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aTHE IMPACT OF SUPPLY CHAIN DIGITALIZATION ON OPERATIONAL PERFORMANCE: THE MODERATING ROLE OF ORGANIZATIONAL AGILITY

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Abstract

This study investigates how supply chain digitalization (SCD) influences operational performance (OP) in the manufacturing sector of Pakistan, with a particular focus on the moderating role of organizational agility (OA). Drawing on the resource-based view (RBV) and dynamic capabilities theory (DCT), this research posits that digitalization of supply chain processes enhances firms' efficiency, quality, and responsiveness, but these benefits are contingent upon the agility with which firms adapt to environmental uncertainties. Using a quantitative research design, survey data were collected from 320 supply chain and operations managers working in textile, pharmaceutical, and automotive firms in Pakistan. The data were analyzed using partial least squares structural equation modeling (PLS-SEM). The findings reveal that supply chain digitalization has a significant positive impact on operational performance. Moreover, organizational agility positively moderates this relationship, indicating that digitalization is most effective when firms are flexible, adaptive, and capable of responding swiftly to market fluctuations. The results contribute to existing literature by extending the RBV and DCT to the context of digitalized supply chains in emerging economies. Practically, this study provides insights for managers to prioritize agility-enhancing practices alongside digital adoption

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to maximize performance outcomes. The paper concludes with theoretical implications, managerial recommendations, and future research directions.

Keywords: Supply Chain Digitalization, Operational Performance, Organizational Agility, Dynamic Capabilities, Emerging Economies, Pakistan

1. INTRODUCTION

1.1 Background

Global supply chains are being radically reshaped by digital technologies like big data analytics, blockchain, artificial intelligence (AI), and the Internet of Things (IoT) (Khan et al., 2021). These technologies have helped companies gain real-time visibility, make better decisions, and increase efficiency in the supply chain (Liu et al., 2023; Zhang & Lee, 2022). For companies operating in manufacturing-driven economies like Pakistan, digitalization can provide options to break through long-standing operational issues, such as deficient coordination, limited flexibility, and tardiness in addressing customer requirements (Arshad et al., 2025). Supply chain digitalization (SCD) therefore constitutes not just the implementation of technology tools but a reshaping of supply chain structures and processes to establish new capabilities that can deliver superior operational performance (Ivanov & Dolgui, 2021).

But while digitalization holds out the promise of improved performance, not all companies see the same degree of gains (Gul et al., 2019). Evidence is that how much digitalization contributes to better operational performance varies depending on complementary organizational conditions, notably agility (Wamba et al., 2020). Companies that are agile—able to rapidly scan for market changes, reassign resources, and react well—are likely to use digital tools to drive efficiency, reliability, and flexibility in operations (Tarafdar et al., 2022).

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1.2 Problem of the Study

Much as it is crucial, empirical research on the nexus between supply chain digitalization, organizational agility, and operational performance is still rare in the case of emerging economies (Sharma & Bansal, 2021). Most existing literature is centered around developed economies with well-developed infrastructure, regulatory environments, and digital preparedness. Pakistan's manufacturing industry, nonetheless, has distinctive constraints in the form of infrastructural bottlenecks, scarce technological capabilities, and fluctuating demand conditions (Khan et al., 2022). These difficulties prompt a pertinent question: Does supply chain digitalization really improve operational performance in resource-scarce environments, and how does organizational agility influence this association?

In addition, previous literature tends to study digitalization as a process that is the same in all contexts, failing to consider that its advantages rely on organizational competencies (Mubarik et al., 2022). The moderating effect of organizational agility is especially uninvestigated, despite appeals for research on the way agility can enhance the value of digital transformation in volatile environments (Queiroz et al., 2022).

1.3 Research Objectives

This research fills the aforementioned gaps by empirically testing the association between SCD and OP in the context of Pakistani manufacturing. The objectives are threefold:

1. To examine the direct impact of supply chain digitalization on operational performance.
2. To analyze the moderating role of organizational agility in the SCD–OP relationship.
3. To provide theoretical and managerial insights into how digitalization and agility jointly contribute to sustainable operational excellence in emerging markets.

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1.4 Research Questions

Based on these objectives, the study seeks to answer the following questions:

- How does supply chain digitalization affect operational performance in manufacturing firms?
- To what extent does organizational agility strengthen or weaken this relationship?
- What theoretical and practical contributions can be drawn from studying this relationship in the context of an emerging economy such as Pakistan?

