

SUPPLY CHAIN DIGITALIZATION AND PERFORMANCE: THE MEDIATING ROLE OF COLLABORATION CAPABILITY AND THE MODERATING EFFECT OF ENVIRONMENTAL UNCERTAINTY*

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This research article aims to: 1) examine the relationship between supply chain digitalization and supply chain performance; 2) investigate the mediating role of supply chain collaboration capability; and 3) examine the moderating effect of environmental uncertainty on the relationship between supply chain digitalization and collaboration capability. This study conducted a quantitative research study by collecting data from 356 manufacturing firms in China and analyzed the data using structural equation modeling (SEM) and bootstrapping techniques.

The research results found that: 1) supply chain digitalization is positively associated with both supply chain performance and collaboration capability; 2) collaboration capability partially mediates the relationship between supply chain digitalization and supply chain performance; and 3) environmental uncertainty positively moderates the relationship between supply chain digitalization and

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collaboration capability while strengthening the indirect effect of digitalization on performance.

Keywords: supply chain digitalization, collaboration capability, environmental uncertainty, supply chain performance, moderated mediation

Introduction

In an increasingly volatile and uncertain business environment, manufacturing firms face growing pressure to enhance supply chain performance. Rapid technological advancements, global competition, and frequent disruptions have intensified the need for more responsive and adaptive supply chains. In this context, supply chain digitalization has emerged as a key strategic approach.

Supply chain digitalization refers to the adoption and integration of digital technologies—such as big data analytics, cloud computing, and the Internet of Things (IoT)—to improve information visibility, coordination, and decision-making across supply chain activities (Büyüközkan & Göçer, 2018; Ivanov & Dolgui, 2021). By enabling real-time data sharing and process integration, digitalization allows firms to optimize operations and improve supply chain responsiveness. Although prior studies generally report a positive relationship between supply chain digitalization and performance (Dubey et al., 2019; Zhou et al., 2023), the mechanisms through which digital technologies create value remain insufficiently understood. Existing research has largely focused on direct effects, while paying less attention to the organizational capabilities that translate digital investments into performance outcomes. According to the resource-based view (RBV), digital technologies can be considered valuable organizational resources; however, their impact depends on how effectively they are embedded within organizational capabilities (Barney, 1991). Among these, supply chain collaboration capability plays a crucial role in enabling firms to coordinate activities, share information, and align decisions with supply chain partners (Cao & Zhang, 2011). In addition,

information processing theory (IPT) suggests that organizations must develop sufficient information processing capacity to cope with environmental uncertainty (Galbraith, 1974). Digital technologies enhance this capacity by facilitating real-time information exchange and system integration. However, the effectiveness of digitalization may depend on the level of environmental uncertainty faced by firms, as higher uncertainty increases the need for coordination and information processing. Despite these insights, limited research has examined how environmental conditions influence the effectiveness of supply chain digitalization. In particular, the moderating role of environmental uncertainty in the relationship between digitalization and collaboration capability remains underexplored, and it is unclear whether the mediating effect of collaboration capability varies across different environmental contexts.

To address these gaps, this study develops a moderated mediation model to examine how supply chain digitalization influences performance through collaboration capability under varying levels of environmental uncertainty. By integrating RBV and IPT perspectives, this study provides a more comprehensive understanding of the conditions under which digitalization creates value in supply chains. This study makes several important contributions to the literature. First, it extends prior research on supply chain digitalization by integrating mediation and contingency perspectives within a single analytical framework. Unlike previous studies that primarily focus on direct effects, this study explains both how and under what conditions digitalization contributes to supply chain performance. Second, this study identifies collaboration capability as a critical organizational mechanism through which digitalization influences performance outcomes. By emphasizing the capability development process, the study advances the resource-based view (RBV) perspective on digital value creation. Third, this study contributes to the growing literature on digital transformation in emerging economies by focusing on the Chinese manufacturing sector, where

firms face high levels of environmental uncertainty and rapid technological change. The findings therefore provide context-specific insights into the effectiveness of digitalization under dynamic and uncertain supply chain conditions. Accordingly, this study seeks to contribute to both the supply chain digitalization literature and the broader discussion of digital transformation in emerging economies.

