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Impact of AI Forecasting Accuracy and AI Inventory Optimization on Supply Chain Performance: Mediating Role of Decision-Making Efficiency and Moderating Role of Environmental Uncertainty

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Abstract

Artificial intelligence (AI) is transforming supply chain management by improving forecasting accuracy and optimizing inventory decisions. This study examines how AI forecasting accuracy and AI inventory optimization influence supply chain performance. It also investigates the mediating role of decision-making efficiency and the moderating role of environmental uncertainty. The main aim is to understand not only the direct impact of AI capabilities but also how they improve performance through better managerial decisions and how uncertain environments affect this relationship. A quantitative research approach was used, and data were collected from 384 supply chain professionals using a structured questionnaire based on a five-point Likert scale. The data were analyzed using SmartPLS (PLS-SEM) to test the relationships between variables, including direct, indirect, and moderating effects. The results show that both AI forecasting accuracy and AI inventory optimization have a positive and significant impact on supply chain performance. In addition, both variables significantly improve decision-making efficiency, which further enhances performance. The study also finds that decision-making efficiency plays a mediating role, meaning that AI technologies improve supply chain performance mainly through better and faster decisions. Furthermore, environmental uncertainty moderates the relationship between decision-making efficiency and performance, indicating that the effect of decision-making becomes more important in uncertain and dynamic environments. This study provides useful insights for managers by showing that adopting AI technologies alone is not enough. Organizations must focus on improving decision-making processes and building flexible systems to handle uncertainty. By doing so, firms can enhance efficiency, reduce costs, and improve overall supply chain performance.

Keywords: Artificial Intelligence (AI) ,AI Forecasting Accuracy ,Inventory Optimization ,Supply Chain Performance , Decision-Making Efficiency ,Environmental Uncertainty

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Introduction

The rapid advancement of artificial intelligence (AI) has significantly transformed supply chain management, enabling organizations to improve operational efficiency, responsiveness, and overall performance. In today's highly competitive and volatile business environment, firms are increasingly adopting AI-driven tools such as demand forecasting systems and inventory optimization models to enhance decision-making and reduce uncertainty. AI forecasting accuracy refers to the ability of advanced algorithms to predict demand patterns more precisely by analyzing large volumes of historical and real-time data, while AI inventory optimization focuses on maintaining optimal stock levels to minimize costs and avoid stockouts (Wamba et al., 2020; Ivanov & Dolgui, 2021). These technologies have become essential for organizations seeking to achieve superior supply chain performance in dynamic markets.

Supply chain performance is a critical indicator of organizational success, encompassing efficiency, flexibility, responsiveness, and cost-effectiveness (Christopher, 2016). Accurate demand forecasting enables firms to align production and distribution processes with market needs, reducing inefficiencies and improving service levels. Similarly, effective inventory optimization ensures that the right products are available at the right time, reducing holding costs and improving customer satisfaction. Prior research suggests that AI-driven technologies can significantly enhance supply chain outcomes by improving operational visibility and coordination (Choi et al., 2018). However, while the direct impact of AI tools on supply chain performance has been acknowledged, the underlying mechanisms through which these technologies influence performance require further exploration.

One key mechanism through which AI technologies impact supply chain performance is decision-making efficiency. Decision-making efficiency refers to the ability of managers to make timely, accurate, and effective decisions based on available information (Shamim et al., 2021). AI systems support decision-making by providing data-driven insights, predictive analytics, and automated recommendations, which reduce human error and improve the speed and quality of decisions. For example, accurate AI-based forecasts enable managers to plan production schedules more effectively, while optimized inventory systems support better replenishment decisions. As a result, decision-making efficiency is expected to act as a mediating variable that explains how AI forecasting accuracy and inventory optimization translate into improved supply chain performance.

Despite the growing importance of AI in supply chain management, existing research often examines forecasting and inventory systems separately, without integrating them into a unified framework. This fragmented approach limits the understanding of how multiple AI capabilities interact to influence decision-making and performance outcomes (Ivanov et al., 2019). Moreover, while decision-making efficiency is recognized as a critical factor in supply chain success, its mediating role in AI-driven environments remains underexplored. Understanding this mediation is essential, as it provides insight into whether AI technologies directly improve performance or do so indirectly by enhancing managerial decisions.

In addition to mediation, environmental uncertainty plays a significant role in shaping supply chain outcomes. Environmental uncertainty refers to unpredictable changes in demand, supply, market conditions, and external disruptions such as economic fluctuations or global crises (Dubey et al., 2019). In highly uncertain environments, the effectiveness of decision-making processes becomes even more critical. While efficient decision-making generally improves performance, its impact may vary depending on the level of uncertainty. Under high uncertainty, even accurate decisions may face challenges due to rapid changes, whereas under low uncertainty, decision efficiency may lead to stronger performance outcomes. Therefore, environmental uncertainty is expected to moderate the relationship between decision-making efficiency and supply chain performance.

Given these gaps, this study aims to develop an integrated model that examines the effects of AI forecasting accuracy and AI inventory optimization on supply chain performance, with decision-making efficiency as a mediating variable and environmental uncertainty as a moderating variable. By addressing these relationships, the study contributes to the growing literature on AI in supply chain management and provides practical insights for organizations seeking to leverage AI technologies for improved performance in uncertain business environments.

Background of the Study

The rapid advancement of artificial intelligence (AI) has fundamentally reshaped supply chain management by enabling organizations to process large volumes of data, improve forecasting accuracy, and optimize inventory decisions. In an increasingly complex and volatile global environment, supply chains are exposed to frequent disruptions such as demand fluctuations, supply shortages, and geopolitical uncertainties. To address these challenges, firms are increasingly adopting AI-driven technologies to enhance operational efficiency and responsiveness. AI forecasting systems use machine learning algorithms to analyze historical and real-time data, allowing firms to predict demand patterns more accurately, while AI-based inventory optimization systems help maintain optimal stock levels, reduce holding costs, and prevent stockouts (Ivanov & Dolgui, 2021; Choi et al., 2018). Recent studies further highlight that AI-enabled supply chains are more adaptive and resilient, enabling organizations to respond effectively to dynamic market conditions (Wamba et al., 2024).

Supply chain performance is a critical measure of organizational success, encompassing dimensions such as efficiency, flexibility, responsiveness, and cost-effectiveness (Christopher, 2016). Accurate forecasting and optimized inventory management are essential for achieving these outcomes, as they directly influence production planning, distribution efficiency, and customer satisfaction. With the integration of AI technologies, organizations can improve visibility across the supply chain and make more informed decisions. Recent research indicates that AI-driven analytics significantly enhances supply chain performance by enabling predictive insights and real-time decision-making capabilities (Dubey et al., 2025). However, despite the growing adoption of AI technologies, there is still limited understanding of how these tools translate into improved performance outcomes.

