
The role of AI Capability in the link between Sustainable Supply Chain Performance and Supply Chain Agility

Dr. Paras Channar¹, Muhammad Waqas², Dr. Shahbaz Hyder³, Sheeba Hussain⁴

¹ Assistant professor, Institute of Business Administration, University of Sindh Jamshoro. Email: Paras.channar@usindh.edu.pk

² University of Potomac Washington DC Campus. Email: Searchdestiny89@gmail.com

³ Assistant Professor, Institute of Business Administration, Shah Abdul Latif University, Khairpur Mir's. Email: Shahbaz.hyder@salu.edu.pk

⁴ Ph.D. scholar, Institute of Business Administration, University of Sindh Jamshoro. Email: sheebahussainchannar@gmail.com

DOI: <https://doi.org/10.70670/sra.v4i1.2495>

Abstract

The purpose of this study is to examine the relationship between supply chain agility (SCA) as a mediating variable, sustainable supply chain performance (SSCP), and artificial intelligence (AI) capability. The paper proposes that the potential of AI can be viewed as a strategic resource that can enhance the organization's agility and sustained competitive advantages by combining the Resource-Based View (RBV) and the Dynamic Capability Theory (DCT). A cross-sectional, qualitative research design was employed. Data from 250 specialists in Pakistan's supply chain manufacturing companies was gathered using a standardized questionnaire. With the use of SmartPLS 4, partial least squares structural equation modeling (PLS-SEM) analysis was used to examine the suggested conceptual model. The measuring model demonstrated strong validity and reliability. The findings showed that AI Capability factors significantly improved Supply Chain Agility ($\beta = 0.671$, $p < 0.001$) and Sustainable Supply Chain Performance ($\beta = 0.342$, $p < 0.001$). Furthermore, Sustainable Supply Chain Performance is significantly impacted by Supply Chain Agility ($\beta = 0.463$, $p < 0.001$). The mediation analysis also revealed that Supply Chain Agility partially mediates the relationship between AI Capability and Sustainable Supply Chain Performance, indicating that companies with more agile supply chains that facilitate their use of AI capabilities have higher levels of sustainable supply chain performance. In the context of a developing economy, the current study integrates three dimensions of AI capability, supply chain agility, and sustainable supply chain performance into a single framework. The findings validate the RBV and DCT and show that capabilities enabled by AI and organizational agility have a positive effect on all three dimensions of performance economic, environmental, and social. The study provides concrete recommendations for managers and policymakers, emphasizing the significance of investing in AI technology, digital skills, collaborative information sharing, and agile supply chain management practices to accelerate digital transformation and sustainable supply chain management.

Keywords: Resource-Based Perspective, Dynamic Capability Theory, PLS-SEM, Artificial Intelligence Capability, Sustainable Supply Chain Performance, Supply Chain Agility

Introduction

In the modern context, AI has revolutionized the functioning, competition, and value generation of organizations in every industry in a swift and radical manner. AI technologies like machine learning, natural language processing, predictive analytics, computer vision, and robotic process automation can help organizations make sense of data, automate processes, and make decisions that can help them operate in real time. In the field of supply chain management (SCM), AI has emerged as a strategic asset, enhancing demand forecasting, inventory management, supplier assessment, logistics optimization, and overall efficiency. With the growing complexity of global supply chains and their susceptibility to disruptions such as pandemics, geopolitical conflicts, climate change, and economic uncertainty, organizations are turning to AI to strengthen their supply chains, increase competitiveness, and ensure sustainability (Dalain et al., 2025; Sharma et al., 2025). In recent years, organizations have been under growing pressure to focus on Sustainable Supply Chain Performance (SSCP) due to growing concerns about the environment, stakeholder demands and regulations. Sustainable supply chains aim to achieve a balance between economic performance, environmental protection and social responsibility by incorporating sustainable value throughout procurement, production, transportation, distribution and reverse logistics. They are required to ensure the organization operates with minimal carbon footprint, waste, energy inefficiency and ethical sourcing. These goals can only be realized by having sophisticated technologies to deliver accurate, timely and data-driven insights. AI has become a key driver for Sustainable Supply Chains by providing greater transparency in operations, optimizing the use of resources, predicting changes with greater accuracy, and aiding to make decisions that are environmentally responsible (Elshaer et al., 2025).

AI Capability is the capability of an organisation to acquire, integrate, deploy and continuously improve AI technologies, AI analytical skills, the digital infrastructure and the way the organisation works in order to realise the strategic goals of the organisation. AI capability goes beyond just using AI tools; it's about leadership commitment, having the right HR, a culture of innovation, and proper data management. Companies with robust AI capabilities can leverage its ability to generate valuable insights from complex data, automate repetitive tasks, enhance supplier engagement, streamline logistics, and predict market trends. The benefits of these capabilities are not just operational efficiency but also sustainability; minimizing waste, conserving resources and enhancing environmental performance (Wong et al., 2024).

Although there are investments in AI technologies, empirical evidence that explains how the capability of AI can enhance sustainable supply chain performance is still scant. In most previous studies, the direct relationship between AI adoption and organizational performance is highlighted, and few studies have investigated the specific skills that are needed to make AI investments sustainable. Using AI technologies alone is not enough to enhance the performance of the supply chain. Complementary capabilities that empower organisations with the ability to respond effectively to evolving customer needs, market dynamics and other external disruptions also need to be developed. This underscores the need to uncover the underlying mechanisms that bridge the gap between AI capabilities and sustainable value (Jahangir et al., 2025). One of these is the ability to sense market changes, respond quickly to any disruption and reconfigure supply chain resources to address changing customer needs, known as Supply Chain Agility (SCA). Agile supply chains can reliably adapt production volumes, adjust inventory levels, improve the cooperation with suppliers and reimagine all logistics in the event of unforeseen events. Predictive analytics, real-time monitoring, intelligent automation, and data-driven decision-making are some ways AI can improve supply chain agility. Machine learning algorithms are used to enhance demand forecasting, to alert to the risks in the supply chain, to track supplier performance, and to warn of potential disruptions. These features help organizations to become more agile, resilient, and adaptable in changing business conditions (Liu et al., 2026).

