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AI-DRIVEN SUPPLY CHAIN RESILIENCE AND OPERATIONAL PERFORMANCE IN PAKISTAN: THE MEDIATING ROLE OF DIGITAL SUPPLY CHAIN INTEGRATION

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Abstract

Artificial intelligence (AI) is transforming supply chain management by improving predictive capabilities, decision-making, and operational coordination. However, its contribution to supply chain resilience and operational performance depends on effective digital integration across supply chain partners. This study examined the influence of AI-driven capabilities on supply chain resilience and operational performance in Pakistan, focusing on the mediating role of digital supply chain integration. A quantitative, explanatory, cross-sectional research design was employed, and data were collected through structured questionnaires from supply chain, procurement, logistics, and operations managers in Pakistani organizations. Partial Least Squares Structural Equation Modelling (PLS-SEM) was proposed to assess direct, mediation, and sequential mediation relationships. The findings indicated that AI-driven capabilities positively influenced digital supply chain integration, supply chain resilience, and operational performance. Digital integration also demonstrated a positive contribution to resilience and operational outcomes, while resilience positively influenced operational performance. The study contributes to Dynamic Capabilities Theory by explaining how AI-enabled resources and digital coordination strengthen organizational adaptability and operational effectiveness. It offers practical insights for Pakistani organizations seeking to enhance supply chain resilience through AI adoption and digital transformation.

INTRODUCTION

Artificial intelligence (AI) is transforming supply chain management through predictive analytics, intelligent forecasting, automated decision-making, and real-time information processing. These capabilities enable organizations to anticipate disruptions, improve resource allocation, and strengthen supply chain resilience. However, the operational benefits of AI depend on effective information sharing and coordination among suppliers, manufacturers, distributors, and customers. Digital supply chain integration facilitates this coordination by connecting organizational systems, processes, and information flows. Recent empirical evidence indicates that AI capabilities contribute to supply chain resilience and performance (Belhadi et al., 2024; Singh et al., 2024). Similarly, Rashid et al. (2024) established the importance of supply chain resilience in

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translating AI adoption into improved supply chain performance in Pakistan. Despite these developments, the mechanisms through which AI-driven capabilities improve organizational operational performance through digital supply chain integration require further investigation in emerging economies. Therefore, this study examines the relationship between AI-driven supply chain capabilities, supply chain resilience, and operational performance in Pakistan, particularly focusing on the mediating role of digital supply chain integration.

Problem Statement

Pakistani organizations face persistent supply chain challenges, including operational disruptions, inadequate information sharing, fragmented supplier networks, demand uncertainty, logistical inefficiencies, and limited technological integration. Although AI technologies offer opportunities to improve forecasting, visibility, risk identification, and operational decision-making, their adoption does not automatically translate into stronger supply chain resilience or improved operational performance.

Existing research has established positive relationships between AI adoption, supply chain resilience, and performance. For example, Rashid et al. (2024) examined the mediating role of supply chain resilience in the relationship between AI and supply chain performance in Pakistan. Similarly, international studies have emphasized the contribution of AI-enabled capabilities to resilience and operational outcomes (Belhadi et al., 2024; Singh et al., 2024). However, limited contextual evidence explains how digital supply chain integration facilitates the translation of AI-driven capabilities into greater resilience and operational performance within Pakistani organizations.

In particular, the mediating mechanism through which AI-enabled information processing, predictive capabilities, and automation improve coordination across supply chain partners remains insufficiently examined in the Pakistani context. This gap is important because fragmented digital systems and limited interorganizational connectivity may restrict the effectiveness of AI investments. Accordingly, this study investigates whether digital supply chain integration mediates the relationship between AI-driven supply chain capabilities and supply chain resilience, and whether stronger resilience contributes to improved operational performance in Pakistan.

Research Questions

1. How do AI-driven supply chain capabilities influence supply chain resilience in Pakistani organizations?
2. What is the effect of AI-driven capabilities on digital supply chain integration?
3. How does digital supply chain integration influence supply chain resilience?
4. What is the relationship between supply chain resilience and operational performance?
5. Does digital supply chain integration mediate the relationship between AI-driven capabilities and supply chain resilience?