Objectives

1. To examine the relationship between supply chain digitalization and supply chain performance in Chinese manufacturing firms.
2. To investigate the mediating role of supply chain collaboration capability in the relationship between supply chain digitalization and supply chain performance.
3. To examine the moderating effect of environmental uncertainty and the moderated mediation effect of collaboration capability on supply chain performance.

Literature Review

1. Supply Chain Digitalization and Supply Chain Performance

Supply chain digitalization refers to the integration and application of digital technologies across supply chain activities to improve operational visibility, information sharing, coordination, and decision-making (Büyüközkan & Göçer, 2018). Technologies such as big data analytics, cloud computing, artificial intelligence, and the Internet of Things (IoT) enable firms to process real-time information and optimize supply chain operations more effectively.

Prior studies have suggested that digitalization is positively associated with operational efficiency, responsiveness, and supply chain performance (Dubey et al., 2019; Zhou et al., 2023). Through digital integration, firms can improve

inventory management, reduce operational delays, enhance information transparency, and respond more effectively to changing customer demands. According to the resource-based view (RBV), digital technologies can be considered valuable organizational resources that contribute to competitive advantage when effectively utilized within organizational processes (Barney, 1991). In supply chain contexts, digitalization may strengthen firms' abilities to coordinate supply chain activities and improve operational performance. Based on the above discussion, supply chain digitalization is expected to be positively associated with supply chain performance. H1. Supply chain digitalization is positively associated with supply chain performance.

2. Supply Chain Digitalization and Collaboration Capability

Supply chain collaboration capability refers to a firm's ability to effectively coordinate activities, share information, and maintain cooperative relationships with supply chain partners (Cao & Zhang, 2011). Collaboration capability is essential for improving communication, reducing information asymmetry, and enhancing joint decision-making across supply chain networks. Digital technologies play an important role in facilitating collaboration among supply chain members. Through integrated information systems, cloud-based platforms, and digital communication technologies, firms are able to exchange real-time information, synchronize operational processes, and strengthen coordination with suppliers and customers. Previous studies have shown that digitalization contributes to higher levels of collaboration and integration within supply chains (Flynn et al., 2010; Simatupang & Sridharan, 2005). From the perspective of information processing theory (IPT), digital technologies enhance firms' information processing capacity, thereby improving their ability to coordinate complex inter-organizational activities under uncertain business environments (Galbraith, 1974). As firms adopt more advanced digital technologies, they are likely to strengthen collaborative interactions and improve

coordination efficiency across supply chain partners. Based on the above discussion, supply chain digitalization is expected to be positively associated with supply chain collaboration capability.

H2. Supply chain digitalization is positively associated with supply chain collaboration capability.

3. Collaboration Capability and Supply Chain Performance

Supply chain collaboration capability is widely recognized as an important organizational capability that contributes to improved supply chain outcomes. Effective collaboration enables firms to share timely information, coordinate operational activities, and jointly solve problems with supply chain partners, thereby improving overall supply chain efficiency and responsiveness. Prior studies have demonstrated that collaboration capability is positively associated with operational performance, customer satisfaction, and supply chain effectiveness (Cao & Zhang, 2011; Flynn et al., 2010). Firms with stronger collaborative relationships are generally better positioned to reduce operational disruptions, improve coordination accuracy, and respond more effectively to market changes. According to the resource-based view (RBV), collaboration capability represents an important intangible organizational capability that allows firms to better utilize their internal and external resources (Barney, 1991). In supply chain environments characterized by increasing complexity and interdependence, collaboration capability may become a critical factor influencing organizational performance. Based on the above discussion, supply chain collaboration capability is expected to be positively associated with supply chain performance.

H3. Supply chain collaboration capability is positively associated with supply chain performance.