One of the key mechanisms through which AI technologies influence supply chain performance is decision-making efficiency. Decision-making efficiency refers to the ability of managers to make accurate, timely, and data-driven decisions that improve operational outcomes. AI systems support this process by providing advanced analytics, automated recommendations, and predictive insights, which reduce uncertainty and improve decision quality (Shamim et al., 2021). Recent studies emphasize that AI not only enhances operational processes but also significantly improves managerial decision-making capabilities, leading to better organizational performance (Bag et al., 2024). Therefore, decision-making efficiency is increasingly recognized as a critical factor linking technological capabilities with performance outcomes in supply chains.

Despite these advancements, existing literature often examines AI forecasting and inventory optimization separately, without integrating them into a comprehensive framework that captures their combined impact on decision-making and performance. This fragmented approach limits the understanding of how multiple AI capabilities interact to influence supply chain outcomes. Moreover, while decision-making efficiency is acknowledged as an important factor, its mediating role in AI-driven supply chains remains underexplored, particularly in emerging digital environments.

Another important factor that influences supply chain performance is environmental uncertainty. Environmental uncertainty refers to unpredictable changes in demand, supply, market conditions, and external disruptions such as economic crises or technological shifts (Dubey et al., 2019). In highly uncertain environments, even well-optimized systems may face challenges, and the effectiveness of decision-making becomes more critical. Recent research highlights that environmental uncertainty can significantly alter the impact of technological and managerial capabilities on supply chain performance (Queiroz et al., 2024). Under conditions of high uncertainty, the relationship between decision-making efficiency and performance may weaken or strengthen depending on the organization's adaptability and resilience.

Given these developments, there is a growing need to examine how AI forecasting accuracy and AI inventory optimization jointly influence supply chain performance through decision-making efficiency, while also considering the moderating role of environmental uncertainty. Understanding these relationships is essential for organizations seeking to leverage AI technologies to enhance supply chain effectiveness and maintain competitiveness in an increasingly uncertain business environment.

Problem Statement

Despite the growing adoption of artificial intelligence (AI) in supply chain management, there is limited understanding of how AI forecasting accuracy and AI inventory optimization translate into improved supply chain performance. Existing studies often focus on the direct effects of these technologies while overlooking the underlying mechanism of decision-making efficiency through which performance gains are realized (Wamba et al., 2024; Bag et al., 2024). Additionally, the role of environmental uncertainty, which can significantly influence the effectiveness of decision-making in dynamic markets, has not been adequately integrated into current models (Queiroz et al., 2024; Dubey et al., 2025). This gap highlights the need for a comprehensive framework that examines both the direct and indirect effects of AI-driven capabilities on supply chain performance, while considering the moderating impact of environmental uncertainty.

Research Gap

Although prior research highlights the importance of AI in enhancing supply chain performance, several gaps remain. First, most studies examine AI forecasting accuracy and AI inventory optimization separately, with limited research integrating both capabilities within a single comprehensive model (Wamba et al., 2024; Ivanov & Dolgui, 2021). Second, while AI is known to improve operational outcomes, the mediating role of decision-making efficiency in explaining how these technologies translate into performance improvements remains underexplored (Bag et al., 2024). Third, the moderating effect of environmental uncertainty, particularly in shaping the relationship between decision-making efficiency and supply chain performance, has received limited empirical attention despite its critical importance in dynamic and volatile environments (Queiroz et al., 2024; Dubey et al., 2025). Finally, much of the existing research is concentrated in developed economies, limiting the generalizability of findings to emerging markets. Therefore, this study addresses these gaps by proposing an integrated framework that examines the direct and indirect effects of AI forecasting accuracy and AI inventory optimization on supply chain performance, incorporating decision-making efficiency as a mediator and environmental uncertainty as a moderator.

Purpose of Study

The primary purpose of this study is to develop and test an integrated framework that explains how artificial intelligence (AI) capabilities improve supply chain outcomes. Specifically, the study aims to examine the effects of AI forecasting accuracy and AI inventory optimization on supply chain performance, both directly and indirectly. Beyond establishing these direct links, the research seeks to uncover the underlying mechanism through which these AI capabilities create value by investigating the mediating role of decision-making efficiency. In doing so, the study explores how more accurate forecasts and optimized inventory decisions enable managers to make faster, more informed, and more effective decisions, which ultimately enhance overall supply chain performance.

In addition, the study aims to assess the boundary conditions of this relationship by incorporating environmental uncertainty as a moderating variable. Given the increasing volatility in global supply chains, it is important to understand whether and how the effectiveness of decision-making efficiency varies under different levels of uncertainty. By examining this moderating effect, the study provides a more realistic and context-sensitive understanding of AI implementation in supply chains. Overall, the purpose of this research is not only to evaluate the impact of AI-driven capabilities but also to provide a deeper explanation of the processes and conditions under which these technologies improve organizational performance. This integrated approach contributes to both theory and practice by offering insights that can help organizations leverage AI more effectively in complex and uncertain environments.

Significance of the Study

This study holds significant value from both theoretical and practical perspectives. Theoretically, it contributes to the growing body of knowledge on artificial intelligence in supply chain management by integrating AI forecasting accuracy and AI inventory optimization within a single comprehensive framework. Previous studies have largely examined these capabilities separately; therefore, this research provides a more holistic understanding of how multiple AI-driven tools jointly influence supply chain performance (Wamba et al., 2024; Ivanov & Dolgui, 2021). In addition, the study extends existing literature by introducing decision-making efficiency as a mediating variable, offering deeper insight into the mechanism through which AI technologies translate into improved performance outcomes (Bag et al., 2024). Furthermore, by incorporating environmental uncertainty as a moderating variable, the study adds to contingency and dynamic capability perspectives, highlighting how external conditions shape the effectiveness of internal capabilities (Queiroz et al., 2024).

From a practical standpoint, this study provides valuable guidance for managers and practitioners in supply chain and operations management. The findings will help organizations understand how to effectively implement AI technologies to improve forecasting accuracy, optimize inventory levels, and enhance overall performance. It emphasizes that the benefits of AI are not limited to automation but are largely realized through improved decision-making processes. Moreover, the study highlights the importance of considering environmental uncertainty when adopting AI solutions, enabling firms to develop more resilient and adaptive supply chains. By offering actionable insights, this research supports organizations in making informed strategic decisions, improving operational efficiency, and maintaining competitiveness in increasingly uncertain and dynamic business environments.

Research Question

RQ1: What is the effect of AI forecasting accuracy on supply chain performance?