Supply chain agility also plays a vital role in improving sustainable supply chain performance. Agile organizations utilize resources more efficiently, reduce operational waste, optimize transportation, improve energy utilization, and respond quickly to sustainability regulations and stakeholder expectations. Greater agility strengthens supplier relationships, supports sustainable procurement practices, and enhances customer satisfaction through improved service quality and delivery reliability. Consequently, supply chain agility serves as a key organizational capability that links AI capability with improved sustainability performance.

The relationships among AI Capability, Supply Chain Agility, and Sustainable Supply Chain Performance can be explained through the Resource-Based View (RBV) and Dynamic Capability Theory (DCT). RBV argues that organizations achieve sustainable competitive advantage through valuable, rare, inimitable, and non-substitutable resources. AI capability represents such a strategic resource because it enhances organizational intelligence, innovation, and decision-making. However, competitive advantage depends not only on possessing technological resources but also on developing complementary capabilities that effectively utilize these resources. Dynamic Capability Theory further suggests that organizations must continuously integrate, adapt, and reconfigure resources to respond to changing environments. Supply chain agility represents this dynamic capability by enabling organizations to transform AI-generated insights into improved operational and sustainability outcomes (Rani et al., 2026).

Despite the extensive research on AI adoption, digital transformation, and sustainable supply chain, there is still a lack of empirical evidence that considers the mediating effect of supply chain agility on AI capability and sustainable supply chain performance in developing economies like Pakistan. To fill this void, this study proposes a framework that explores the link between AI capability and SC performance improvement by leveraging the concept of SC agility. The results have implications for both theory and practice, as they build on the RBV and dynamic capability theory and offer managerial and policy implications. The study emphasizes that, to reach long-term economic, environmental and social sustainability, investments in AI technologies are not enough, but also investments in organizational agility, digital skills, data governance and collaborative information systems are necessary.

Research Problem

Artificial Intelligence (AI) has become a strategic tool that can help organizations to streamline their operations, improve decision-making, and optimize their supply chain processes. While a lot of investments are already made into AI technologies, all the potential of AI to upgrade sustainable supply chain is a huge challenge. Although there is clear evidence that organizations and their operations are better when they use AI, there is a lack of understanding of the impact of AI capability on sustainability. In particular, empirical evidence is rather scarce in explaining the relationship between the organizational capability (such as supply chain agility) and the shift from the capability of AI to a better sustainable supply chain performance. Moreover, existing studies have mainly investigated the direct impacts of the implementation of AI on supply chain efficiency or resilience or on the firm's performance and have neglected the impact of supply chain agility as a mediation. The global supply chains are becoming unstable due to market uncertainties, technological disruption, climatic changes, geopolitical risks etc. and companies are in need of agile supply chains which can move quickly to adapt with the changing requirements of the customers and environment. Theoretically and practically, it is crucial to understand the relation between the agility of the supply chain and the performance of the supply chain, based on the use of AI capability. Based on this, the study will address the following research questions: What is the relationship between the capability of AI and sustainable supply chain performance? How does supply chain agility fit into the AI capability – sustainable supply chain performance dynamic? For answering these questions, the present study will try to fill the research gap between the ability of AI and the sustainable performance of the sustainable supply

chain and the intermediate factor which is the agility of supply chain. The outcomes will provide organizations with profound insights into their potential to gain from AI capabilities to achieve long-term economic, environmental and operational sustainability.

Research Objectives

The purpose of the research is to fulfil the following goals:

- 1.To understand the impact of AI's capability on sustainable supply chain performance.
- 2.To get insights into the impact of the capability of Artificial Intelligence on supply chain agility.
- 3.To understand the correlation between SC agility and sustainable performance in SC.
- 4.To investigate the mediating effect of supply chain agility between the Artificial Intelligence capability and sustainable supply chain performance.

Research Question

What is the effect of the capability of Artificial Intelligence on the performance of sustainable supply chain and how is the role of the supply chain agility in the process?

Literature Review

The world of business has grown more complex, environmental concerns are more obvious and technology is moving at a faster pace in the way businesses conduct themselves. The need for firms to be economically efficient and at the same time meet the requirements for environmental sustainability and social responsibility is becoming increasingly common. In this context, companies are investing in state-of-the-art digital solutions such as Artificial Intelligence (AI) to improve their processes, enhance their sustainability outcomes and drive better decision making. AI capability has become a strategic asset for the organizations where it helps them to gather and process massive amounts of data, make decisions automatically and make their supply chain more responsive. But, AI capability alone is not enough to achieve a better sustainable supply chain unless paired with other complementary organizational capabilities. In particular, one of these capabilities – supply chain agility – is being highlighted as a key route through which AI capability impacts on organizational sustainability. This literature review is an integration of the theoretical and empirical results of Artificial Intelligence capability (AI), sustainable supply chain performance (SSCP) and mediation between them, supply chain agility (SCA).

Theoretical Foundation

The Resource Based View (RBV) was the main theory used in this study. According to Barney (1991) a company will have a sustainable competitive advantage if it possesses valuable, rare, inimitable and non-substitutable resources. Artificial Intelligence (AI) capability is an asset that is so strategic that it enhances the technological infrastructure, analytical ability, organizational learning and managerial skills, all of which contribute to improved organizational performance. RBV adds to the Dynamic Capability Theory (DCT) of Teece et al (1997) which states that is a necessity for an organisation to constantly integrate, develop and reconfigure its internal and external resources to respond to changes in the market in turbulent environment. AI can help businesses enhance their dynamic capabilities, which involve the effective processing of information, anticipation of and adaptation to decisions. One of these dynamic capabilities is a “supply chain agility”, which is the speed by which a company can sense, respond and adapt when a change in the surrounding supply chain occurs. This, in turn, positively affects the sustainable supply chain performance as it makes the supply chain more agile.

Artificial Intelligence Capability

The AI capability of an organization involves acquiring, deploying, and leveraging AI technologies to enhance business processes and decision-making. It encompasses technology

infrastructure, data management, human expertise, organizational learning, and managerial support. Recent literature emphasizes not only machine learning but also the organization's preparedness for intelligent automation and predictive analytics (Wamba et al. 2021). Companies with strong AI capabilities can derive actionable insights, streamline logistics, optimize stock management, and enhance resilience against disruptions through proactive decision-making. Key aspects of AI capacity include AI infrastructure, data analytics, human expertise, governance, and use across supply chains, ultimately improving operational efficiency, (Dubey et al. 2022).