4. The Mediating Role of Collaboration Capability

Although supply chain digitalization is often associated with improved performance, the mechanisms through which digital technologies create value remain insufficiently understood. Existing studies suggest that digital technologies may not directly generate performance benefits unless firms develop organizational capabilities that allow them to effectively utilize digital resources. Supply chain collaboration capability may serve as an important mediating mechanism linking digitalization and performance. Digital technologies facilitate information sharing, coordination, and communication among supply chain partners, thereby strengthening collaborative relationships and operational integration. Enhanced collaboration capability may subsequently contribute to improved supply chain performance by reducing inefficiencies, improving responsiveness, and supporting joint decision-making. From the perspective of the resource-based view (RBV), organizational capabilities are essential for transforming technological resources into performance outcomes (Barney, 1991). In this context, collaboration capability may represent a key organizational mechanism through which supply chain digitalization contributes to supply chain performance. Based on the above discussion, supply chain collaboration capability is expected to mediate the relationship between supply chain digitalization and supply chain performance.

H4. Supply chain collaboration capability mediates the relationship between supply chain digitalization and supply chain performance.

5. The Moderating Role of Environmental Uncertainty

Environmental uncertainty refers to the degree of unpredictability associated with market conditions, customer demand, technological change, and competitive environments (Miller, 1993). In highly uncertain environments, firms often face greater difficulties in forecasting demand, coordinating operations, and responding to supply chain disruptions. Information processing theory (IPT)

suggests that organizations operating under higher levels of uncertainty require greater information processing capacity and coordination capability to effectively manage environmental complexity (Galbraith, 1974). Digital technologies enhance firms' ability to process and exchange real-time information, thereby supporting more effective collaboration among supply chain partners. Under conditions of high environmental uncertainty, firms require greater information processing and coordination capability, making digital technologies more valuable for inter-organizational collaboration. As environmental uncertainty increases, firms may rely more heavily on digital technologies to improve communication, coordination, and collaborative decision-making across supply chain networks. Therefore, the relationship between supply chain digitalization and collaboration capability is expected to become stronger when environmental uncertainty is high.

H5. Environmental uncertainty positively moderates the relationship between supply chain digitalization and supply chain collaboration capability, such that the relationship becomes stronger under higher levels of environmental uncertainty.

6. Moderated Mediation Effect

In addition to its direct moderating role, environmental uncertainty may also influence the indirect relationship between supply chain digitalization and supply chain performance through collaboration capability. As environmental uncertainty increases, firms are likely to depend more heavily on digital technologies and collaborative mechanisms to manage operational complexity and maintain supply chain effectiveness. When firms operate in uncertain environments, the ability to exchange timely information, coordinate activities, and respond rapidly to disruptions becomes increasingly important. Under such conditions, digital technologies may contribute more strongly to collaboration capability, which subsequently enhances supply chain performance. In contrast, under relatively stable environments, the indirect effect of digitalization through

collaboration capability may become less pronounced. According to information processing theory (IPT), organizations facing higher uncertainty require stronger information processing and coordination mechanisms to achieve effective operational outcomes (Galbraith, 1974). Therefore, environmental uncertainty may strengthen the indirect effect of supply chain digitalization on performance through collaboration capability. Based on the above discussion, the indirect relationship between supply chain digitalization and supply chain performance through collaboration capability is expected to become stronger under higher levels of environmental uncertainty.

H6. Environmental uncertainty positively moderates the indirect relationship between supply chain digitalization and supply chain performance through collaboration capability.

Methodology

1. Sample and Data Collection

This study adopted a quantitative research approach to examine the relationships among supply chain digitalization, collaboration capability, environmental uncertainty, and supply chain performance. Data were collected from manufacturing firms in China, where digital transformation and supply chain upgrading have become increasingly important.

The target respondents included managers and professionals involved in supply chain operations, digital transformation activities, procurement, logistics, and organizational decision-making processes. Respondents were selected based on their involvement in supply chain management and their familiarity with digitalization practices within their organizations.

Data collection was conducted using structured questionnaires distributed through both online and offline channels. Participation in the survey

was voluntary, and respondents were assured that all responses would remain anonymous and confidential.

A total of 400 questionnaires were distributed. After excluding incomplete and invalid responses, 356 valid questionnaires were retained for analysis, representing an effective response rate of 89.0%.