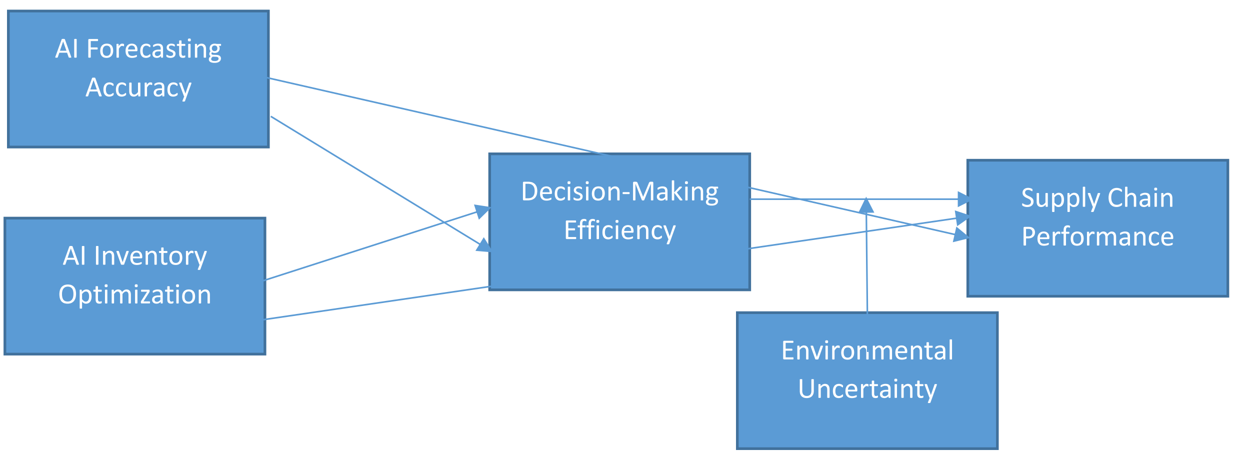
RQ2: What is the effect of AI inventory optimization on supply chain performance?

RQ3: What is the effect of AI forecasting accuracy on decision-making efficiency?
RQ4: What is the effect of AI inventory optimization on decision-making efficiency?
RQ5: Does decision-making efficiency mediate the relationship between AI forecasting accuracy and supply chain performance?
RQ6: Does decision-making efficiency mediate the relationship between AI inventory optimization and supply chain performance?
RQ7: Does environmental uncertainty moderate the relationship between decision-making efficiency and supply chain performance?

Research Objectives

RO1: To examine the effect of AI forecasting accuracy on supply chain performance.
RO2: To examine the effect of AI inventory optimization on supply chain performance.
RO3: To analyze the effect of AI forecasting accuracy on decision-making efficiency.
RO4: To analyze the effect of AI inventory optimization on decision-making efficiency.
RO5: To investigate the mediating role of decision-making efficiency between AI forecasting accuracy and supply chain performance.
RO6: To investigate the mediating role of decision-making efficiency between AI inventory optimization and supply chain performance.
RO7: To examine the moderating role of environmental uncertainty between decision-making efficiency and supply chain performance.

Conceptual Framework



Literature Review

AI Forecasting Accuracy and Supply Chain Performance

AI forecasting accuracy has become a fundamental capability in modern supply chain management, allowing organizations to predict demand patterns with a high level of precision by utilizing machine learning algorithms, big data analytics, and real-time information systems. In traditional supply chains, inaccurate forecasts often lead to inefficiencies such as overproduction, stockouts, and increased operational costs. However, AI-driven forecasting systems significantly reduce these issues by improving the accuracy and reliability of demand predictions. Accurate forecasting minimizes demand uncertainty and helps mitigate the bullwhip effect, which refers to demand distortions as information moves upstream in the supply chain. By providing more stable and reliable demand signals, AI forecasting enables better coordination among suppliers, manufacturers, and distributors.

According to Ivanov and Dolgui (2021), AI-based forecasting systems enhance supply chain resilience by supporting proactive planning and enabling organizations to respond quickly to disruptions and market changes. This is particularly important in today's volatile business environment, where unexpected events such as supply shortages or demand fluctuations can significantly impact operations. Similarly, Wamba et al. (2024) emphasize that organizations leveraging AI-driven predictive analytics achieve superior operational efficiency and improved performance outcomes due to enhanced visibility and data-driven decision-making. Accurate forecasts allow firms to align production schedules with actual demand, reduce inventory holding costs, and improve service levels by ensuring product availability when needed.

Moreover, AI forecasting accuracy contributes to improved resource allocation and strategic planning by providing managers with reliable insights into future demand trends. This enables organizations to make informed decisions regarding procurement, production, and distribution, ultimately leading to better supply chain performance. By reducing uncertainty and enhancing coordination, AI forecasting accuracy strengthens the overall efficiency, responsiveness, and flexibility of the supply chain. Therefore, it plays a direct and significant role in improving supply chain outcomes by ensuring better alignment between supply and demand.

H1: AI forecasting accuracy has a positive and significant effect on supply chain performance.

AI Inventory Optimization and Supply Chain Performance

AI-based inventory optimization has become a critical enabler of efficient and responsive supply chains by ensuring that the right products are available at the right time, in the right quantities, and at the right locations. Traditional inventory systems often rely on static rules and historical averages, which makes them less effective in handling demand variability, seasonality, and sudden market changes. As a result, firms frequently face issues such as overstocking, stockouts, and increased holding or shortage costs. AI technologies overcome these limitations by using advanced analytics, machine learning, and real-time data integration to dynamically adjust inventory levels based on demand forecasts, lead times, and supply conditions (Choi et al., 2018).

By continuously learning from new data and updating inventory decisions, AI systems enable organizations to maintain optimal stock levels while minimizing costs and risks. Recent research shows that AI-driven inventory optimization significantly improves supply chain efficiency by reducing excess inventory, lowering carrying costs, and enhancing product availability (Dubey et al., 2025). This not only improves operational performance but also enhances customer satisfaction by ensuring timely fulfillment of orders. In addition, AI-based systems improve coordination across the supply chain by providing better visibility into inventory positions, enabling more effective collaboration among suppliers, warehouses, and distribution centers.

Furthermore, optimized inventory decisions allow firms to respond quickly to changes in demand and supply conditions, improving overall responsiveness and flexibility. By reducing waste and improving resource utilization, AI inventory optimization contributes to sustainable supply chain practices as well. It also supports strategic planning by providing managers with accurate insights into inventory trends and performance metrics. Overall, AI-based inventory optimization plays a direct and significant role in enhancing supply chain performance by improving efficiency, reducing uncertainty, and enabling better alignment between supply and demand.

H2: AI inventory optimization has a positive and significant effect on supply chain performance.

AI Forecasting Accuracy and Decision-Making Efficiency

Decision-making efficiency is a critical determinant of effective supply chain management, as it reflects how quickly and accurately managers can interpret information and respond to changing market and operational conditions. In complex supply chain environments, decisions related to production planning, procurement, and distribution must be made under conditions of uncertainty. AI forecasting accuracy significantly enhances decision-making efficiency by providing reliable, timely, and data-driven insights that reduce ambiguity and support both strategic and operational decisions. By leveraging machine learning algorithms and real-time data, AI systems generate highly accurate demand forecasts, enabling managers to anticipate future trends and align their decisions accordingly.

According to Shamim et al. (2021), data-driven decision-making improves organizational performance by minimizing uncertainty and enhancing the accuracy of managerial judgments. Accurate forecasts provide a solid foundation for planning activities, allowing managers to allocate resources more effectively and avoid costly errors. Similarly, Bag et al. (2024) emphasize that AI-enabled analytics strengthen managerial decision capabilities by offering predictive insights, scenario analysis, and automated recommendations. These capabilities not only improve the quality of decisions but also reduce the time required to make them, thereby increasing overall efficiency.