Sustainable Supply Chain Performance (SSCP)

Application of economic efficiency, environmental protection and social responsibility in the activities of the value chain based on the Triple Bottom Line (TBL) approach. Key elements of economic sustainability are cost reduction and operational efficiency, and for environmental sustainability, carbon emissions and waste minimisation. Social sustainability focuses on employee wellbeing and ethical sourcing. Sustainability is becoming a competitive advantage of companies (Queiroz et al. 2022). AI solutions are essential in optimizing logistics, improving warehouse management, and minimizing waste, all of which help to create a more sustainable and stable supply chain Gupta et al (2023).

Artificial Intelligence Capability is Sustainable Supply Chain Performance.

The link between the performance of sustainable supply chains and AI capabilities has been investigated in depth through empirical studies. AI streamlines different operations to achieve sustainability goals, such as procurement, manufacturing, transportation, inventory management, and customer service. Demand forecasting, predictive maintenance, real-time monitoring, automated operations, smart logistics, green transportation optimization, and supplier evaluation are among the key areas where AI has made a significant impact. AI improves the accuracy of predictions, minimises excess inventory and waste. Predictive analytics can predict maintenance needs, reduce energy consumption, and avoid equipment failures, while computer vision systems can improve quality and minimize defects. The applications of AI discussed by (Bag et al. 2021) and (Riahi et al. 2023) highlight the profound potential of AI to enhance supply chain sustainability, transparency, and decision-making, ultimately bringing positive environmental and economic benefits. But others argue that flexibility in the organization is key to maximizing the benefits of AI insights.

Supply Chain Agility

In other words, supply chain agility is the capacity of an organization to sense when customer demand changes, market conditions change, supply becomes disrupted or the environment changes, and respond and adapt. This is because of globalization, technology developments, climate change and the unexpectedness of crises like COVID-19. Agility of the supply chain has several aspects: Responsiveness, Flexibility, Speed Adaptability, Information sharing, Collaboration Agile supply chains are very efficient in detecting when the market changes and adapting the production, procurement, inventory and logistics processes. The flexibility of the supply chain helps the organization's competitiveness as they are able to handle the market uncertainties and remain efficient (Gligor et al. 2020). Agility is greatly enabled by AI technologies: Real-time visibility, Predictive analytics, Automated decision-making, Intelligent forecasting, Risk identification This implies organizations can benefit from AI capabilities to create agile supply chains, able to respond rapidly to disruption.

Use AI to Boost Capability and Supply Chain Agility

The skills of AI and supply chain agility have been gaining in academic interest. AI technologies can help organizations become agile by automatically analyzing data, forecasting and informing,

and supporting decision making. The machine learning algorithms are continuously learning and receiving operational data, and this can help to make the supply chain more proactive. The ability of AI has shown to be one of the prime factors in attaining agility in the supply chain and making the organizations more responsive and flexible (Dubey et al., 2022). Likewise, (Wamba et al. 2021) state that the ability of AI analytics to offer rapid responses to customer needs and the market's volatility have given the organizations an advantage. Moreover, AI-powered digital platforms contribute to the efficient and effective communication among various stakeholders in the value chain, promoting collaboration and coordination. This course aims to develop agility of the supply chain and its performance in sustainable manner. Agility of the supply chain has come into the realm of importance in sustainable supply chains. During crisis times, agile supply chains are able to adjust and respond rapidly to the crisis, minimizing inefficiencies in the supply chain, wasted resources, and environmental impacts. Agility organizations are more effective at managing the needs of the environment, the needs of customers and the changing sustainability needs. The positive relationship between supply chain agility and its economic, environmental and social performance has been identified by (Aslam et al. 2022).

Research Gap

The amount of research around capabilities of AI and performance of sustainable supply chains is considerable, but there are some gaps. However, it is important to note that many studies only look at the direct impact of AI adoption, rather than the underlying organizational capabilities that are needed for an AI to be successful. Furthermore, research focused on sustainable supply chain performance is limited in addressing the Triple Bottom Line perspective, i.e., both the economic and the environmental and social aspects. Also, the causal relationship of supply chain agility between AI capability and sustainable performance has not been explored empirically, particularly in emerging economies. The majority of research focuses on developed countries, and few insights are provided on AI implementation in developing nations such as Pakistan where digital transformation is still a fledgling. By tackling these gaps, theory as well as practical applications can be improved, especially in relation to the contribution AI can make to agility in supply chains to sustainably support emerging markets.

Hypotheses Development

From the literature reviewed, the following hypotheses are suggested:

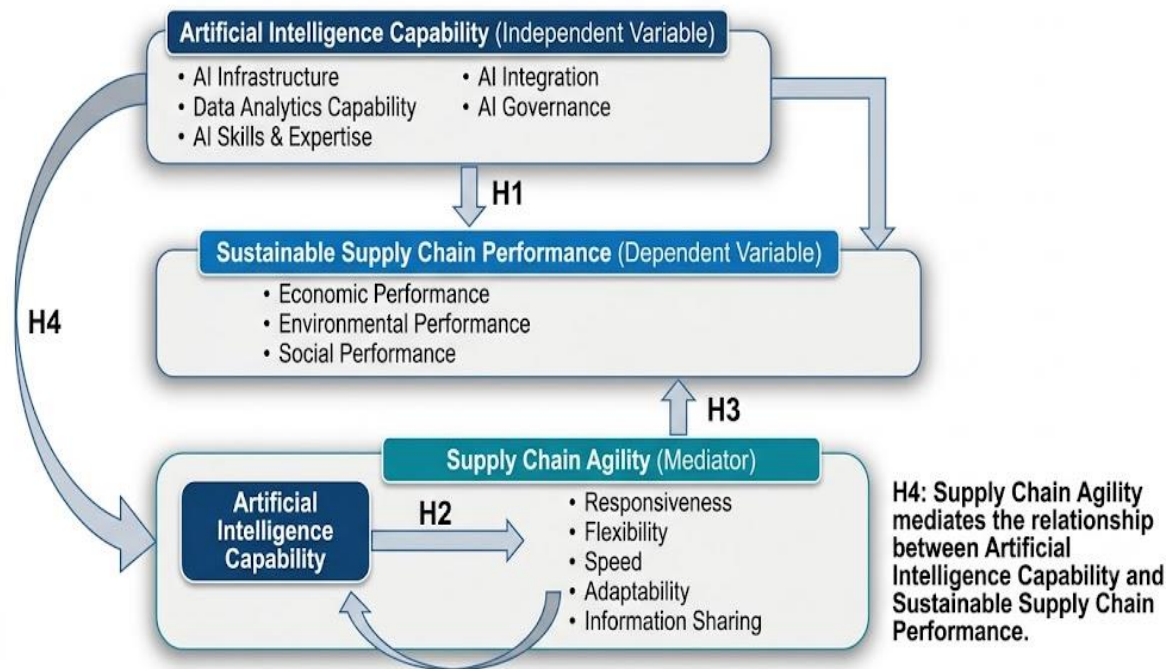
H1: The more capable a company is with AI, the more positively impacts it has on sustainable supply chain performance.