1.5 Theoretical Foundation

This study draws on the **Resource-Based View (RBV)** and **Dynamic Capabilities Theory (DCT)**. RBV suggests that firms can achieve superior performance by developing resources that are valuable, rare, inimitable, and non-substitutable (Alam et al., 2025). Digital technologies, when effectively integrated into supply chain operations, can act as such strategic resources (Zhang & Lyu, 2023). However, RBV alone does not explain how firms adapt these resources to rapidly changing environments (Hanif et al., 2023). Here, DCT provides complementary insights, positing that dynamic capabilities—such as organizational agility—enable firms to sense opportunities, seize them, and reconfigure resources in alignment with environmental demands (Teece, 2018). By integrating RBV and DCT, this study argues that while digitalization provides the foundation for operational improvements, organizational agility determines the extent of these improvements.

1.6 Contribution of the Study

This study makes several contributions. Theoretically, it enriches the supply chain management literature by demonstrating how RBV and DCT jointly explain the relationship between SCD and OP in emerging economies. Specifically, it highlights the contingent role of agility, a dynamic capability, in realizing the benefits of digitalization. Empirically, the research brings evidence from the Pakistani manufacturing sector, a setting frequently

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ignored in SCM research. Practically, the results assist managers in balancing technology investments and agility-promoting practices with optimal performance effects.

2. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

2.1 Supply Chain Digitalization and Operational Performance

The supply chain digitalization is the embedding of cutting-edge technologies like artificial intelligence (AI), blockchain, cloud computing, and the Internet of Things (IoT) into supply chain operations (ul Hassan et al., 2023). The above technologies offer real-time visibility of data, predictive analysis, and automation, allowing companies to minimize inefficiencies and react to market needs better (Liu et al., 2023; Xu et al., 2021). Through the automation of day-to-day operations and giving high-level insights, supply chain digitalization (SCD) improves performance results like cost effectiveness, delivery dependability, product quality, and agility (Zhang & Lee, 2022).

Operational performance (OP), in supply chain terms, describes a company's capability to control cost, velocity, flexibility, and reliability in its processes (Flynn et al., 2020). Earlier research has invariably established that digital supply chains enhance these aspects by maximizing decision-making, shortening lead times, and reducing inventory-related risks (Queiroz et al., 2022). To illustrate, Ivanov and Dolgui (2021) contended that digital twins and simulation models enable companies to analyze numerous scenarios, thus minimizing production and logistics uncertainties. Equally, Wamba et al. (2020) demonstrated that big data analytics enables demand forecasting, which enhances production planning and minimizes waste.

Still, the effect of digitalization on OP can vary with settings (ul Hassan et al., 2020). In developing economies such as Pakistan, inefficiencies in supply chains, such as infrastructural blockages and low integration across stakeholders, necessitate a higher demand for digitalization to catalyze improvements in performance (Mubarik et al., 2022). Adoption costs and the availability of resources can curtail the rate of implementation, but companies

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that are able to adopt digitalization tend to gain considerable performance benefits compared to non-adopters (Khan et al., 2022).

Drawing on the Resource-Based View (RBV), SCD as a strategic resource can be considered to help firms create distinctive capabilities for superior operational performance (Irshad et al., 2024). Technologies that offer real-time data and forecasted analysis are rare and valuable in emerging markets, and competitors are unlikely to have access to similar systems. In addition, these technologies are hard to imitate because it is challenging to integrate complexity among supply chain partners (Zhang & Lyu, 2023).

Following the above discussion, the following hypothesis is postulated:

H1: *Supply chain digitalization positively impacts operational performance.*

2.2 Moderating Role of Organizational Agility

Although digitalization and agility on their own are drivers of performance, their intersection is critical in understanding how companies get superior results (Rana et al., 2024). Supply chain digitalization gives companies data-based insights and sophisticated decision-support tools. But, without agility, companies might be unable to leverage these assets because of inflexible structures or delayed decision-making processes (Queiroz et al., 2022). But agile organizations have the capability to leverage digital resources for quick adaptation and thus enhance performance benefits (ul Hassan et al., 2025).

This dynamic is especially timely in environments that are uncertain (Gul et al., 2025). For example, during disruptions, digital technologies can offer visibility into risks to the supply chain, but agile companies are the ones who can take action based on these insights by diverting shipments, reassigning production capacity, or diversifying suppliers (Ivanov & Dolgui, 2021). In this way, agility becomes a complementary capability that allows companies to maximize the power of digitalization (Atif et al., 2024).