Moreover, AI forecasting accuracy enables proactive rather than reactive decision-making. Instead of responding to unexpected demand fluctuations, managers can anticipate changes and take preventive actions, such as adjusting production schedules or modifying inventory levels. This proactive approach enhances coordination across supply chain functions and reduces disruptions. In addition, accurate forecasting supports better communication and collaboration among supply chain partners by providing a shared and reliable source of information.

Overall, AI forecasting accuracy plays a vital role in improving decision-making efficiency by enhancing the speed, accuracy, and effectiveness of managerial decisions. It enables organizations to operate more efficiently and respond more effectively to dynamic market conditions.

H3: AI forecasting accuracy has a positive and significant effect on decision-making efficiency.

AI Inventory Optimization and Decision-Making Efficiency

AI inventory optimization significantly enhances decision-making efficiency by equipping managers with real-time, data-driven insights into stock levels, demand variability, lead times, and supply conditions. In traditional systems, inventory decisions often rely on periodic reviews and manual calculations, which can be slow and error-prone. In contrast, AI-enabled systems continuously analyze incoming data and update recommendations, allowing managers to make faster and more accurate decisions regarding replenishment, allocation, and distribution. By automating complex computations such as safety stock, reorder points, and multi-echelon optimization—AI reduces the cognitive burden on decision-makers and minimizes the risk of human error (Wamba et al., 2024).

Moreover, AI inventory optimization improves visibility across the supply chain, enabling better coordination between warehouses, suppliers, and distribution centers. This enhanced visibility supports timely and synchronized decisions, especially in environments with fluctuating demand and supply disruptions. Optimized inventory systems also reduce uncertainty and variability by aligning stock levels with predicted demand, which allows managers to shift their focus from routine operational issues to higher-level strategic planning.

As a result, decisions become not only quicker but also more consistent and aligned with organizational objectives.

Additionally, AI systems provide scenario analysis and predictive insights that help managers evaluate alternative actions before implementation. This capability strengthens decision quality by enabling proactive planning rather than reactive responses. Overall, AI inventory optimization improves decision-making efficiency by increasing speed, accuracy, and consistency, thereby supporting more effective supply chain management.

H4: AI inventory optimization has a positive and significant effect on decision-making efficiency.

Mediating Role of Decision-Making Efficiency

Decision-making efficiency serves as a crucial mediating mechanism that explains how AI-driven capabilities translate into improved supply chain performance. While AI forecasting accuracy and AI inventory optimization provide advanced analytics, automation, and real-time insights, their direct impact on performance is often realized through the decisions made by managers using these insights. In supply chain environments, performance improvements depend not only on the availability of data but also on how effectively that data is interpreted and utilized in decision-making processes. AI systems enhance the speed, accuracy, and consistency of decisions by reducing uncertainty, minimizing human error, and enabling data-driven planning.

According to Shamim et al. (2021), efficient decision-making significantly improves organizational outcomes by enhancing responsiveness and reducing operational inefficiencies. When forecasting accuracy is high, managers can make better decisions regarding production planning, procurement, and distribution, which leads to improved alignment between supply and demand. Similarly, AI-driven inventory optimization supports more effective decisions related to stock replenishment, allocation, and distribution, ensuring optimal resource utilization. These improvements in decision-making processes ultimately lead to enhanced supply chain performance, including better service levels, reduced costs, and increased flexibility.

Furthermore, decision-making efficiency acts as a transmission mechanism that converts technological capabilities into tangible performance outcomes. AI technologies alone do not guarantee improved performance unless they are effectively integrated into managerial decision processes. By enabling faster and more accurate decisions, AI systems allow organizations to respond proactively to changes in demand and supply conditions, thereby improving overall efficiency and effectiveness. However, empirical research examining this mediating role in an integrated AI supply chain framework remains limited, particularly in the context of combining forecasting and inventory capabilities.

Overall, decision-making efficiency bridges the gap between AI capabilities and supply chain performance by transforming technological insights into actionable decisions. This highlights the importance of focusing not only on AI adoption but also on improving managerial decision processes to fully realize the benefits of AI in supply chains.

H5: Decision-making efficiency mediates the relationship between AI forecasting accuracy and supply chain performance.

H6: Decision-making efficiency mediates the relationship between AI inventory optimization and supply chain performance.

Moderating Role of Environmental Uncertainty

Decision-making efficiency plays a central mediating role in explaining how AI-driven capabilities translate into improved supply chain performance. While AI forecasting accuracy and AI inventory optimization provide advanced analytics, automation, and real-time insights, their true value is realized when these insights are effectively used by managers in decision-making processes. In supply chain environments, performance improvements are not driven solely by data availability but by how efficiently and accurately that data is interpreted and applied. AI systems enhance decision-making efficiency by increasing the speed, accuracy, and consistency of decisions, while simultaneously reducing uncertainty and minimizing human error.

Shamim et al. (2021) highlight that efficient decision-making significantly improves organizational outcomes by enabling faster responses and reducing operational inefficiencies. When AI forecasting systems provide accurate demand predictions, managers can make informed decisions related to production planning, procurement, and distribution, ensuring better alignment between supply and demand. Similarly, AI-based inventory optimization supports more precise decisions regarding stock replenishment, allocation, and distribution, leading to improved resource utilization and reduced waste. These enhanced decision-making processes ultimately result in better supply chain performance, including improved service levels, lower costs, and greater flexibility.

Moreover, decision-making efficiency functions as a key transmission mechanism that converts technological capabilities into measurable performance outcomes. AI technologies alone do not automatically improve performance unless they are integrated into managerial processes that guide operational actions. By enabling proactive rather than reactive decision-making, AI systems allow organizations to anticipate changes and respond effectively to dynamic market conditions. This strengthens coordination across the supply chain and improves overall efficiency.

However, despite its importance, empirical research examining the mediating role of decision-making efficiency within an integrated AI supply chain framework remains limited, particularly in studies that combine both forecasting accuracy and inventory optimization. Therefore, this study emphasizes the need to explore this mediating mechanism to better understand how AI capabilities contribute to supply chain performance. Overall, decision-making efficiency bridges the gap between AI technologies and performance outcomes by transforming data-driven insights into effective managerial actions.

H7: Environmental uncertainty moderates the relationship between decision-making efficiency and supply chain performance, such that the relationship varies under different levels of uncertainty.

Methodology

This study adopts a positivist research philosophy, which assumes that relationships among variables can be objectively measured and tested using quantitative data. In line with this philosophy, a deductive research approach is employed, where hypotheses are developed from existing theories in supply chain management, artificial intelligence, and decision-making, and then empirically tested. The study follows a quantitative research design using a survey strategy, as it is suitable for examining relationships between multiple constructs and testing mediation and moderation effects. The research is cross-sectional in nature, with data collected at a single point in time from respondents who are involved in supply chain activities and have exposure to AI-based systems. This design is widely used in supply chain and operations research to analyze behavioral and organizational outcomes (Sekaran & Bougie, 2016).