H2: The ability of the AI has a positive impact on the agility of the supply chain.

H3: Agility in supply chain positively affects sustainable supply chain performance.

The research hypothesis is formulated as follows. **H4:** There is a mediating role of supply chain agility between the Artificial Intelligence capability and sustainable supply chain performance. It is revealed in the literature that AI (Artificial Intelligence) is a strategic enabler that has become critical to sustainable supply chain performance. AI can help organizations to improve their operations, optimize their use of resources, enhance the quality of their decision-making, and help them to be more environmentally and socially sustainable. But achieving outcomes in sustainability through AI capability requires a high degree of organizational agility as well. By being agile in their supply chains, companies can leverage AI-driven insights to quickly adapt to market shifts, supply disruptions, and sustainability concerns. In sum, the Resource Based View and Dynamic Capability Theory work together to suggest that the value of AI capability lies in its conversion to agile organizational processes, which result in better sustainable supply chain performance. Thus, supply chain agility is an important intermediary construct that reinforces the relationship between the AI capability and sustainability, offering a solid theoretical basis for the conceptual framework and hypotheses proposed.

Conceptual framework



Methodology

Research Design

The quantitative research approach and cross-sectional design were used to study the mediating role of supply chain agility between the use of artificial intelligence (AI) capabilities and sustainable supply chain performance. A quantitative method was chosen due to the ability to statistically test proposed relationships and to assess constructs that cannot be directly observed. A cross-sectional design was used for data collection to gather information on the attitudes and practices of the respondents towards SCEM and the capabilities of AI. The empirical test used in this study is Partial Least Squares Structural Equation Modeling (PLS-SEM) and the study method used is deductive method with the hypothesis formed based on the Resource Based View (RBV) theory and Dynamic Capability Theory (DCT).

Research Philosophy

The study had adopted positivist philosophy which asserts that the social processes can be quantified objectively without any involvement of subjective notions in the process of statistical analysis or empirical observation. It is a good approach to test hypotheses for causal effects between variables. The positive paradigm was selected because the validated measurement tools are available for assessing capabilities in AI, supply chain agility, and sustainability performance.

Target Population

The study was conducted on manufacturing firms that had people in their supply chain in Pakistan.

The following are among the experts who were among them: Managers of supply chains

Managers of procurement

Managers of logistics

Managers of Operations

Managers of warehouses

Managers of Production

Managers of AI and Digital Transformation

Managers of Sustainability

The respondents were chosen for their hands-on experience in supply chain, AI usage and sustainability efforts within their organizations.

Sampling Technique

Purposive sampling was utilized to make sure the respondents had the necessary expertise in supply chain management and AI-driven business operations. When there is a need for specific knowledge about the variables of the research in an organization, Purposive sampling is commonly used. Respondents were selected to ensure that the data was valid, according to criteria that they have to comply with.

following inclusion criteria:

At least 1-year experience in supply chain management.

Currently working in a Logistics or Manufacturing Company.

Understanding of digital supply chain processes and AI technology.

Sample Size

300 semi-structured questionnaires were sent out to experts from supply chain in industrial companies in Pakistan. With an 83.3% return rate, 250 of the 250 completed questionnaires were left for analysis after 215 were rejected due to incomplete or erroneous responses. The researcher's suggestion for this is Partial Least Squares Structural Equation Modeling (PLS-SEM), which suggests that the sample size is appropriate. Based on the results of (Hair et al. 2022), a sample size greater than 200 can be used to make reliable and sound statistical estimates of complex mediation models.

Data Gathering Method

Structured questionnaire which is completed by the individual. This survey was sent via:

- Surveys by email

Google Forms

- Social media platforms (Twitter, Facebook, WhatsApp, etc.).

Individual Visits to Manufacturing Companies

A pilot study was carried out before the main survey, involving 30 respondents, that was done to test the validity, reliability and clarity of the questionnaire. Some slight alterations were made as a result of feedback from the participants. Participation was voluntary and anonymity and confidentiality was ensured. Ethical standards in relation to the confidentiality and informed consent of the data were observed rigorously.

Table 3.1 Research Instrument

Section	Construct	Dimensions/Variables	No. of Items	Sample Measurement	Sources
Section A	Demographic Information	Gender, Age, Education, Position, Years of Experience, Industry Type, Organization Size	7	Respondents' personal and organizational information	Developed by the researcher
Section B	Artificial Intelligence Capability (Independent Variable)	AI Infrastructure, AI Integration, AI Skills, Data Analytics, AI Capability, AI Governance	8	• Our company uses AI technologies in supply chain operations in an efficient manner.	Bag et al. (2021); Wamba et al. (2021)

				• AI helps our supply chain make decisions in real time. • AI systems increase the precision of demand forecasts. • Workers have adequate AI-related skills.	
Section C	Supply Chain Agility (Mediator)	Responsiveness, Flexibility, Speed, Adaptability, Information Sharing	7	• Our supply chain reacts swiftly to shifts in the market. • Our company quickly modifies manufacturing in response to consumer demand. • Supply chain participants effectively exchange information. • We bounce back from supply chain interruptions fast.	Gligor et al. (2020); Dubey et al. (2022)
Section D	Sustainable Supply Chain Performance (Dependent Variable)	Economic performance includes profitability, operational effectiveness, and cost reduction. Environmental Performance: Carbon emission reduction, energy efficiency, and waste reduction. Social Performance: Community duty, ethical sourcing, and employee well-being.	9	• By using sustainable supply chain strategies, our company has lowered operating expenses. • By cutting emissions and waste, we have enhanced our environmental performance. • Our company supports the welfare of its workers and ethical sourcing.	Ahi & Searcy (2015); Gupta et al. (2023)