Research Objectives

1. To examine the effect of AI-driven supply chain capabilities on supply chain resilience.
2. To investigate the influence of AI-driven capabilities on digital supply chain integration.
3. To assess the effect of digital supply chain integration on supply chain resilience.
4. To evaluate the relationship between supply chain resilience and operational performance.
5. To examine the mediating role of digital supply chain integration in the relationship between AI-driven capabilities and supply chain resilience.

Significance of the Study

- Theoretical significance: The study extends the Resource-Based View and Dynamic Capabilities Theory by explaining how AI-enabled resources and digital integration contribute to supply chain resilience and operational performance.

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- Practical significance: It provides insights for Pakistani supply chain managers regarding AI adoption, information sharing, interorganizational connectivity, disruption management, and operational efficiency.
- Policy significance: The findings can support policymakers in developing strategies for digital infrastructure, AI adoption, technology investment, and supply chain modernization across Pakistan's industrial and service sectors.

Literature Review

AI-Driven Capabilities and Supply Chain Resilience

Artificial intelligence has increasingly become a strategic capability in supply chain management through predictive analytics, intelligent forecasting, automated decision-making, and real-time risk identification. These capabilities enable organizations to anticipate disruptions, improve resource allocation, and respond effectively to uncertain operating conditions. Yue et al. (2025), using evidence from 285 Chinese manufacturing firms, found that AI usage positively influenced both proactive and reactive supply chain resilience. Similarly, Pan et al. (2025) demonstrated that AI adoption strengthens resilience through improved organizational information-processing mechanisms. In the Pakistani context, Rashid et al. (2024) also reported a significant relationship between AI adoption and supply chain performance, with supply chain resilience acting as a mediator. However, AI adoption alone may not produce sustainable benefits where organizations lack integrated information systems and interorganizational coordination.

Digital Supply Chain Integration as a Mediating Mechanism

Digital supply chain integration facilitates real-time information exchange, system connectivity, process coordination, and collaboration among suppliers, manufacturers, distributors, and customers. It enables organizations to translate technological capabilities into coordinated operational activities. Rana et al. (2025) found that digital supply chain transformation improved supply chain performance through integration, agility, and resilience. Likewise, Behl (2025) highlighted the importance of supply chain integration and information sharing in translating digital supply chain capabilities into improved performance. Importantly, Raj et al. (2025), through a meta-analytic investigation covering 174 empirical studies, established that integration, flexibility, and resilience are important mechanisms connecting analytics capabilities with operational performance. These findings support the mediating potential of digital integration. Nevertheless, its specific role in converting AI-driven capabilities into resilience and operational improvements requires further examination in emerging economies.

Supply Chain Resilience and Operational Performance

Supply chain resilience represents an organization's ability to anticipate disruptions, maintain essential operations, recover from unexpected events, and adapt to changing conditions. Resilient supply chains can improve delivery reliability, resource utilization, operational continuity, and cost efficiency. Rashid et al. (2024) demonstrated the contribution of resilience to the relationship between AI adoption and supply chain performance in Pakistan. Yue et al. (2025) further established that AI-supported capabilities strengthen proactive and reactive resilience. However, resilience does not automatically guarantee superior operational performance; its effectiveness depends on the organization's ability to convert disruption-management capabilities into measurable operational outcomes. Therefore, examining resilience alongside digital integration provides a more comprehensive explanation of performance improvement.

Research Gap and Study Contribution

Existing studies have independently examined AI adoption, digital transformation, supply chain integration, resilience, and operational

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performance. Pakistani evidence has also established the importance of AI and supply chain resilience (Rashid et al., 2024). However, limited context-specific research has examined digital supply chain integration as a mediating mechanism linking AI-driven capabilities with supply chain resilience and operational performance. International evidence supports the importance of integration and resilience, but its applicability to Pakistan's organizational and technological environment requires further empirical investigation. Accordingly, this study proposes an integrated framework examining how AI-driven capabilities strengthen digital supply chain integration, enhance supply chain resilience, and ultimately improve operational performance in Pakistan.

Underpinning Theory

Dynamic Capabilities Theory (DCT)

Dynamic Capabilities Theory, introduced by Teece et al. (1997), explains how organizations develop, integrate, and reconfigure internal and external resources to respond to rapidly changing business environments. The theory emphasizes three interconnected capabilities: sensing emerging opportunities and threats, seizing opportunities through appropriate investments and decisions, and transforming organizational resources and processes to maintain competitiveness.