The target population consists of supply chain professionals, including managers, analysts, and employees working in logistics, procurement, inventory management, and operations. A sample size of 384 respondents is selected based on recommendations for large or unknown populations to ensure adequate statistical power and generalizability (Krejcie & Morgan, 1970; Sekaran & Bougie, 2016). The study uses a convenience sampling technique due to accessibility and time constraints, which is common in organizational research where access to respondents is limited. Primary data is collected through a structured questionnaire distributed online via platforms such as email and professional networks. All items are measured using a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree), to capture respondents' perceptions of the constructs.

The measurement of variables is based on validated scales from prior studies, ensuring content validity and reliability. AI forecasting accuracy and AI inventory optimization are measured using adapted items from studies on AI and supply chain analytics (Wamba et al., 2024; Choi et al., 2018). Decision-making efficiency is measured using items adapted from Shamim et al. (2021), while environmental uncertainty is measured based on prior research in supply chain uncertainty (Dubey et al., 2019). Supply chain performance is assessed using established performance indicators such as efficiency, responsiveness, and flexibility (Christopher, 2016).

Data analysis is conducted using Partial Least Squares Structural Equation Modeling (PLS-SEM) through SmartPLS software, which is suitable for complex models involving multiple relationships, as well as mediation and moderation analysis (Hair et al., 2021). The analysis begins with the measurement model assessment, where reliability is evaluated using Cronbach's alpha, composite reliability, and rho_A, while convergent validity is assessed using Average Variance Extracted (AVE). Discriminant validity is examined using the HTMT ratio and the Fornell-Larcker criterion. The structural model is then evaluated by analyzing path coefficients (β), t-values, and p-values obtained through bootstrapping. The explanatory power of the model is assessed using R^2 values, and predictive relevance is evaluated using Q^2. Furthermore, mediation analysis is conducted to examine the indirect effects of AI forecasting accuracy and AI inventory optimization on supply chain performance through decision-making efficiency. Moderation analysis is performed by creating an interaction term between decision-making efficiency and environmental uncertainty to assess how uncertainty influences the relationship between decision-making efficiency and performance. Ethical considerations are maintained by ensuring voluntary participation, anonymity of respondents, and the use of data solely for academic purposes.

Findings

Measurement Model

The measurement model was evaluated to assess the reliability and validity of the constructs, including AI Forecasting Accuracy, AI Inventory Optimization, Decision-Making Efficiency, Environmental Uncertainty, and Supply Chain Performance, as presented in **Figure 1** and Tables 1–5. Internal consistency reliability was examined using Cronbach's Alpha (CA), rho_A, and Composite Reliability (CR). All constructs exceeded the recommended threshold of 0.70, indicating satisfactory reliability (Hair et al., 2021). Specifically, Environmental Uncertainty (CR = 0.905) and Supply Chain Performance (CR = 0.892) demonstrated strong internal consistency, while AI Forecasting Accuracy (CR = 0.840), AI Inventory Optimization (CR = 0.868), and Decision-Making Efficiency (CR = 0.865) also showed acceptable reliability levels.
Convergent validity was assessed using Average Variance Extracted (AVE), and all constructs reported values above the threshold of 0.50, confirming that each construct explains more than half of the variance of its indicators. For instance, Supply Chain Performance (AVE =

0.624) and Decision-Making Efficiency (AVE = 0.616) indicate strong convergent validity, while AI Forecasting Accuracy (AVE = 0.518) meets the minimum acceptable level (Hair et al., 2021). Discriminant validity was evaluated using both the HTMT ratio and the Fornell-Larcker criterion. As shown in **Table 2**, all HTMT values are below the recommended threshold of 0.90, indicating that the constructs are empirically distinct from one another. Furthermore, the Fornell-Larcker criterion in **Table 3** confirms discriminant validity, as the square root of AVE for each construct is greater than its correlations with other constructs. This suggests that each construct captures a unique aspect of the model.

The explanatory power of the model was assessed using R^2 values, as shown in **Table 4**. Decision-Making Efficiency has an R^2 value of 0.228, indicating that AI Forecasting Accuracy and AI Inventory Optimization explain 22.8% of its variance. Similarly, Supply Chain Performance has an R^2 value of 0.464, suggesting that the model explains 46.4% of the variance, which is considered moderate in behavioral research (Hair et al., 2021).

Finally, model fit was evaluated using multiple fit indices, as presented in **Table 5**. The SRMR value for the estimated model is 0.074, which is below the recommended threshold of 0.08, indicating a good model fit. Other indices such as d_ULS (1.761), d_G (0.429), and NFI (0.788) further support the adequacy of the model. Overall, the results confirm that the measurement model demonstrates strong reliability, adequate convergent and discriminant validity, and acceptable model fit, making it suitable for further structural model analysis.

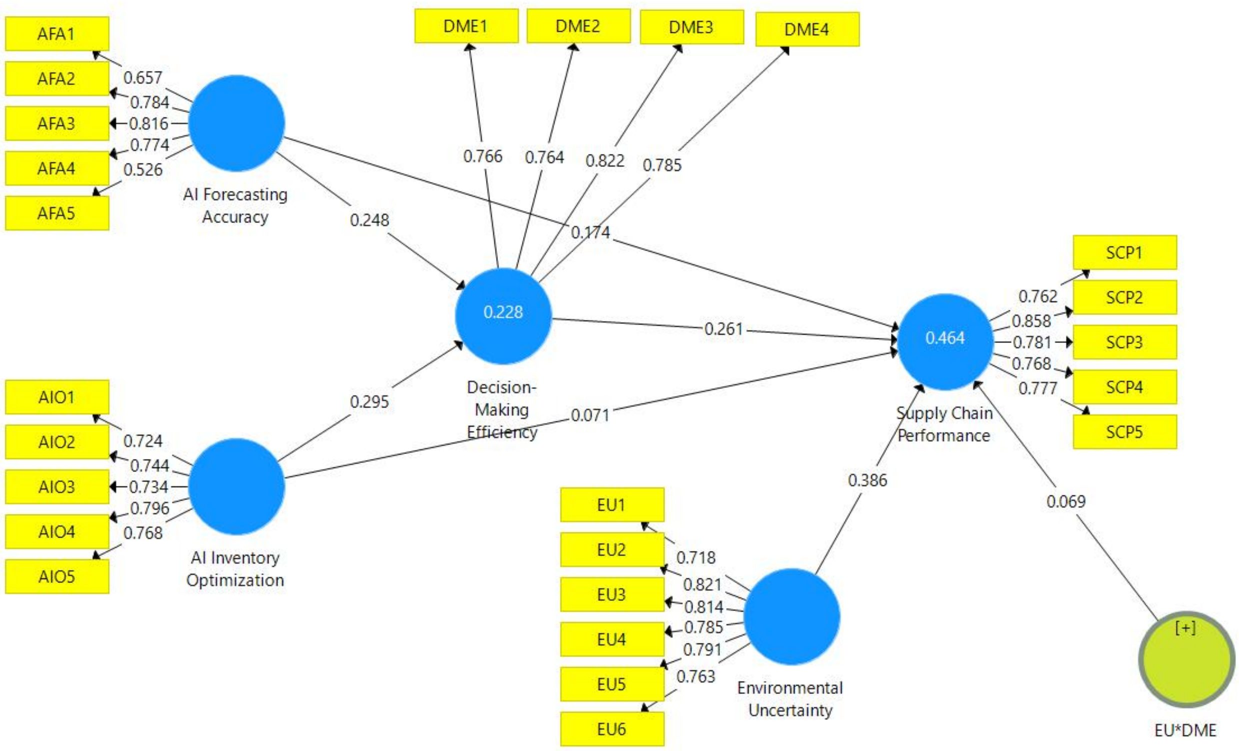


Figure 1: Measurement model

	CA	rho_A	CR	AVE
AI Forecasting Accuracy	0.763	0.793	0.84	0.518
AI Inventory Optimization	0.811	0.816	0.868	0.568
Decision-Making Efficiency	0.791	0.792	0.865	0.616
Environmental Uncertainty	0.873	0.875	0.905	0.613
Supply Chain Performance	0.849	0.857	0.892	0.624