As shown in Table 1, the sample includes firms of different sizes, industries, and organizational positions, indicating adequate diversity and representativeness.

Table 1 Sample Characteristics

Category	Classification	Frequency	Percentage
Firm Size	Small (<100 employees)	92	25.8%
	Medium(100–500employees)	147	41.3%
	Large (>500 employees)	117	32.9%
Respondent Position	Senior management	96	27.0%
	Middle management	168	47.2%
	Operational staff	92	25.8%
Industry Type	Electronics	104	29.2%
	Automotive	86	24.2%
	Equipment manufacturing	79	22.2%
	Others	87	24.4%
Firm Age	<5 years	54	15.2%
	5–10 years	131	36.8%
	>10 years	171	48.0%

2. Measurement of Variables

All constructs in this study were measured using previously validated scales adapted from prior studies. Minor modifications were made to ensure consistency with the context of Chinese manufacturing firms. A five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree was used for all measurement items. Supply chain digitalization (SCD) was measured using items adapted from Büyüközkan and Göçer (2018), focusing on digital integration, real-time information sharing, and the use of digital technologies within supply chain operations. Supply chain collaboration capability (SCC) was measured using scales adapted from Cao and Zhang (2011) and Simatupang and Sridharan (2005). The measurement items emphasized information sharing, joint decision-making, coordination, and collaborative relationships among supply chain partners. Supply chain performance (SCP) was measured using items adapted from Flynn et al. (2010), focusing on operational efficiency, responsiveness, and overall supply chain effectiveness. Environmental uncertainty (EU) was measured using items adapted from Miller (1993), which assessed the unpredictability of market conditions, customer demand, and environmental changes.

Table 2 summarizes the measurement constructs and sources used in this study.

Table 2 Measurement Scales and Sources

Construct	Number of Items	Sample Measurement Focus	Source
Supply Chain Digitalization (SCD)	5	Digital integration and real-time information sharing	Büyüközkan & Göçer (2018)

Supply Chain		Information sharing	Cao & Zhang
Collaboration	5	and coordination with	(2011); Simatupang
Capability (SCC)		partners	& Sridharan (2005)
Supply Chain	4	Operational efficiency	Flynn et al. (2010)
Performance (SCP)		and responsiveness	
Environmental	4	Market and demand	Miller (1993)
Uncertainty (EU)		unpredictability	

3. Data Analysis Technique

This study employed structural equation modeling (SEM) using AMOS to test the proposed hypotheses and examine the relationships among the constructs. SEM was considered appropriate because the study involves multiple latent variables, mediation effects, moderation effects, and simultaneous relationship testing. Following Anderson and Gerbing (1988), a two-step structural equation modeling approach was adopted. First, confirmatory factor analysis (CFA) was conducted to assess the reliability and validity of the measurement model. Second, the structural model was analyzed to test the hypothesized relationships among the constructs. Reliability was assessed using Cronbach's alpha and composite reliability (CR), while convergent validity was evaluated using average variance extracted (AVE) and standardized factor loadings. Discriminant validity was assessed using the Fornell–Larcker criterion and HTMT ratios. Model fit was evaluated using several commonly recommended fit indices, including chi-square/degrees of freedom ratio (χ^2/df), goodness-of-fit index (GFI), comparative fit index (CFI), Tucker–Lewis index (TLI), normed fit index (NFI), and root mean square residual (RMR). The recommended threshold values suggested by Hair et al. (2019) were used to assess model adequacy. In addition, firm size, firm age, and industry type were included as control variables because prior

studies suggest that these factors may influence supply chain performance and organizational capability development.

4. Moderation and Moderated Mediation Analysis

To examine the moderating effect of environmental uncertainty, an interaction term between supply chain digitalization and environmental uncertainty was constructed and included in the structural model. Following standard moderation analysis procedures, all variables involved in the interaction term were mean-centered before constructing the interaction variable in order to reduce potential multicollinearity. The moderating effect was assessed by examining whether environmental uncertainty significantly changes the strength of the relationship between supply chain digitalization and collaboration capability. In addition, this study examined the moderated mediation effect to determine whether the indirect relationship between supply chain digitalization and supply chain performance through collaboration capability varies across different levels of environmental uncertainty.