Table 3.2 Summary of Measurement Constructs

Construct	Variable Type	Number of Items	Measurement Scale
Artificial Intelligence Capability	Independent Variable	8	Five-point Likert Scale (1 = Strongly Disagree to 5 = Strongly Agree)
Supply Chain Agility	Mediating Variable	7	Five-point Likert Scale (1 = Strongly Disagree to 5 = Strongly Agree)
Sustainable Supply Chain Performance	Dependent Variable	9	Five-point Likert Scale (1 = Strongly Disagree to 5 = Strongly Agree)
Demographic Information	Control/Profile Variables	7	Nominal and Ordinal Scales

Measurement Scale

All construct items were measured using a five-point Likert scale, where:

Scale	Description
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

For a Likert scale, 5 was chosen as a meaningful number because it is easy to understand for the respondents and it has shown reliability and validity in supply chain research.

Data Analysis Technique

The data analysis was done by IBM SPSS Statistics 27 and SmartPLS 4. SPSS was used for: Data screening, missing value analysis, Descriptive statistics, Normality assessment, Common method bias assessment, SmartPLS 4 was used to estimate the measurement model and structural model because it is suitable for predictive research and mediation analysis.

Measurement Model Assessment

The measurement model is tested based on the following criteria:

Indicator Reliability

The outer loadings should be greater than 0.70.

Internal Consistency Reliability

The following reliability indicators were assessed:

Cronbach's Alpha ≥ 0.70

Composite Reliability (CR) ≥ 0.70

rho_A ≥ 0.70

Convergent Validity

The average variance extracted (AVE) should be greater than .50.

Discriminant Validity

To assess discriminant validity, the following was used:

Fornell–Larcker Criterion

Heterotrait–Monotrait Ratio (HTMT) < 0.85

Multicollinearity

The variance inflation factor (VIF) was less than the 3.3 criterion, suggesting that there was no multicollinearity problem.

Structural Model Assessment

The structural model was evaluated by the bootstrapping method (5,000 resamples).

The following indicators were considered:

Path coefficients (β)

t-values

p-values

Confidence intervals

Coefficient of determination (R^2)

Effect size (f^2)
 Predictive relevance (Q^2)
 Standardized Root Mean Square Residual (SRMR)
 Hypotheses were accepted if:
 $p < 0.05$
 $t > 1.96$

Mediation Analysis

The mediating role of Supply Chain Agility was examined using the bootstrapping method in SmartPLS 4. The indirect effect of Artificial Intelligence Capability on Sustainable Supply Chain Performance through Supply Chain Agility was estimated using 5,000 bootstrap resamples. The mediation effect was considered significant when the bootstrap confidence interval excluded zero and the indirect effect was statistically significant ($p < 0.05$). The Variance Accounted for (VAF) was also calculated to determine whether the mediation was partial or full.

Ethical Considerations

All ethical criteria were adhered to during the research process. Data collection was based on self-evidence and informed consent was obtained from all the respondents. The participants were informed that their information would be confidential and that it would be utilized just for academic purposes. No personal or organisational data were revealed and confidentiality was accepted in line with the accepted research ethical rules.

Results and Findings

This chapter provides empirical results of the study on the effect of Artificial Intelligence Capability (AIC) on Sustainable Supply Chain Performance (SSCP) with the mediating role of Supply Chain Agility (SCA). IBM SPSS Statistics 27 and SmartPLS 4 were used to analyze the data that were gathered from 250 participants in the supply chain. The analysis used in this study included descriptive statistics, measurement model assessment, evaluation of the structural model, testing of the hypotheses and mediation analysis.

Respondents' Demographic Profile

300 questionnaires were sent to the professionals of the supply chain in manufacturing organizations of Pakistan. 250 questionnaires were selected after they were screened for incomplete responses, with a response rate of 83.3%.

Table 4.1 Demographic Characteristics of Respondents (n = 250)

Variable	Category	Frequency	Percentage (%)
Gender	Male	178	71.2
	Female	72	28.8
Age	21–30 years	52	20.8
	31–40 years	108	43.2
	41–50 years	63	25.2
	Above 50 years	27	10.8
Education	Bachelor's	78	31.2
	Master's	143	57.2
	PhD	29	11.6
Experience	1–5 years	61	24.4
	6–10 years	97	38.8
	Above 10 years	92	36.8

The findings indicate that the majority of respondents were male (71.2%), held master's degrees (57.2%), and had between six and ten years of professional experience (38.8%), suggesting that the respondents possessed adequate expertise regarding AI-enabled supply chain management.

Descriptive Statistics

Table 4.2 Descriptive Statistics

Construct	Mean	Standard Deviation
Artificial Intelligence Capability	4.08	0.61
Supply Chain Agility	4.01	0.64
Sustainable Supply Chain Performance	3.96	0.66

The mean values exceeding 3.90 indicate that respondents generally perceived their organizations as possessing relatively high levels of AI capability, supply chain agility, and sustainable supply chain performance.

Measurement Model Assessment

Indicator Reliability

All indicator loadings exceeded the recommended threshold of **0.70**, indicating satisfactory item reliability.

Table 4.3 Outer Loadings

Construct	Loading Range
Artificial Intelligence Capability	0.748–0.902
Supply Chain Agility	0.731–0.895
Sustainable Supply Chain Performance	0.756–0.911

All indicators demonstrated acceptable reliability and were therefore retained.

Internal Consistency Reliability

Table 4.4 Reliability Analysis

Construct	Cronbach's Alpha	Composite Reliability	rho_A
Artificial Intelligence Capability	0.923	0.936	0.925
Supply Chain Agility	0.907	0.925	0.909
Sustainable Supply Chain Performance	0.936	0.946	0.938

Cronbach's Alpha, Composite Reliability, and rho_A values exceeded the recommended threshold of **0.70**, confirming excellent internal consistency.