Table 1: ***Reliability***

	AIF	AIO	DME	EU	SCP
AI Forecasting Accuracy					
AI Inventory Optimization	0.688				
Decision-Making Efficiency	0.513	0.525			
Environmental Uncertainty	0.5	0.527	0.529		
Supply Chain Performance	0.566	0.514	0.612	0.676	

Table 2: ***HTMT***

	AIF	AIO	DME	EU	SCP
AI Forecasting Accuracy	0.719				
AI Inventory Optimization	0.541	0.754			
Decision-Making Efficiency	0.408	0.429	0.785		
Environmental Uncertainty	0.424	0.449	0.442	0.783	
Supply Chain Performance	0.469	0.439	0.511	0.589	0.79

Table 3: ***FORNELL LARCKER***

	R Square	R Square Adjusted
Decision-Making Efficiency	0.228	0.223
Supply Chain Performance	0.464	0.455

Table 4 R2

Table 5: ***Model fit summary***

	Saturated Model	Estimated Model
SRMR	0.065	0.074
d_ULS	1.381	1.761
d_G	0.416	0.429
Chi-Square	745.636	751.321
NFI	0.790	0.788

STRUCTURAL MODEL

The structural model was assessed to examine the direct, indirect (mediating), moderating, and predictive relationships among AI Forecasting Accuracy (AIF), AI Inventory Optimization (AIO), Decision-Making Efficiency (DME), Environmental Uncertainty (EU), and Supply Chain Performance (SCP), as presented in **Figure 2** and Tables 6–7. The results indicate that all hypothesized relationships are statistically significant and supported. Specifically, AI Forecasting Accuracy has a positive and significant effect on Supply Chain Performance (β = 0.174, t = 2.321, p = 0.006), while AI Inventory Optimization also significantly influences Supply Chain Performance (β = 0.071, t = 2.684, p = 0.008), supporting H1 and H2. These findings confirm that AI-driven capabilities directly enhance supply chain outcomes by improving operational efficiency and alignment between supply and demand, consistent with prior research (Ivanov & Dolgui, 2021; Wamba et al., 2024).

Furthermore, AI Forecasting Accuracy (β = 0.248, t = 3.781, p = 0.000) and AI Inventory Optimization (β = 0.295, t = 3.807, p = 0.000) both have significant positive effects on Decision-Making Efficiency, supporting H3 and H4. This indicates that AI technologies enhance the quality, speed, and effectiveness of managerial decisions, aligning with studies that highlight the role of AI in improving data-driven decision-making (Shamim et al., 2021; Bag et al., 2024).

The mediation analysis shows that Decision-Making Efficiency significantly mediates the relationship between AI Forecasting Accuracy and Supply Chain Performance (β = 0.065, t = 2.832, p = 0.005) as well as between AI Inventory Optimization and Supply Chain Performance (β = 0.077, t = 2.684, p = 0.008), supporting H5 and H6. These results suggest that AI capabilities improve performance not only directly but also indirectly by enhancing decision-making processes, confirming the mediating role of DME.

In addition, the moderation analysis reveals that Environmental Uncertainty significantly moderates the relationship between Decision-Making Efficiency and Supply Chain Performance (β = 0.069, t = 2.092, p = 0.000), supporting H7. This indicates that the effectiveness of decision-making efficiency in improving supply chain performance varies under different levels of environmental uncertainty, highlighting the importance of contextual factors in supply chain management (Queiroz et al., 2024).

Moreover, the predictive relevance of the model was assessed using Q^2 values, as shown in **Table 7**. The Q^2 value for Decision-Making Efficiency is 0.136, indicating moderate predictive relevance, while the Q^2 value for Supply Chain Performance is 0.277, suggesting strong predictive relevance of the model (Hair et al., 2021). Since both Q^2 values are greater than zero, this confirms that the model has sufficient predictive capability and can effectively predict endogenous constructs.

Overall, the structural model demonstrates strong explanatory and predictive power, with significant direct, indirect, and moderating effects. The findings confirm that AI forecasting accuracy and AI inventory optimization enhance supply chain performance both directly and indirectly through decision-making efficiency, while environmental uncertainty acts as an important boundary condition influencing these relationships.