Bootstrapping procedures with 5,000 resamples were employed to test the mediation and moderated mediation effects. The significance of indirect effects was assessed using bias-corrected confidence intervals. An indirect effect was considered significant when the confidence interval did not include zero.

5. Common Method Bias Assessment

Because the data were collected using self-reported questionnaires from single respondents, common method bias (CMB) may potentially affect the results. To assess this issue, Harman's single-factor test was conducted. All measurement items were entered into an exploratory factor analysis (EFA) without rotation. The results indicated that the first unrotated factor accounted for 34.7% of the total variance, which is below the recommended threshold of 50% (Podsakoff et al., 2003). This suggests that common method bias is unlikely to be a serious concern in this study. In addition, several procedural remedies

were adopted during questionnaire design and data collection, including respondent anonymity, clear item wording, and the separation of construct measurement sections, to further reduce the potential impact of common method bias.

Results

1. Measurement Model Assessment

Confirmatory factor analysis (CFA) was conducted to assess the reliability and validity of the measurement model. The results indicate that all standardized factor loadings exceeded the recommended threshold of 0.60, demonstrating satisfactory indicator reliability. Internal consistency reliability was evaluated using Cronbach's alpha and composite reliability (CR). All constructs achieved values above the recommended threshold of 0.70, indicating satisfactory reliability. Convergent validity was assessed using average variance extracted (AVE), and all AVE values exceeded the recommended threshold of 0.50. Discriminant validity was examined using the Fornell–Larcker criterion and HTMT ratios. The square root of AVE for each construct exceeded its correlations with other constructs, and all HTMT values were below the recommended threshold, indicating adequate discriminant validity.

The overall measurement model demonstrated a satisfactory fit to the data. Table 3 presents the measurement model fit indices.

Table 3 Measurement Model Fit Indices

Fit Index	Recommended Value	Model Result	Evaluation
χ^2/df	< 3.0	1.019	Excellent
GFI	> 0.90	0.901	Acceptable
RMR	< 0.08	0.041	Good
NFI	> 0.90	0.903	Good

IFI	> 0.90	0.998	Excellent
TLI	> 0.90	0.998	Excellent
CFI	> 0.90	0.998	Excellent

These results indicate that the measurement model demonstrates strong reliability, validity, and overall model fit, and is therefore appropriate for subsequent structural model analysis.

2. Structural Model Results

The structural model analysis was conducted to examine the hypothesized relationships among the constructs. The structural model demonstrated a satisfactory fit to the data and met the recommended model fit criteria.

Table 4 presents the results of the direct relationships among supply chain digitalization, collaboration capability, and supply chain performance.

Table 4 Structural Model Results

Hypothesis	Path	Std. β	C.R.	p-value	Result
H1	SCD $\rightarrow$ SCP	0.778	8.099	<0.001	Supported
H2	SCD $\rightarrow$ SCC	0.563	7.510	<0.001	Supported
H3	SCC $\rightarrow$ SCP	0.278	3.907	<0.001	Supported

The results indicate that supply chain digitalization is positively associated with supply chain performance ($\beta = 0.778$, $p < 0.001$), supporting H1. This finding suggests that firms with higher levels of digitalization tend to achieve better supply chain outcomes.

The results further show that supply chain digitalization is positively associated with collaboration capability ($\beta = 0.563$, $p < 0.001$), supporting H2. This finding indicates that digital technologies facilitate information sharing,

coordination, and collaborative interactions among supply chain partners. In addition, collaboration capability is positively associated with supply chain performance ($\beta = 0.278$, $p < 0.001$), supporting H3. Firms with stronger collaborative capabilities are more likely to achieve improved operational efficiency and supply chain effectiveness. Overall, the findings provide substantial support for the proposed structural relationships among supply chain digitalization, collaboration capability, and supply chain performance.

3. Mediation Analysis

To further examine the underlying mechanism linking supply chain digitalization and supply chain performance, mediation analysis was conducted using bootstrapping procedures with 5,000 resamples.