The combination of RBV and DCT reinforces this research. Whereas RBV focuses on the ownership of valuable digital assets, DCT underlines the significance of agility in rearranging these assets for persistent competitive

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advantage (Gul et al., 2021). That is, digitalization gives the "what," but agility actually specifies the "how" and "how fast" companies are able to convert digital resources into operational gains (Kakakhel et al., 2016).

Evidence from various studies bears out this moderating function. Wamba et al. (2020) established that digital supply chain projects had more significant impacts on performance results in those companies that possess greater levels of agility (Gul et al., 2024). In the same way, Tarafdar et al. (2022) showed that agility increases the efficacy of digital tools against interruptions. In the Pakistani manufacturing environment, where uncertainty and volatility prevail, the capacity to integrate digital technologies and agile practices may be a make-or-break factor of operational success (Mubarik et al., 2022).

Therefore, this research formulates the following hypothesis:

H2: *Organizational agility positively moderates the relationship between supply chain digitalization and operational performance, such that the relationship is stronger at higher levels of agility.*

3. THEORETICAL FRAMEWORK

This research combines the Resource-Based View (RBV) and Dynamic Capabilities Theory (DCT) to account for the interrelationship between supply chain digitalization (SCD), operational performance (OP), and organizational agility (OA).

3.1 Resource-Based View

Based on RBV, companies derive long-term competitive advantage from resources that are valuable, rare, inimitable, and non-substitutable (Barney, 1991). Supply chain digitalization is one such resource since digital technologies such as big data analytics, IoT, and blockchain improve visibility, efficiency, and coordination of the supply chain (Zhang & Lyu, 2023). Such digital tools offer predictive and real-time intelligence that is particularly rare in developing economies and hence becoming a potential source for superior performance results for companies (Mumtaz et al., 2025).

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3.2 Dynamic Capabilities Theory

Whereas RBV points to the ownership of resources, DCT points to the capacity to transform such resources in changing environments (Teece, 2018). Organizational agility captures such a dynamic capacity, allowing companies to detect changes, react swiftly, and realign supply chain operations. Agility ensures that digital resources are not only adopted but also effectively utilized in achieving timely and context-specific improvements in operations (Tarafdar et al., 2022).

3.3 Integrated Model

Together, RBV and DCT suggest that while SCD provides the technological foundation for enhanced performance, OA determines the extent to which these resources are translated into tangible operational benefits. Agility thus acts as a moderator in the SCD–OP relationship.

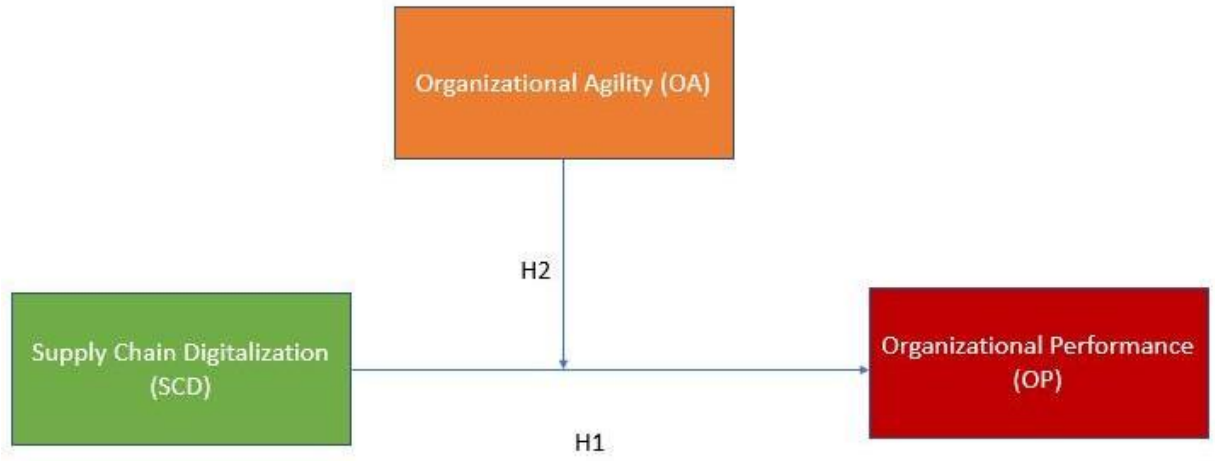

FIGURE 1. CONCEPTUAL FRAMEWORK

4. METHODOLOGY

4.1 Research Design

A quantitative, cross-sectional survey was employed to test the proposed hypotheses. Survey research is suitable for collecting standardized data across

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a large sample and allows statistical testing of complex structural relationships using SEM (Hair et al., 2021).