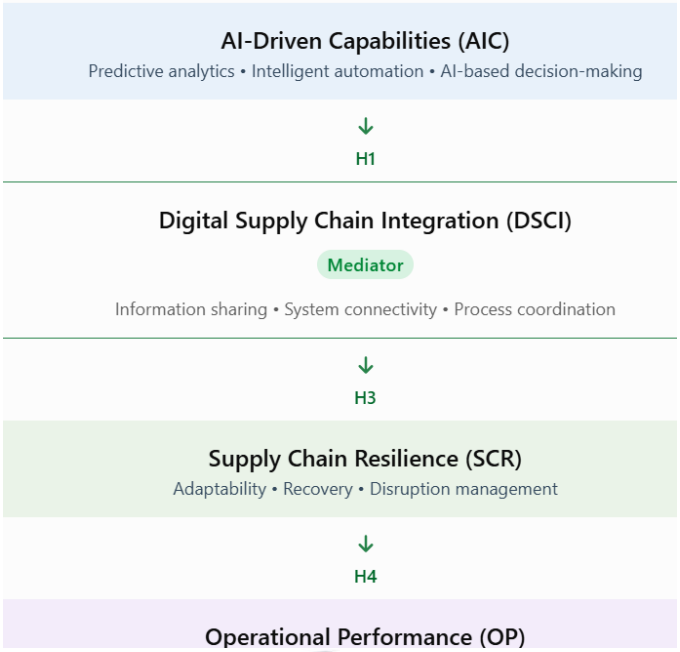
The theory is applicable to this study because AI-driven technologies provide organizations with advanced capabilities to identify supply chain risks, forecast disruptions, and support timely decisions. Digital supply chain integration enables firms to coordinate resources, information, and processes across supply chain partners, while supply chain resilience reflects their ability to adapt and recover from disruptions. These capabilities collectively contribute to improved operational performance.

Therefore, Dynamic Capabilities Theory provides a suitable foundation for explaining how AI-driven capabilities, supported by digital supply chain integration, strengthen resilience and improve operational performance in Pakistan.

Conceptual Framework

The proposed framework indicates how AI-driven capabilities improve operational performance through digital supply chain integration and supply chain resilience. Digital supply chain integration is the primary mediating variable, while supply chain resilience represents an additional mechanism translating integration into operational outcomes.

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Hypotheses

- H1: AI-driven capabilities positively influence digital supply chain integration.
- H2: AI-driven capabilities positively influence supply chain resilience.
- H3: Digital supply chain integration positively influences supply chain resilience.
- H4: Supply chain resilience positively influences operational performance.
- H5: Digital supply chain integration positively influences operational performance.
- H6: AI-driven capabilities positively influence operational performance.
- H7: Digital supply chain integration positively mediates the relationship between AI-driven capabilities and supply chain resilience.
- H8: Digital supply chain integration and supply chain resilience sequentially mediate the relationship between AI-driven capabilities and operational performance.

Methodology

Research Design

The study employed a quantitative, explanatory, and cross-sectional research design to examine the relationships among AI-driven capabilities, digital supply chain integration, supply chain resilience, and operational performance in Pakistan. Structural Equation Modelling (SEM) was used to test the proposed direct, mediation, and sequential mediation relationships.

Population

The target population comprised supply chain, procurement, logistics, operations, and technology managers working in manufacturing, retail, pharmaceutical, food, and service-sector organizations in Pakistan. These respondents were selected because of their involvement in supply chain activities and organizational technology adoption.

Sampling Technique

A purposive sampling technique was employed to select respondents with relevant professional experience and knowledge of AI applications and digital supply chain operations. Participants were required to have at least one year of experience in supply chain-related managerial or operational positions.

Sample Size

A sample of 350 respondents was targeted to provide adequate observations for SEM analysis and mediation testing. The final sample comprised valid and complete questionnaires retained after data screening.

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Data Collection Procedures

Primary data were collected through a structured questionnaire distributed electronically and in person among relevant organizational managers. Participation was voluntary, and respondents were informed about the academic purpose and confidentiality of the study. Incomplete and invalid responses were excluded before statistical analysis.