The mediation results are presented in Table 5.

Table 5 Mediation Analysis Results

Path	Indirect Effect	p-value	95% CI	Result
SCD $\rightarrow$ SCC $\rightarrow$ SCP	0.148	0.002	[0.076, 0.221]	Supported

The results indicate that the indirect relationship between supply chain digitalization and supply chain performance through collaboration capability is statistically significant. The confidence interval does not include zero, confirming the presence of a mediation effect. This finding suggests that supply chain digitalization is associated with improved supply chain performance not only directly, but also indirectly through enhanced collaboration capability. In other words, digital technologies may contribute to better supply chain outcomes by strengthening coordination, communication, and collaborative relationships among supply chain partners. The findings therefore support the important

mediating role of collaboration capability in the relationship between supply chain digitalization and supply chain performance.

4. Moderation Analysis

Moderation analysis was performed to assess whether environmental uncertainty changes the strength of the relationship between supply chain digitalization and collaboration capability. The interaction effect between supply chain digitalization and environmental uncertainty was examined using the interaction term included in the structural model. The moderation analysis results are presented in Table 6.

Table 6 Moderation Analysis Results

Hypothesis	Path	Std. β	C.R.	p-value	Result
H5	SCD $\times$ EU $\rightarrow$ SCC	0.121	2.214	0.027	Supported

The results indicate that environmental uncertainty positively moderates the relationship between supply chain digitalization and collaboration capability ($\beta = 0.121$, $p < 0.05$), supporting H5. This finding suggests that the positive relationship between digitalization and collaboration capability becomes stronger under higher levels of environmental uncertainty. In uncertain business environments, firms may rely more heavily on digital technologies to improve coordination, information sharing, and collaborative decision-making across supply chain networks. Figure 1 illustrates the moderating effect of environmental uncertainty on the relationship between supply chain digitalization and collaboration capability. The positive slope under high environmental uncertainty indicates that digitalization is more strongly associated with collaboration capability when environmental uncertainty is high.

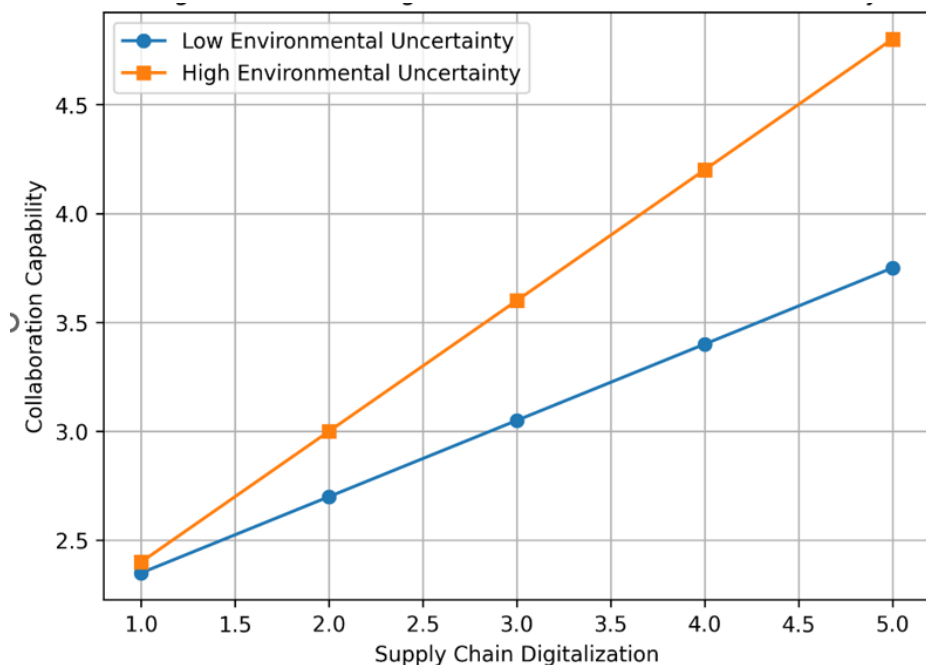


Figure 1 Moderating Effect of Environmental Uncertainty

5. Moderated Mediation Analysis

This study further examined whether environmental uncertainty moderates the indirect relationship between supply chain digitalization and supply chain performance through collaboration capability. Conditional indirect effects were estimated using bootstrapping procedures with 5,000 resamples at different levels of environmental uncertainty. The results are presented in Table 7.