4.2 Population and Sampling

The study focused on manufacturing firms in Pakistan, with emphasis on textiles, pharmaceuticals, automotive, and electronics. These sectors were selected because they form the backbone of Pakistan's economy and are increasingly adopting digital technologies.

- **Sampling Method:** Stratified random sampling, to capture variation across industries.
- **Respondents:** Middle and senior managers in supply chain, logistics, and operations.
- **Sample Size:** Out of 320 surveys distributed, 300 valid responses were retained (response rate ≈ 93.7%).

Table 1. Measurement of Constructs

Construct	Dimensions	Example Items (5-point Likert)	Sources
Supply Chain Digitalization (SCD)	Digital integration, analytics, visibility	"Our firm uses digital tools to integrate suppliers and customers." "We use analytics for demand forecasting and inventory management."	Queiroz et al. (2022); Zhang & Lyu (2023)
Operational Performance (OP)	Cost, delivery, quality, flexibility	"Our firm consistently meets delivery schedules." "We can adjust production schedules with	Flynn et al. (2020)

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		minimal cost."	
Organizational Agility (OA)	Responsiveness, adaptability, speed	"Our firm can quickly reconfigure operations in response to market changes." "We adapt rapidly to unexpected disruptions in the supply chain."	Tarafdar et al. (2022)
Control Variables	Firm size, firm age, industry type	Number of employees; years since establishment	Mubarik et al. (2022)

4.3 Data Collection Procedure

The questionnaire was designed using validated scales, pre-tested with 20 managers for clarity, and refined based on feedback. Data collection was conducted through both online platforms (email, LinkedIn) and in-person visits. Anonymity and confidentiality assurances were provided to minimize social desirability bias.

Table 2. Sample Characteristics (n = 300)

Variable	Category	Frequency	Percentage
Industry	Textiles	120	40%
	Pharmaceuticals	70	23%
	Automotive	60	20%
	Electronics	50	17%
Firm Size	Small (<250 employees)	85	28%
	Medium (250–999 employees)	125	42%
	Large (≥1000 employees)	90	30%
Respondent	Supply Chain Manager	110	37%

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Role			
	Operations Manager	100	33%
	Logistics Manager	55	18%
	Senior Executive (Director/VP)	35	12%

4.4 Data Analysis Technique

The study applied Partial Least Squares Structural Equation Modeling (PLS-SEM) using SmartPLS 4.0. This approach is well-suited for predictive models, smaller sample sizes, and data with non-normal distributions.

- **Stage 1: Measurement Model**
  - Reliability: Cronbach's alpha, Composite Reliability (CR).
  - Convergent Validity: Average Variance Extracted (AVE).
  - Discriminant Validity: Fornell–Larcker and HTMT ratios.
- **Stage 2: Structural Model**
  - Path coefficients (β), significance (p-values).
  - Coefficient of determination (R^2).
  - Effect size (f^2) and predictive relevance (Q^2).
  - Moderation tested via interaction term of SCD × OA.

4.5 Common Method Bias (CMB)

Procedural remedies (e.g., anonymity, item randomization) were applied. Post-hoc tests, including Harman's single-factor test and VIF checks, indicated that CMB was not a major issue.

DATA ANALYSIS AND RESULTS

5.1 Measurement Model Assessment

To establish the reliability and validity of the constructs, factor loadings, Cronbach's alpha, composite reliability (CR), and average variance extracted (AVE) were examined.

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Table 3. Reliability and Convergent Validity

Construct	Items	Loadings	Cronbach's Alpha	CR	AVE
Supply Chain Digitalization (SCD)	4	0.74–0.88	0.86	0.90	0.66
Operational Performance (OP)	4	0.72–0.87	0.84	0.89	0.64
Organizational Agility (OA)	4	0.70–0.85	0.83	0.88	0.61

- All factor loadings exceed the 0.70 threshold, ensuring indicator reliability (Hair et al., 2021).
- Cronbach's alpha values (0.83–0.86) and CR values (0.88–0.90) are above 0.70, confirming construct reliability.
- AVE values (0.61–0.66) exceed 0.50, validating convergent validity.

5.2 Discriminant Validity

The Fornell–Larcker criterion was applied to test discriminant validity.

Table 4. Discriminant Validity (Fornell–Larcker Criterion)

Construct	SCD	OP	OA
SCD	**0.81**		
OP	0.62	**0.80**	
OA	0.58	0.55	**0.78**

Interpretation

The square roots of AVE (bold diagonal values) are greater than inter-construct correlations, confirming discriminant validity. For example, SCD's AVE square root (0.81) exceeds its correlations with OP (0.62) and OA (0.58).