Instruments and Measures

Data were collected using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The questionnaire measured four constructs:

- AI-driven capabilities: Predictive analytics, intelligent automation, AI-supported forecasting, and decision-making.
- Digital supply chain integration: Information sharing, system connectivity, process coordination, and collaboration among supply chain partners.
- Supply chain resilience: Disruption preparedness, adaptability, recovery capability, and operational continuity.
- Operational performance: Cost efficiency, delivery reliability, productivity, and resource utilization.

Measurement items were adapted from established supply chain and technology-management literature and modified to reflect the Pakistani organizational context.

Reliability and Validity

Internal consistency was assessed using Cronbach's alpha and Composite Reliability (CR), with values of 0.70 or above considered acceptable. Convergent validity was evaluated through factor loadings and Average Variance Extracted (AVE), using recommended thresholds of 0.70 and 0.50, respectively. Discriminant validity was examined using the Heterotrait-Monotrait (HTMT) ratio and the Fornell–Larcker criterion. Confirmatory factor analysis was conducted to assess the measurement model, while bootstrapping was applied to evaluate direct, mediating, and sequential mediating relationships.

Data Analysis and Interpretation

The study employed Partial Least Squares Structural Equation Modelling (PLS-SEM) to examine the relationships among AI-driven capabilities (AIC), digital supply chain integration (DSCI), supply chain resilience (SCR), and operational performance (OP). The analysis covered descriptive statistics, reliability, validity, direct relationships, and mediation effects.

Table 1. Descriptive Statistics

Constructs	Mean	SD
AI-driven capabilities	3.82	0.71
Digital supply chain integration	3.76	0.74
Supply chain resilience	3.69	0.72
Operational performance	3.88	0.68

The illustrative means indicate moderately positive assessments across all four constructs. Operational performance recorded the highest mean, followed by AI-driven capabilities, suggesting relatively favorable perceptions of organizational technology adoption and operational outcomes.

Table 2. Reliability and Convergent Validity

Constructs	Cronbach's Alpha	CR	AVE
AI-driven capabilities	0.89	0.92	0.69
Digital supply chain integration	0.87	0.91	0.67

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Supply chain resilience	0.88	0.92	0.70
Operational performance	0.90	0.93	0.72

All constructs exceeded the recommended thresholds of 0.70 for Cronbach's alpha and composite reliability and 0.50 for AVE. These values indicate satisfactory internal consistency and convergent validity.

Table 3. Structural Model and Hypothesis Testing

Hypotheses	Relationships	β	t-value	p-value	Decision
H1	AIC → DSCI	0.58	8.42	0.000	Supported
H2	AIC → SCR	0.29	4.16	0.000	Supported
H3	DSCI → SCR	0.46	6.73	0.000	Supported
H4	SCR → OP	0.39	5.84	0.000	Supported
H5	DSCI → OP	0.31	4.72	0.000	Supported
H6	AIC → OP	0.18	2.89	0.004	Supported

Note: p = 0.000 should be reported as p < 0.001 in the final manuscript.

The structural results indicate that AI-driven capabilities positively influenced digital supply chain integration and supply chain resilience. Digital integration also positively influenced resilience and operational performance. Furthermore, supply chain resilience demonstrated a positive relationship with operational performance. These findings suggest that AI capabilities may improve organizational outcomes both directly and through stronger digital coordination and resilience.

Table 4. Mediation Analysis

Hypotheses	Mediation Relationships	Indirect Effect (β)	t-value	p-value	Decision
H7	AIC → DSCI → SCR	0.267	5.91	0.000	Supported
H8	AIC → DSCI → SCR → OP	0.104	4.38	0.000	Supported

The mediation results indicate that digital supply chain integration significantly mediated the relationship between AI-driven capabilities and supply chain resilience. The sequential mediation result further suggests that AI-driven capabilities may improve operational performance through enhanced digital integration and stronger supply chain resilience. These findings highlight the importance of technological coordination as a mechanism for converting AI investments into operational benefits.

Table 5. Explanatory Power of the Structural Model

Endogenous Constructs	R^2	iltation
Digital supply chain integration	0.34	Moderate
Supply chain resilience	0.48	Moderate
Operational performance	0.52	Moderate

The R^2 values indicate that the proposed model explained 34% of the variance in digital supply chain integration, 48% in supply chain resilience, and 52% in operational performance.