Table 7 Moderated Mediation Analysis Results

Environmental Uncertainty	Indirect Effect	95% CI	Result
Low EU (-1 SD)	0.112	[0.051, 0.198]	Significant
High EU (+1 SD)	0.182	[0.097, 0.289]	Significant

The results indicate that the indirect relationship between supply chain digitalization and supply chain performance through collaboration capability becomes stronger under higher levels of environmental uncertainty. Specifically, the indirect effect under high environmental uncertainty ($\beta = 0.182$) is stronger than the indirect effect under low environmental uncertainty ($\beta = 0.112$). The confidence intervals for both conditions do not include zero, confirming the significance of the moderated mediation effect. These findings suggest that environmental uncertainty strengthens the effectiveness of digitalization and collaboration capability in improving supply chain performance. Firms operating in highly uncertain environments may therefore derive greater value from digital technologies and collaborative supply chain practices. Accordingly, the findings support H6 and provide additional evidence regarding the contingent role of environmental uncertainty in digital supply chain transformation.

6. Summary of Hypotheses Testing

Table 8 summarizes the results of the hypothesis testing conducted in this study.

Table 8 Summary of Hypotheses Testing

Hypothesis	Description	Result
H1	Supply chain digitalization is positively associated with supply chain performance.	Supported
H2	Supply chain digitalization is positively associated with supply chain collaboration capability.	Supported
H3	Supply chain collaboration capability is positively associated with supply chain performance.	Supported
H4	Supply chain collaboration capability mediates the relationship between supply chain digitalization and supply chain performance.	Supported

	Environmental uncertainty positively moderates	
H5	the relationship between supply chain digitalization and collaboration capability.	Supported
	Environmental uncertainty positively moderates	
H6	the indirect relationship between supply chain digitalization and supply chain performance through collaboration capability.	Supported

Overall, the findings provide substantial support for the proposed moderated mediation framework. The results suggest that supply chain digitalization is positively associated with supply chain performance both directly and indirectly through collaboration capability, and that these relationships become stronger under conditions of higher environmental uncertainty.

Discussion

The findings of this study provide important insights into the relationship between supply chain digitalization, collaboration capability, environmental uncertainty, and supply chain performance in the context of Chinese manufacturing firms. First, the results indicate that supply chain digitalization is positively associated with supply chain performance. This finding is consistent with prior studies suggesting that digital technologies improve operational visibility, information sharing, coordination efficiency, and responsiveness within supply chain activities (Dubey et al., 2019; Zhou et al., 2023). The results further suggest that digital transformation has become an important strategic approach for manufacturing firms seeking to improve operational effectiveness under increasingly dynamic business environments. Second, the findings demonstrate that supply chain digitalization is positively associated with collaboration capability. Digital technologies facilitate communication, real-time information exchange, and coordination among supply chain partners, thereby strengthening

collaborative relationships and improving joint decision-making processes. This finding supports the information processing theory (IPT) perspective that digital technologies enhance firms' information processing capacity and coordination capability under conditions of uncertainty. Third, collaboration capability was found to be positively associated with supply chain performance and to partially mediate the relationship between digitalization and performance. This finding suggests that digital technologies alone may not automatically generate performance benefits unless firms simultaneously develop organizational capabilities that allow them to effectively utilize digital resources. The result therefore supports the resource-based view (RBV), which emphasizes that organizational capabilities play an important role in transforming technological resources into performance outcomes. The results also indicate that environmental uncertainty positively moderates the relationship between supply chain digitalization and collaboration capability. Under highly uncertain environments, firms appear to rely more heavily on digital technologies to strengthen coordination, information sharing, and collaborative decision-making across supply chain networks. In addition, the moderated mediation analysis demonstrates that the indirect effect of digitalization on performance through collaboration capability becomes stronger under higher levels of environmental uncertainty. The findings also suggest that the effectiveness of digitalization should not be viewed as universally beneficial across all organizational contexts. While digital technologies may improve coordination and information processing, their performance implications appear to depend heavily on environmental conditions and organizational capabilities. This finding challenges overly deterministic views of digital transformation and suggests that digitalization alone may not guarantee superior performance outcomes. This finding contrasts with technology-deterministic perspectives that assume digital transformation automatically leads to performance improvement. Instead, firms must develop