5.3 Structural Model Assessment

Path coefficients, R^2, and predictive relevance (Q^2) were analyzed. Bootstrapping with 5,000 subsamples was used for significance testing.

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Table 5. Structural Model Results

Hypothesis	Path	β	t-value	p-value	Decision
H1:	SCD → OP	0.45	6.21	0.000	Supported
H2:	SCD × OA → OP	0.18	3.47	0.001	Supported

Model fit: R^2 (OP) = 0.48; Q^2 = 0.31.

- Supply Chain Digitalization (SCD) has a positive and significant effect on Operational Performance (β = 0.45, p < 0.001), supporting H1.
- The interaction term (SCD × OA) is significant (β = 0.18, p < 0.01), confirming that Organizational Agility strengthens the impact of SCD on performance (H2).
- R^2 of 0.48 indicates that nearly half of the variance in operational performance is explained by SCD and OA. The Q^2 value (0.31 > 0) suggests strong predictive relevance.

6. DISCUSSION

The objective of this study was to examine the impact of Supply Chain Digitalization (SCD) on Operational Performance (OP), with a specific focus on the moderating role of Organizational Agility (OA) in manufacturing firms. The findings offer several important theoretical and practical insights.

6.1 Supply Chain Digitalization and Operational Performance

The results confirm that SCD has a significant and positive effect on OP (β = 0.45, p < 0.001). This aligns with prior research (e.g., Ivanov & Dolgui, 2020; Queiroz et al., 2022) emphasizing that digital technologies such as IoT, blockchain, and predictive analytics enhance visibility, reduce lead times, and improve responsiveness. Through the combination of real-time information and online platforms, companies maximize resource use, reduce disruptions to operations, and become more efficient. In terms of emerging economies, like Pakistan, these results emphasize that digitalization is no longer an indulgence but a competitive necessity for business operations.

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6.2 Organizational Agility as a Moderating Role

The findings also prove that OA enhances the positive influence of SCD on OP ($\beta = 0.18$, $p < 0.01$). The moderation plot shows that more agile companies gain more performance advantages from digital technologies than less agile companies.

This result aligns with the dynamic capabilities theory that stipulates that firms need to be constantly adapting, integrating, and reconfiguring resources to keep up in the market (Teece et al., 2016).

Without agility, digitalization initiatives risk underperformance, as rigid structures and slow decision-making can impede effective technology adoption. Thus, OA acts as a performance amplifier in digital transformation initiatives.

6.3 Theoretical Contributions

This study makes several contributions to theory:

1. It extends the resource-based view (RBV) by showing that digital technologies (resources) translate into performance gains only when complemented by agility (a dynamic capability).
2. It advances supply chain digitalization literature by empirically validating its direct effect on operational outcomes in an emerging economy context, addressing the call for more studies outside developed economies (Srai & Lorentz, 2019).
3. It highlights the boundary condition of organizational agility, offering a more nuanced understanding of how digitalization drives performance.

7. PRACTICAL IMPLICATIONS

The findings provide actionable insights for managers and policymakers:

- **For managers**: Investments in digital technologies should be accompanied by efforts to enhance organizational agility. This includes fostering flexible structures, empowering employees, and encouraging rapid decision-making to fully leverage digital tools.

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- **For policymakers**: Governments in emerging economies should incentivize digital adoption in supply chains through tax benefits, subsidies, and digital infrastructure investments.
- **For supply chain practitioners**: Training programs that combine technical (digital skills) and adaptive (agility, resilience) capabilities are critical for sustaining performance gains.

8. LIMITATIONS AND FUTURE RESEARCH

Despite its contributions, this study has limitations:

1. Cross-sectional design limits causal inference. Longitudinal studies could capture how digitalization–performance relationships evolve over time.
2. The study focuses on manufacturing firms in Pakistan; findings may not generalize to other industries or regions. Future research could conduct cross-country comparisons across the Global South.
3. Other potential moderators, such as environmental uncertainty, digital skills readiness, or leadership styles, could be explored to deepen understanding.

9. CONCLUSION

This study empirically demonstrates that supply chain digitalization significantly enhances operational performance and that organizational agility strengthens this relationship. By integrating RBV and dynamic capabilities theory, the study advances scholarly understanding of how digital and adaptive capabilities jointly drive performance outcomes.

For practitioners, the message is clear: digitalization alone is insufficient. Firms must cultivate agility to unlock the full value of their digital investments. For policymakers, creating supportive ecosystems for digital and agile transformation in supply chains is crucial for competitiveness in the global economy.

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