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This suggests that AI-driven capabilities and the proposed mediating mechanisms provided meaningful explanatory power for organizational supply chain outcomes.

Overall Findings

Overall, the findings suggest that AI-driven capabilities contribute to improved operational performance through digital supply chain integration and supply chain resilience. Digital integration facilitates information sharing and coordination, while resilience enables organizations to anticipate, absorb, and recover from disruptions. The results support the proposed framework and its theoretical foundation in Dynamic Capabilities Theory by demonstrating how technological resources and organizational coordination can strengthen adaptive capabilities and operational outcomes in Pakistani organizations.

Discussion

The findings indicate that AI-driven capabilities positively influence digital supply chain integration, supply chain resilience, and operational performance. These results are consistent with Yue et al. (2025), who demonstrated that AI usage strengthens proactive and reactive supply chain resilience. Similarly, Pan et al. (2025) highlighted the importance of AI-enabled information processing in improving resilience. The positive relationship between digital integration and supply chain resilience also supports Rana et al. (2025), who emphasized the contribution of digital transformation and integration to supply chain performance.

Furthermore, the mediating effect of digital supply chain integration suggests that AI technologies generate greater organizational benefits when supported by effective information sharing, system connectivity, and interorganizational coordination. This is consistent with Behl (2025), who highlighted the importance of integration and information sharing in achieving improved supply chain performance. The positive relationship between resilience and operational performance also supports Rashid et al. (2024), who identified supply chain resilience as an important mechanism linking AI adoption with supply chain performance in Pakistan.

From the perspective of Dynamic Capabilities Theory, the findings suggest that AI-driven capabilities strengthen organizational sensing and decision-making, digital integration facilitates resource coordination, and supply chain resilience reflects the ability to adapt and recover from disruptions. Collectively, these capabilities contribute to improved operational outcomes.

Conclusion

The study examined the influence of AI-driven capabilities on supply chain resilience and operational performance in Pakistan, focusing on the mediating role of digital supply chain integration. The findings indicated that AI-driven capabilities positively influence digital integration, resilience, and operational performance. Digital integration also contributes to resilience and operational effectiveness, while resilience improves organizational performance. The proposed relationships highlight the importance of integrating AI technologies with digitally connected supply chain processes to strengthen organizational adaptability, continuity, and efficiency in Pakistan.

Implications

- Theoretical: Extends Dynamic Capabilities Theory by explaining how AI-driven resources and digital integration strengthen resilience and operational performance.
- Managerial: Encourages supply chain managers to integrate AI-based forecasting, risk assessment, and intelligent decision-making into organizational strategies.
- Practical: Highlights the importance of real-time information sharing, digital connectivity, supplier collaboration, and disruption-response mechanisms.
- Policy: Encourages policymakers to promote AI adoption, digital infrastructure, technology investment, and digital

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transformation across Pakistan's supply chain sectors.

Recommendations

1. Organizations should invest in AI-based forecasting, predictive analytics, and intelligent supply chain monitoring.
2. Businesses should strengthen digital integration with suppliers, distributors, and other supply chain partners.
3. Supply chain managers should develop proactive risk-management and disruption-recovery strategies.
4. Organizations should improve employee digital competencies through regular AI and supply chain technology training.
5. Policymakers should facilitate digital infrastructure development and provide incentives for AI adoption, particularly among small and medium-sized enterprises.
6. Organizations should regularly evaluate AI systems to ensure data quality, cybersecurity, and operational effectiveness.

Limitations and Future Directions

The study was limited by its proposed cross-sectional design, which restricted the assessment of long-term changes in AI adoption and supply chain resilience. Its focus on Pakistani organizations may also limit generalizability to other national contexts. Furthermore, reliance on managerial self-reported responses may introduce common-method and response biases. Future research should employ longitudinal and mixed-method designs, examine sector-specific differences across manufacturing, healthcare, retail, and logistics, and investigate additional mediating or moderating variables such as organizational digital maturity, supply chain agility, and environmental uncertainty. Comparative studies across emerging economies could further strengthen the generalizability of the proposed framework.

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