complementary organizational capabilities, such as collaboration capability, to fully realize the value of digital investments. This study provides several important theoretical implications. First, it extends the supply chain digitalization literature by integrating mediation and moderation perspectives within a unified analytical framework. Unlike previous studies that primarily focus on direct effects, this study explains both how and under what conditions digitalization contributes to supply chain performance. Second, this study contributes to the resource-based view (RBV) by emphasizing that digital technologies alone may not be sufficient to generate performance advantages. Instead, organizational capabilities such as collaboration capability are necessary to transform digital resources into operational outcomes. Third, this study advances information processing theory (IPT) by demonstrating that environmental uncertainty changes the effectiveness of digitalization and collaboration mechanisms. The findings therefore highlight the contingent nature of digital transformation in supply chains, suggesting that the value of digitalization depends heavily on external environmental conditions.

Conclusion

This study examined the relationship between supply chain digitalization and supply chain performance, with particular emphasis on the mediating role of collaboration capability and the moderating effect of environmental uncertainty in Chinese manufacturing firms. By integrating the resource-based view (RBV) and information processing theory (IPT), this study developed a moderated mediation framework to explain both how and under what conditions digitalization contributes to supply chain performance. The findings indicate that supply chain digitalization is positively associated with both collaboration capability and supply chain performance. In addition, collaboration capability partially mediates the relationship between digitalization and performance,

suggesting that digital technologies create value not only directly but also indirectly through organizational capability development. The results further demonstrate that environmental uncertainty strengthens the relationship between supply chain digitalization and collaboration capability, as well as the indirect effect of digitalization on performance. This study makes several important contributions to the literature. First, it extends existing research on supply chain digitalization by integrating mediation and contingency perspectives within a unified analytical framework. Second, it highlights the important role of collaboration capability in transforming digital resources into operational outcomes. Third, the findings provide empirical evidence from the Chinese manufacturing context, where digital transformation and environmental uncertainty are becoming increasingly significant. Despite these contributions, this study has several limitations. The use of cross-sectional data limits the ability to establish causal relationships, and the reliance on self-reported questionnaire data may introduce potential response bias. Future research may employ longitudinal designs, objective performance indicators, and comparative cross-country analyses to further examine the dynamic relationship between digitalization, organizational capabilities, and supply chain performance. Overall, this study provides a more comprehensive understanding of how supply chain digitalization creates value in manufacturing supply chains and offers a useful foundation for future research on digital transformation and capability development in supply chain management.

Recommendation

Based on the findings of this study, manufacturing firms should strengthen digital transformation initiatives and invest in collaborative supply chain practices to improve operational performance. Managers should prioritize digital integration, real-time information sharing, and inter-organizational coordination,

particularly under conditions of high environmental uncertainty. In addition, firms should focus not only on technological investment, but also on the development of organizational capabilities that support collaboration and communication across supply chain partners. Building strong collaboration capability may help organizations better utilize digital technologies and respond more effectively to environmental changes and operational disruptions. Managers should also recognize that the effectiveness of digitalization depends on organizational and environmental conditions. Firms operating in highly uncertain environments may benefit more significantly from digital technologies and collaborative supply chain practices. Therefore, organizations should adopt flexible digital strategies that align with changing environmental demands and supply chain complexity. Policymakers and industry practitioners may further encourage digital supply chain development through technological support programs, digital infrastructure investment, and training initiatives that enhance firms' digital and collaborative capabilities. Strengthening digital ecosystems and promoting inter-organizational collaboration may contribute to more resilient and competitive manufacturing supply chains.

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