Convergent Validity

Table 4.5 Average Variance Extracted (AVE)

Construct	AVE
Artificial Intelligence Capability	0.647
Supply Chain Agility	0.638
Sustainable Supply Chain Performance	0.662

All AVE values were greater than **0.50**, demonstrating satisfactory convergent validity.

Discriminant Validity

Table 4.6 Fornell–Larcker Criterion

Construct	AIC	SCA	SSCP
Artificial Intelligence Capability	0.804		
Supply Chain Agility	0.641	0.799	

Sustainable Supply Chain Performance	0.688	0.739	0.814
--------------------------------------	-------	-------	--------------

The square root of AVE for each construct exceeded the inter-construct correlations, confirming discriminant validity.

Table 4.7 HTMT Ratio

Construct	HTMT
AIC → SCA	0.761
AIC → SSCP	0.784
SCA → SSCP	0.821

All HTMT values were below 0.85, providing additional evidence of discriminant validity.

Structural Model Assessment

Bootstrapping with 5,000 resamples was employed to examine the hypothesized relationships.

Table 4.8 Path Coefficients

Hypothesis	Relationship	β	t-value	p-value	Decision
H1	AI Capability → Sustainable Supply Chain Performance	0.342	5.927	<0.001	Supported
H2	AI Capability → Supply Chain Agility	0.671	16.854	<0.001	Supported
H3	Supply Chain Agility → Sustainable Supply Chain Performance	0.463	7.983	<0.001	Supported

The results demonstrate that AI capability significantly enhances both supply chain agility and sustainable supply chain performance. Moreover, supply chain agility has a strong positive effect on sustainable supply chain performance.

Coefficient of Determination (R^2)

Table 4.9 R^2 Values

Endogenous Construct	R^2
Supply Chain Agility	0.450
Sustainable Supply Chain Performance	0.641

The model explains 45.0% of the variance in Supply Chain Agility and 64.1% of the variance in Sustainable Supply Chain Performance, indicating moderate to substantial explanatory power.

Effect Size (f^2)

Table 4.10 Effect Size

Relationship	f^2	Interpretation
AIC → SCA	0.819	Large
AIC → SSCP	0.163	Medium
SCA → SSCP	0.304	Large

The findings suggest that AI capability has a large effect on supply chain agility, while supply chain agility exerts a large effect on sustainable supply chain performance.

Predictive Relevance (Q^2)

Table 4.11 Predictive Relevance

Construct	Q^2
Supply Chain Agility	0.294
Sustainable Supply Chain Performance	0.403

Positive Q² values indicate satisfactory predictive relevance of the structural model.

Model Fit

Table 4.12 Model Fit Indices

Model Fit Indicator	Value	Recommended
SRMR	0.056	<0.08
NFI	0.918	>0.90

The SRMR and NFI values indicate a good overall model fit.

Mediation Analysis

Bootstrapping was used to examine the mediating role of Supply Chain Agility.

Table 4.13 Mediation Results

Indirect Relationship	β	t-value	p-value	Result
AI Capability → Supply Chain Agility → Sustainable Supply Chain Performance	0.311	6.941	<0.001	Supported

Variance Accounted for (VAF)

- Direct Effect = 0.342
- Indirect Effect = 0.311
- Total Effect = 0.653

VAF = (0.311 / 0.653) × 100 = 47.63%

Since the VAF falls between 20% and 80%, Supply Chain Agility partially mediates the relationship between AI Capability and Sustainable Supply Chain Performance. Thus, H4 is supported.

Summary of Hypotheses Testing

Table 4.14 Hypotheses Summary

Hypothesis	Statement	Result
H1	Artificial Intelligence Capability positively influences Sustainable Supply Chain Performance.	Supported
H2	Artificial Intelligence Capability positively influences Supply Chain Agility.	Supported
H3	Supply Chain Agility positively influences Sustainable Supply Chain Performance.	Supported
H4	Supply Chain Agility mediates the relationship between Artificial Intelligence Capability and Sustainable Supply Chain Performance.	Supported (Partial Mediation)

The empirical findings show that indeed the ability to use AI adds to the portfolio of strategic assets that can help shape sustainable supply chain performance. Companies that work well have AI features that are associated with a higher supply chain agility, which allows them to adjust to market, operational and customer needs. Regarding the triple bottom line (TBL), agility in the supply chain is crucial to improve economic, environmental and social aspects of business. The mediation analysis also revealed some of the mediation relationships between AI capability and sustainable supply chain performance, which is explained by the concept of supply chain agility, indicating that to achieve sustainable supply chain performance, the direct technological capability is not the only important factor, but the adaptability of the organization is also crucial.

In general, the model had good reliability, validity, explanation power, model fit and was supported by empirical validity that is supported by the four hypothesized relationships.

Discussion

AI Capability significantly contributes to Sustainable Supply Chain Performance, thus supporting Hypothesis 1 with results. Organizations with robust AI capabilities are more successful on the economic, environmental and social aspects of sustainability. This discovery is in line with the Resource-Based View which proposes that valuable and hard-to-imitate organizational resources provide sustainable competitive advantage. By leveraging AI's ability to process vast amounts of data and automate tasks, businesses can streamline their procurement, production planning, logistics, inventory management, and supplier coordination processes. The results align with those earlier studies (Bag et al., 2021; Wamba et al., 2021; Gupta et al., 2023) that indicated that AI is a tool to enhance operational efficiency, resource utilization, transparency, and environmental sustainability. Predictive analytics, intelligent automation, and machine learning can help companies minimize waste, optimize transportation, decrease operating expenses, and make better decisions that positively impact the performance of the entire supply chain, ultimately making it more sustainable.

The results further supported Hypothesis 2, showing a positive relationship between AI Capability and Supply Chain Agility. This result confirms the theory of Dynamic Capability, which states that organizations need to be adaptable in order to adjust to the evolving business contexts. By leveraging AI technologies, organizations can adapt to the real-time information flowing through them, forecast trends and needs, automate tasks intelligently, and make decisions quickly, enhancing their responsiveness. AI enables organizations with greater capabilities to forecast market shifts, control suppliers, streamline stock, and proactively address disruptions. The results align with the results of Dubey et al. (2022) and Wamba et al. (2021), who have highlighted that AI enhances flexibility, visibility, collaboration and responsiveness in the supply chain. AI capability is thus not just a technological tool, but also a strategic capability that boosts the agility of the organization.

