribute to the development of accurate demand forecasting and inventory management, thereby reducing uncertainties in global supply chains (Elufioye et al., 2024; Anumula et al., 2025). The respondents in the quantitative analysis reported that predictive accuracy was often high and exceeded that of standard statistical models, consistent with academic findings that AI-based predictive forecasting systems outperformed standard pricing models in dynamic markets (Elufioye et al., 2024). This was beneficial to organizations operating in volatile environments because these predictive insights enabled them to detect demand changes in advance, reducing stockouts, preserving time, and reducing waste and related operational expenses.

In addition to forecasting, AI in supply chain decision models was perceived to have increased operational responsiveness and resilience. Past empirical reviews emphasized that AI systems, particularly those integrating predictive analytics and reinforcement learning, could be used to stimulate proactive disruption management and dynamically challenging rerouting solutions (Zerine et al., 2023; Teixeira et al., 2025). The qualitative data obtained during the study supported the idea that AI-powered decision engines could respond to unplanned interference, e.g., the slowing of supply or demand, more efficiently than the old system, thereby improving overall supply chain resilience. In fact, resilience did not involve only surviving disruptions but also modifying systems to operate under new equilibrium conditions, which means that AI input went beyond the option to make corrections in response to strategic risk reduction and rapid response plans.

The analysis also found that AI has a significant influence on supply chain sustainability through resource allocation, energy optimization, and waste minimization. The recent literature has validated that AI solutions have helped implement sustainable logistics practices, such as minimizing carbon emissions and advancing the circular economy by streamlining routes and stock levels and integrating environmental requirements into decision models (Ali et al., 2024; Anumula et al., 2025). The same results were confirmed by the respondents, who reported enhanced environmental performance measures following the introduction of AI systems, indicating that sustainability improvements were closely intertwined with AI-based analytics and optimization. By automating routine optimization and integrating sustainability constraints into planning algorithms, organizations promoted environmental objectives without sacrificing (or even improving) operational efficiency.

There were undoubtedly great benefits, but the adoption of AI in the supply chain did not occur without serious challenges and complexities. The study of barriers to AI implementation showed that data quality, integration difficulties with existing IT infrastructure, and the lack of skilled talent were frequent pitfalls that delayed implementation and reduced the effectiveness of its application (Babai & Arampatzis, 2024; Teixeira et al., 2025). These limitations were reiterated by respondents in this research, who cited challenges in gathering, cleaning, and merging massive data volumes that are critical to developing sound predictive models. Also, the inequality in technological maturity among companies and even countries made the equal spread of AI benefits an issue, revealing a gap between digital transformation leaders and organizations that lacked the means or ability to deploy up-to-date AI products effectively.

The main priorities of most operational research were on the performance indexes of accuracy, speed, and resilience. Recent studies have highlighted that ethical issues, including data privacy, algorithmic transparency, and accountability, are essential to building trust and long-term acceptance of AI in supply chains (Aghaei et al., 2025). The respondents recognized that AI had strategic benefits, but organizations would require strong governance structures and ethical principles to curb the potential misuse of data, biased decision-making, and the undermining of human control in key supply chain decisions.

The interdependencies between predictive intelligence, sustainability, and resilience identified in this research align with external scholarly discourse that frames AI as a disruptive tool in contemporary supply chain management. Literature reviews revealed that the level of AI applications had increased at an impressive pace, including integrative architecture incorporating predictive analytics and real-sense sensing, reinforcement learning, and optimization algorithms (Teixeira et al., 2025). Subsequently, those supply chains that capitalized on these emerging systems exhibited higher levels of strategic flexibility, enabling not only better predictions but also more data-driven, self-sufficient responses to environmental and market ambiguities.

The evidence indicated that Intelligent Supply Chain 5.0 paradigms emerged following the integration of AI's predictive and optimization capabilities with organizational logics, which set sustainability and resilience as essential performance outcomes. However, the full potential of AI only became achievable once the underlying issues, such as data governance, the development of workforce skills, ethical considerations, and cross-functional integration, were tackled, which implies that future research and practice should take holistic approaches that incorporate both technical progress and organizational preparedness and support of the policies.

Conclusion

The research concluded that artificial intelligence was transformational in improving supply chain performance across predictive, adaptive, and sustainable dimensions. Predictive analytics powered by AI dramatically improved forecast accuracy, enabling organizations to anticipate demand shifts, manage inventory, and reduce operational uncertainty. Moreover, AI applications enhanced resilience in logistics networks, enabling firms to respond dynamically to disruptions, optimize routes, and maintain operational continuity despite volatile market environments. The study also revealed that AI integration helped reduce carbon emissions, energy use, and waste. The study, however, highlighted the roles of organizational preparedness, data quality, and governance structures, as well as other important factors in achieving AI implementation. In general, the results highlighted that AI was not only an innovative technology but also a strategic facilitator of Intelligent Supply Chain 5.0, capable of supporting the organization's operational performance in line with its long-term objectives.

Recommendations

Based on the study's results, several suggestions were made to fully leverage AI in supply chains. One is that organizations must invest in workforce training and skills development to ensure their workers can use AI devices and analyse predictive insights. Second, companies need to focus on data management and integration by establishing data quality protocols, standardization protocols, and protocols for safely sharing data in the supply chain. Third, organizations were advised to pursue a progressive and incremental strategy of implementing AI, begin with some of their most important processes, and expand AI to some additional supply chain roles. Fourth, companies are to integrate sustainability standards into both AI algorithms and logistics strategies, ensuring that operational effectiveness and environmentally committed behaviour are achieved simultaneously. Finally, ethical concerns, such as transparency, accountability, and fairness, must be integrated into AI governance systems to cultivate trust and long-term adoption.

Future Research Directions

Future studies ought to focus on more sophisticated AI designs and integrated practices that combine machine learning, reinforcement learning, and optimization strategies to further enhance predictive and adaptive supply chains. It is advised to conduct longitudinal research to determine the effects of AI adoption on the operational efficiency, sustainability, and resilience in various industrial sectors and geographic locations over a long period. Studies can also examine explainable AI (XAI) systems to enhance the understandability of artificial intelligence conclusions, enhancing the rate of organizational credibility and implementation. Moreover, opportunities in AI and new technologies, including blockchain, IoT, and digital twins, should be tapped to develop complete, intelligent, transparent, and independent supply networks. Lastly, research to date on the social and ethical aspects of AI in supply chains, such as its effects on the workforce, equity, and regulatory compliance, will inform responsible and sustainable AI behaviour in future logistical systems.

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