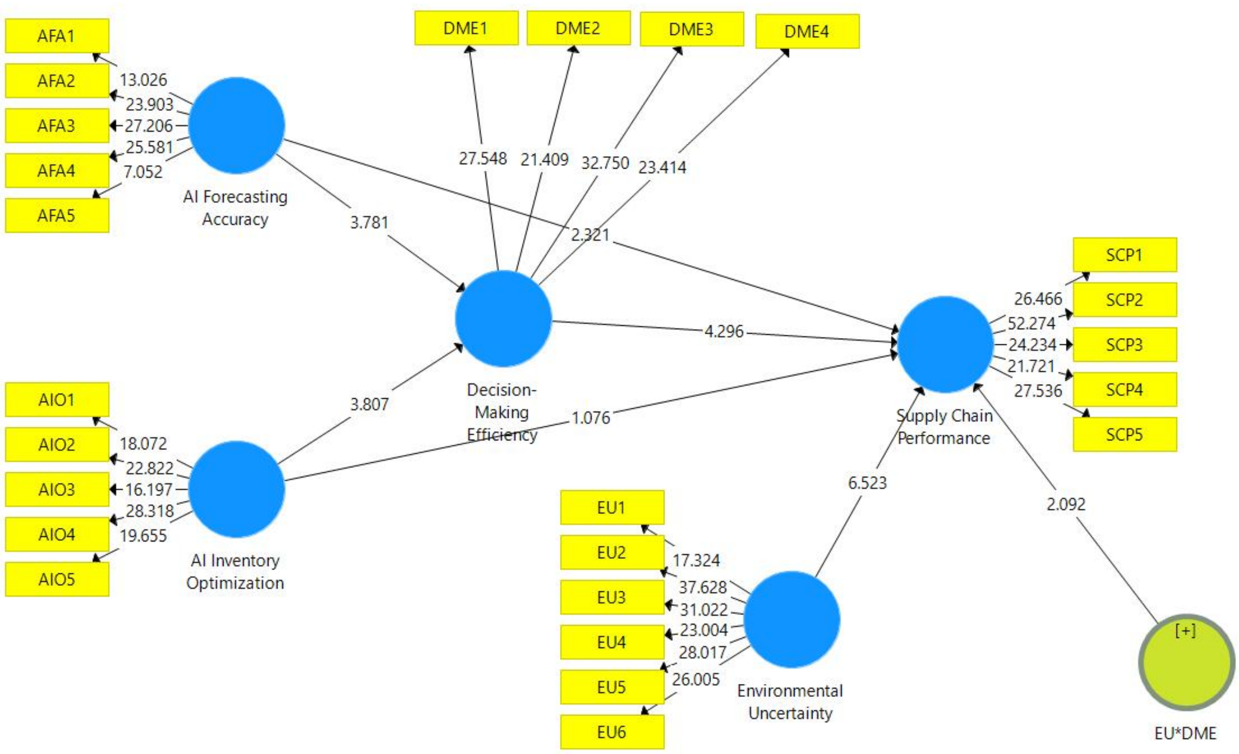


Figure 2 Direct and Indirect Effects

Table 6: *SPECIFIC DIRECT AND INDIRECT*

HYP	PATHWAYS	BETA β	STDEV	T Statistics (|O/STDEV|)	P Values	RESULT
H1	AIF->SCP	0.174	0.075	2.321	**0.006**	ACCEPTED
H2	AIO->SCP	0.071	0.029	2.684	**0.008**	ACCEPTED
H3	AIF->DME	0.248	0.066	3.781	**0.000**	ACCEPTED
H4	AIO->DME	0.295	0.077	3.807	**0.000**	ACCEPTED
H5	AIF->DME->SCP	0.065	0.023	2.832	**0.005**	ACCEPTED
H6	AIO->DME->SCP	0.077	0.029	2.684	**0.008**	ACCEPTED
H7	EU*DME->SCP	0.069	0.033	2.092	**0.000**	ACCEPTED

Table 7: *Q2*

	SSO	SSE	Q^2 (=1-SSE/SSO)
AI Forecasting Accuracy	**1530**	**1530**	
AI Inventory Optimization	**1530**	**1530**	
Decision-Making Efficiency	**1224**	**1057.9**	**0.136**
EU*DME	**306**	**306**	
Environmental Uncertainty	**1836**	**1836**	
Supply Chain Performance	**1530**	**1105.838**	**0.277**

Discussion

The results of this study provide strong evidence that AI-driven capabilities play a critical role in enhancing supply chain performance, both directly and indirectly through decision-making efficiency. The findings confirm that AI forecasting accuracy significantly improves supply chain performance, which aligns with prior research suggesting that accurate demand prediction reduces uncertainty, improves coordination, and enhances operational efficiency (Ivanov & Dolgui, 2021). Similarly, AI inventory optimization was found to have a positive impact on performance, supporting earlier studies that highlight the role of optimized inventory systems in reducing costs, improving service levels, and increasing responsiveness (Choi et al., 2018; Dubey et al., 2025). These results collectively reinforce the importance of adopting AI technologies as strategic tools for improving supply chain outcomes.

The study further reveals that both AI forecasting accuracy and AI inventory optimization significantly enhance decision-making efficiency. This finding is consistent with the work of Shamim et al. (2021) and Bag et al. (2024), who emphasize that AI-enabled analytics improve managerial decision-making by providing timely, accurate, and data-driven insights. The relatively stronger effect of AI inventory optimization on decision-making efficiency suggests that real-time operational insights related to inventory management may have a more immediate influence on managerial decisions compared to forecasting alone. This highlights the importance of integrating multiple AI capabilities to support both strategic and operational decision-making processes.

A key contribution of this study is the confirmation of the mediating role of decision-making efficiency. The results indicate that AI technologies improve supply chain performance not only through direct effects but also indirectly by enhancing the efficiency of managerial decisions. This supports the theoretical argument that technological capabilities must be effectively translated into actionable decisions to generate performance outcomes. In other words, AI tools create value when they improve how decisions are made, rather than merely providing data or automation. This finding extends existing literature by empirically validating the mechanism through which AI capabilities influence performance in supply chain contexts. Furthermore, the moderating role of environmental uncertainty provides important insights into the contextual factors that influence supply chain performance. The results show that environmental uncertainty significantly affects the relationship between decision-making efficiency and supply chain performance. In highly uncertain environments, the importance of efficient decision-making becomes more pronounced, as organizations must respond quickly to unpredictable changes. This finding is consistent with contingency theory, which suggests that the effectiveness of organizational capabilities depends on external environmental conditions (Queiroz et al., 2024). It also highlights the need for organizations to develop adaptive and flexible decision-making processes in volatile markets.

In addition, the Q^2 values indicate that the model has strong predictive relevance, particularly for supply chain performance, suggesting that the proposed framework is robust and capable of explaining and predicting outcomes effectively. This enhances the practical value of the study, as it demonstrates that AI capabilities and decision-making efficiency can be used to forecast supply chain performance in real-world settings.

Overall, this study contributes to the literature by providing an integrated understanding of how AI forecasting accuracy and inventory optimization jointly influence supply chain performance through decision-making efficiency, while also considering the role of environmental uncertainty. The findings emphasize that organizations should not only invest in AI technologies but also focus on improving decision-making processes and adapting to environmental conditions to fully realize the benefits of AI in supply chain management.

Conclusion

This study set out to examine the impact of AI forecasting accuracy and AI inventory optimization on supply chain performance, while considering the mediating role of decision-making efficiency and the moderating role of environmental uncertainty. The findings confirm that both AI forecasting accuracy and AI inventory optimization have significant positive effects on supply chain performance, highlighting the importance of AI-driven capabilities in improving operational outcomes. These results indicate that organizations that effectively leverage AI technologies can achieve better alignment between supply and demand, reduce inefficiencies, and enhance overall performance.

The study further demonstrates that decision-making efficiency plays a crucial mediating role in this relationship. This suggests that the benefits of AI technologies are not realized solely through automation or data availability, but through the improvement of managerial decision processes. When organizations use AI-generated insights effectively, they are able to make faster, more accurate, and more informed decisions, which ultimately lead to improved supply chain performance. This highlights the importance of integrating AI systems into decision-making frameworks rather than treating them as standalone tools.

In addition, the moderating effect of environmental uncertainty provides important insights into the contextual conditions under which these relationships operate. The findings indicate that environmental uncertainty influences the strength of the relationship between decision-making efficiency and supply chain performance, emphasizing the need for organizations to remain flexible and adaptive in dynamic environments. In uncertain conditions, efficient decision-making becomes even more critical for maintaining performance and competitiveness.

Overall, this study contributes to both theory and practice by providing an integrated framework that explains how AI capabilities influence supply chain performance through decision-making efficiency, while also considering the role of environmental uncertainty. The results suggest that organizations should adopt a holistic approach that combines advanced AI technologies with effective decision-making processes and adaptability to external conditions. By doing so, firms can enhance their supply chain performance and sustain competitive advantage in an increasingly complex and uncertain business environment.