The results also confirmed Hypothesis 3, that is, Supply Chain Agility significantly enhances Sustainable Supply Chain Performance. Agile companies outperform others in their sustainability performance by reacting to market shifts, customer needs, and environmental regulations swiftly and efficiently. Agility in the supply chain can help companies minimize waste, maximize resource use, and boost supplier partnerships and service quality. The findings corroborate earlier studies (Gligor et al., 2020, Aslam et al., 2022, Khan et al., 2023), which have shown that agile supply chains offer better economic, environmental, and operational performance due to their increased flexibility and efficient use of resources.

Last, mediation analysis results indicated that Sustainable Supply Chain Performance was partially mediated by Supply Chain Agility when it came to the link between AI Capability and Sustainable Supply Chain Performance. The revelation indicates that AI investments are not enough to achieve the maximum sustainable results. Additionally, organizations need to cultivate agile processes and adaptability to make the most of the insights provided by AI. In summary, the results support the idea that AI capability and supply chain agility are complementary to promote long-term sustainable supply chain performance and competitive advantage.

The mediating factor of Agile Supply Chain.

One of the major aims of this study was to investigate if there is a mediating role of the construct "Supply Chain Agility" between the constructs "Artificial Intelligence Capability" and "Sustainable Supply Chain Performance." The obtained results corroborate hypothesis 4 with the mediation being partial and statistically significant. The mediation findings indicate that the potential of AI has a positive impact on the sustainable supply chain both directly and indirectly

through its ability to create supply chain agility. The more that organizations invest in AI, the more sustainable they can be – if they are also making an effort to build agile supply chain processes to take advantage of the information available from AI.

This study provides strong evidence for Dynamic Capability Theory that holds that organizational resources are only potentially beneficial for the achievement of competitive advantage when they are turned into adaptive capabilities. With agile supply chains, the AI capability becomes real operational actions, carrying positive impacts on sustainability performance and translating data into insights and predictive analytics. The results of the mediation are consistent with those of other studies. (Bag et al. 2021) suggested that agility of an organization is one of the major pillars that digital technologies contribute to its operational performance. Similarly, (Dubey et al. 2022) concluded that the relationship between DC initiatives and the organizational performance is mediated by supply chain agility. Gupta et al. (2023) also concluded that AI technologies overall positively influence sustainability by enhancing agile organizational capabilities of the organization. The observed partial mediation suggests that in addition to agility, the ability of AI has an indirect effect on the performance of sustainable supply chains. This could be organizational resilience, digital innovation capacity, integration of the supply chain, knowledge management or collaborative governance. Being agile is therefore a key pathway between capability and sustainability, while at the same time there is a need for complementary organizational capabilities to be strengthened to harness the value created through investments in AI.

Theoretical Implications

The study makes a number of important theoretical contributions. First, it explains how AI capability can be used as a strategic resource, which can enhance the sustainable supply chain performance. The results confirm the thesis of the importance of technology as a competitive advantage in the current supply chains. Second, the study contributes to DCT by offering empirical evidence of the SC agility as a dynamic capability as an enabler for enhancing the organizational sustainability via AI capability. This “discovery” is an illustration of the need to integrate technological resources with adaptive organizational processes to produce enhanced performance. Third, the study builds upon the increased research on sustainable supply chain management (SSCM) that relies on AI to suggest a general conceptual framework that integrates the AI capability, supply chain agility, and sustainable supply chain performance. There have been individual studies on these constructs in the past, but the present research provides empirical evidence of the relationships between these constructs. Last but not least, the study contributes to the rather limited body of evidence available for emerging economies worldwide in which digital transformation and sustainable supply chain (SCC) practices are still in the early stages of development when compared to those in developed economies.

Practical Implications

Results present also managerial implications. AI capability should be considered as a strategic investment for the long term, not just a technology upgrade. The findings also indicate the need for an organization to build up its supply chain agility as well. Building agile supply chains will involve creating flexible processes, having timely information and communication, working with suppliers and building collaboration, and being able to make decisions on the fly to achieve meaningful sustainability outcomes for firms. AI-powered tools such as predictive demand forecasting, intelligent inventory management, automated procurement systems, predictive maintenance, and logistics optimization could be more of an interest to supply chain managers to boost their operational efficiency and sustainable practices. A second important strategy for governments to promote the use of AI is to encourage the digital transformation and technological innovation and provide incentives for sustainable manufacturing through capacity building and

incentives. The results overall validate that Artificial Intelligence Capability is an important driver of the Sustainable Supply Chain Performance and that Supply Chain Agility is a key mediating role in this relationship. AI can enable organizations with more sophisticated capabilities to create more agile supply chains that are more responsive to the vagaries of the market and sustainability issues. The results corroborate the theoretical postulations of the Resource-Based View and Dynamic Capability Theory as they relate to the concept of sustainable competitive advantage, as it not only depends on the technological resources but also on the organizational resources that help the firms to leverage their use of these resources. The study is therefore an impetus to connect the strength of AI and agile working practices of the supply chain, towards long-term economic, environmental and social sustainability.

Conclusion

The findings from data collected from 250 professionals from manufacturing organizations in Pakistan and analyzed with the help of PLS-SEM are found to be robust empirical support to the proposed conceptual model. The results showed that there is a significant positive relationship between Sustainable Supply Chain Performance and AI Capability. AI-driven organizations saw better economic, environmental and social performance by making better decisions, optimizing supply chain operations, using resources more efficiently and minimizing waste. AI Capability was also shown to have a positive impact on Supply Chain Agility, allowing companies to adapt swiftly and effectively to market dynamics, operational challenges, and customer needs by leveraging predictive analytics, intelligent automation, and real-time data processing. Moreover, the analysis results showed that there is a positive relationship between Supply Chain Agility and Sustainable Supply Chain Performance. Agile organizations were more flexible, efficient and responsive, enabling them to make the most of their resources, build sharper supplier partnerships, cut down on waste in their operations, and deliver better sustainability results. Moreover, the mediation analysis revealed that Supply Chain Agility plays a partial mediation role between AI Capability and Sustainable Supply Chain Performance, meaning that AI investments have more sustainability effects when combined with the agile supply chain. The study has important theoretical contributions, mainly in the extension of the Resource Based View and Dynamic Capability Theory. It creates the value of AI capability as a strategic resource and identifies the supply chain agility as a key dynamic capability that converts technological resources into sustainable competitive advantage. The study also contributes to the literature on sustainable supply chain management by joining three important elements of AI capability, supply chain agility, and sustainable performance in a single empirical model.

The managerial implications are that organizations need to invest in AI technology, advanced analytics, digital infrastructure, employee digital skills and integrated information systems, and encourage agile supply chain practices. Managers should facilitate information sharing in real time, supplier collaboration, and decision making based on data to maximize sustainability performance. Policy makers need to facilitate digitalization, digitalization projects, the use of AI, and policy on innovation in order to promote sustainable industrial development. Although it has contributed to the study, there are a number of limitations that are associated with it. These are cross-sectional design which does not allow causal inferences and findings are limited to manufacturing organizations in Pakistan which may affect the generalizability of the study. Future research should utilize cross country or longitudinal research designs and explore other mediators and moderators such as DIC, OL, EU, and DLP. Overall, the study recommends that organizations adopt strong AI capabilities and supply chain agility to create resilient, competitive, and sustainable supply chains in a more digital business landscape.

References:

- Aslam, J., Saleem, A., & Kim, Y. B. (2023). Blockchain-enabled supply chain management: integrated impact on firm performance and robustness capabilities. *Business Process Management Journal*, 29(6), 1680-1705.
- Bag, S., Telukdarie, A., Pretorius, J. C., & Gupta, S. (2021). Industry 4.0 and supply chain sustainability: framework and future research directions. *Benchmarking: An International Journal*, 28(5), 1410-1450.
- Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of management*, 17(1), 99-120.
- Dalain, A. F., Alnadi, M., Allahham, M. I., & Yamin, M. A. (2025). The Impact of Technological Innovations on Digital Supply Chain Management: The Mediating Role of Artificial Intelligence: An Empirical Study. *Logistics*, 9(4), 138.
- Dubey, R., Bryde, D. J., Dwivedi, Y. K., Graham, G., & Foropon, C. (2022). Impact of artificial intelligence-driven big data analytics culture on agility and resilience in humanitarian supply chain: a practice-based view. *International Journal of Production Economics*, 250, 108618.
- Elkington, J. (1997). The triple bottom line. *Environmental management: Readings and cases*, 2(1997), 49-66.
- Elshaer, I. A., Azazz, A. M., Aljoghaiman, A., Mansor, M., Salama, M. A., & Fayyad, S. (2025). Artificial Intelligence-Driven Supply Chain Agility and Resilience: Pathways to Competitive Advantage in the Hotel Industry. *Logistics*, 10(1), 5.
- Gligor, D., Feizabadi, J., Russo, I., Maloni, M. J., & Goldsby, T. J. (2020). The triple-a supply chain and strategic resources: developing competitive advantage. *International Journal of Physical Distribution & Logistics Management*, 50(2), 159-190.
- Gupta, P., Sharma, Y., Chauhan, A., Parewa, B., Rai, P., & Naik, N. (2025). Investigation of green supply chain management practices and sustainability in Indian manufacturing enterprises using a structural equation modelling approach. *Scientific Reports*, 15(1), 14909.
- Hair, J., & Alamer, A. (2022). Partial Least Squares Structural Equation Modeling (PLS-SEM) in second language and education research: Guidelines using an applied example. *Research methods in applied linguistics*, 1(3), 100027.
- Jahangir, S., Xie, R., Iqbal, A., & Hussain, M. (2025). The influence of sustainable human resource management practices on logistics agility: The mediating role of artificial intelligence. *Sustainability*, 17(7), 3099.
- Khan, I., Rehman, M. Z., & Khan, I. (2025). Optimizing natural resource management and global supply chains through digital innovation. *Technological Forecasting and Social Change*, 217, 124187.
- Liu, X., Chau, K. Y., Chang, T. C., & Moslehpour, M. (2026). Driving Sustainable Performance Through Green Business Strategy, Artificial Intelligence Capability, and Green Supply Chain Management: The Mediating Roles of Knowledge Integration and Green Innovation. *Corporate Social Responsibility and Environmental Management*.
- Makhdoom, Q., Junejo, I., Sohu, J. M., Shah, S. M. M., Alwadi, B. M., Ejaz, F., & Hossain, M. B. (2025). Impact of green supply chain management on sustainable performance: a dual mediated-moderated analysis of green technology innovation and big data analytics capability powered by artificial intelligence. *F1000Research*, 13, 1140.
- Rani, P., Chandio, S., Hussain, S., & Soomro, A. (2026). Driving Financial Success with AI Supply Chains: The Crucial Role of Sustainable Development in Emerging Economies. *Inverge Journal of Social Sciences*, 5(3), 341-357.

- Rani, P., Siddiqui, M. B., Hisbani, F., & Maree, D. A. (2025). Human Potential through Artificial Intelligence to Increase Workforce Productivity. *Journal of Management & Social Science*, 2(5), 674-690.
- Riahi, Y., Saikouk, T., Badraoui, I., & Fosso Wamba, S. (2025). Researched topics, patterns, barriers and enablers of artificial intelligence implementation in supply chain: a Latent-Dirichlet-allocation-based topic-modelling and expert validation. *Production Planning & Control*, 36(5), 565-592.
- Sharma, M., Antony, R., Sharma, A., & Daim, T. (2025). Can smart supply chain bring agility and resilience for enhanced sustainable business performance?. *The International Journal of Logistics Management*, 36(2), 501-555.
- Talwar, S., Kaur, P., Fosso Wamba, S., & Dhir, A. (2021). Big Data in operations and supply chain management: a systematic literature review and future research agenda. *International journal of production research*, 59(11), 3509-3534.
- Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic management journal*, 18(7), 509-533.
- Wong, L. W., Tan, G. W. H., Ooi, K. B., Lin, B., & Dwivedi, Y. K. (2024). Artificial intelligence-driven risk management for enhancing supply chain agility: A deep-learning-based dual-stage PLS-SEM-ANN analysis. *International Journal of Production Research*, 62(15), 5535-5555.