Recommendations

Based on the findings of this study, several important recommendations can be made for organizations aiming to improve supply chain performance through AI technologies. First, firms should invest in advanced AI-based forecasting systems that enhance demand prediction accuracy. Accurate forecasting reduces uncertainty and enables better planning of production, procurement, and distribution activities. Organizations should ensure that these systems are continuously updated with real-time data and supported by strong data management practices to maximize their effectiveness.

Second, companies should adopt AI-driven inventory optimization systems to maintain optimal stock levels and improve operational efficiency. These systems should be integrated across the supply chain to provide real-time visibility and enable better coordination between suppliers, warehouses, and distribution centers. By doing so, firms can reduce excess inventory, minimize stockouts, and improve customer service levels.

Third, organizations must focus on improving decision-making efficiency by effectively integrating AI tools into managerial processes. Training programs should be provided to employees and managers to enhance their ability to interpret AI-generated insights and use them in decision-making. Firms should also encourage a data-driven culture where decisions are based on analytics rather than intuition.

Furthermore, organizations should develop strategies to manage environmental uncertainty. This includes building flexible and adaptive supply chain systems that can respond quickly to changes in demand and supply conditions. Scenario planning and risk management practices should be implemented to prepare for potential disruptions.

Additionally, firms are encouraged to adopt a hybrid approach that combines AI capabilities with human expertise. While AI systems provide valuable insights, human judgment remains essential for handling complex and strategic decisions. Continuous monitoring and evaluation of AI systems should also be conducted to ensure their accuracy and effectiveness over time.

Overall, organizations should take a comprehensive approach by combining AI technologies, efficient decision-making processes, and adaptive strategies to fully realize the benefits of AI in supply chain management and achieve superior performance.

Limitations of the Study

Despite its contributions, this study has several limitations that should be considered when interpreting the findings. First, the research adopts a cross-sectional design, with data collected at a single point in time. This limits the ability to establish causal relationships and capture dynamic changes in AI adoption, decision-making efficiency, and supply chain performance over time. Future studies may employ longitudinal designs to better understand how these relationships evolve.

Second, the study uses a convenience sampling technique, which may restrict the generalizability of the results. The sample may not fully represent the broader population of supply chain professionals, especially across different industries or regions. Future research should consider probability sampling methods and larger, more diverse samples to enhance external validity.

Third, the data is based on self-reported responses, which may introduce common method bias and social desirability bias. Respondents may overestimate or underestimate their use of AI systems or performance outcomes. Future studies could incorporate objective data sources, such as organizational records or system-generated data, to improve accuracy.

Another limitation is the geographical and contextual focus of the study. The findings may not be fully applicable to other countries or industries with different levels of technological adoption, infrastructure, or environmental uncertainty. Comparative studies across different contexts would provide more generalizable insights.

Furthermore, the study focuses on specific AI capabilities forecasting accuracy and inventory optimization—while other relevant technologies such as predictive maintenance, blockchain integration, or autonomous logistics systems are not considered. Including additional variables such as supply chain resilience, agility, or digital capability could provide a more comprehensive understanding.

Lastly, while environmental uncertainty is included as a moderator, other contextual factors such as organizational culture, technological readiness, or regulatory environments were not examined. Future research can explore these additional moderators to better understand the conditions under which AI technologies enhance supply chain performance.

Future Research Recommendations

Future research can extend this study in several meaningful directions to deepen understanding of AI-driven supply chain management. First, researchers should consider using longitudinal research designs to examine how the impact of AI forecasting accuracy and AI inventory optimization evolves over time. Since AI systems continuously learn and improve, a time-based analysis would provide better insight into causal relationships and long-term performance effects.

Second, future studies are encouraged to use probability sampling techniques and larger, more diverse samples across different industries and geographical regions. This would enhance the generalizability of findings and allow comparisons between developed and emerging markets, where the adoption and impact of AI technologies may differ significantly. In addition, future research can expand the current model by incorporating additional variables, such as supply chain agility, resilience, digital capability, perceived risk, or organizational culture. These factors may act as mediators or moderators and provide a more comprehensive understanding of how AI technologies influence supply chain performance. Researchers may also explore other AI applications, including predictive maintenance, autonomous logistics, blockchain integration, and AI-driven transportation systems, to examine their combined effects on supply chain efficiency.

Moreover, future studies can adopt mixed-method approaches, combining quantitative analysis with qualitative techniques such as interviews or case studies to gain deeper insights into managerial perspectives and organizational practices. Experimental designs can also be used to test cause-and-effect relationships in controlled environments.

Another important direction is to investigate industry-specific applications of AI, such as in manufacturing, retail, healthcare, or logistics, to determine whether the effects vary across sectors. Finally, future research should further explore the role of environmental uncertainty and other contextual factors, such as regulatory changes, technological readiness, and market turbulence, to better understand how external conditions influence the effectiveness of AI-driven decision-making.

By addressing these areas, future research can build on the current study and contribute to a more comprehensive and robust understanding of AI in supply chain management.

Managerial Implications

The findings provide clear direction for managers seeking to leverage AI in supply chains. First, organizations should treat AI forecasting accuracy and AI inventory optimization as strategic capabilities, not just IT tools. Investments should focus on improving data quality, integrating internal and external data sources (sales, POS, weather, promotions), and selecting models that can learn and adapt in real time. Second, managers should embed AI outputs into decision-making workflows. This means aligning S&OP/IBP processes with AI insights, setting decision rights, and using dashboards that translate forecasts and inventory signals into clear actions. Third, firms should prioritize decision-making efficiency by training managers to interpret AI outputs, run scenario analyses, and act quickly. Establishing KPIs such as forecast accuracy, decision cycle time, and service level will help track improvements.

Fourth, given the moderating role of environmental uncertainty, managers should build flexible and resilient supply chains. This includes maintaining safety buffers where necessary, using multi-sourcing strategies, and implementing dynamic policies that adjust to demand volatility. Fifth, organizations should adopt a hybrid decision model, combining AI recommendations with human expertise for strategic or high-risk decisions. Finally, continuous monitoring and governance of AI systems covering model accuracy, bias, and drift—are essential to sustain performance and trust in AI-driven decisions.

Practical Implications

From an implementation perspective, firms should deploy integrated AI platforms that connect forecasting, inventory management, and operational systems (ERP, WMS, TMS). Real-time visibility into demand and inventory positions should be enabled through dashboards and automated alerts. Companies should implement automated replenishment and dynamic inventory policies that adjust reorder points and safety stock based on predictive insights.

In practice, organizations should run pilot projects to test AI models in specific product categories or regions before scaling. Continuous A/B testing and performance tracking can help refine forecasting models and inventory rules. To enhance decision-making efficiency, firms should create standard operating procedures (SOPs) that clearly define how AI insights are used in planning and execution.

Additionally, businesses should invest in employee training and upskilling, ensuring that staff can effectively use AI tools and interpret analytics. Establishing feedback loops—such as post-forecast reviews and exception tracking will help improve model accuracy over time. To handle environmental uncertainty, firms should adopt scenario planning tools and maintain contingency plans for disruptions. Overall, by integrating AI technologies with efficient decision-making processes and adaptive strategies, organizations can achieve significant improvements in supply chain performance.

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