



Modeling the Digital Foundations of Supply Chain Resilience: A Firm-Level Theoretical Framework

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Abstract. In an era characterized by rising supply chain uncertainty and increasingly frequent external shocks, strengthening supply chain resilience has become fundamental to ensuring firms' operational stability and sustaining long-term competitiveness. Using panel data on Chinese A-share listed firms from 2009 to 2024, this study investigates whether digital transformation can effectively enhance supply chain resilience. Digital transformation is captured through the frequency of established digitalization-related keywords in annual reports, and supply chain resilience is proxied by days of inventory outstanding. Based on a two-way fixed effects model, the empirical results indicate that digital transformation significantly shortens inventory cycles, reflecting marked improvements in supply chain efficiency and responsiveness. This finding remains robust after excluding years affected by major macroeconomic shocks, removing observations from municipalities, and employing a balanced panel. Further heterogeneity analysis shows that the positive impact of digital transformation is stronger for firms with lower financial constraints, larger scale, those operating in high-tech industries, and those located in more developed eastern regions. Overall, the results underscore the pivotal role of digital capabilities in bolstering supply chain resilience and provide valuable policy insights for advancing differentiated digital strategies and fostering more resilient supply chain systems.

Keywords: Digital transformation; Supply chain resilience; Textual analysis; Inventory efficiency; Firm heterogeneity; Chinese listed firms

1 Introduction

In the context of cyclical global economic volatility and rising geopolitical uncertainty, corporate supply chain systems are facing unprecedented pressure (Aljabhan, 2023^[1]). Since the 2008 global financial crisis, supply chain networks have become increasingly interconnected. While this interconnectedness has improved resource allocation efficiency, it has also exposed structural vulnerabilities such as “single-point dependence,” “global risk propagation,” and “chain fragility.” Recent events—including China–U.S.

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trade frictions, the COVID-19 pandemic, disruptions in international logistics, and regional conflicts—have further highlighted the speed and breadth of supply chain risk transmission. As a result, supply chain resilience has become a core capability for firms seeking to maintain operational continuity, stability, and competitiveness. For enterprises, supply chain resilience reflects not only their ability to withstand and recover from unexpected disruptions but also their capacity to maintain resource allocation efficiency, stabilize production rhythms, and ensure market supply under complex conditions. Its importance has thus risen beyond traditional operations management and evolved into a central issue in strategic management and risk governance (Kano et al., 2022^[2]; Rashid et al., 2024^[3]).

Meanwhile, a new wave of technological revolution driven by digital technologies is reshaping organizational structures and supply chain management paradigms. Digital transformation has become a critical pathway for firms to reconstruct production systems, optimize decision-making processes, and enhance resource coordination capabilities, and it is increasingly integrated into various stages of supply chain operation (Alvarenga et al., 2023^[4]). Technologies such as big data, cloud computing, the Internet of Things, and artificial intelligence have significantly improved supply chain visibility, strengthened risk monitoring, and enhanced response speed, thereby providing the technical foundation for improving supply chain resilience (Liu et al., 2023^[5]). Theoretically, digitalization can enhance supply chain robustness and recovery capacity by improving visualization, facilitating cross-organizational data sharing, strengthening flexible production and intelligent scheduling, and optimizing supplier management (Ding and Chen, 2025^[6]). However, despite extensive evidence showing the positive impact of digitalization on operational performance, considerable debate and research gaps remain regarding whether—and through what mechanisms—digital transformation enhances supply chain resilience.

Existing studies reveal three main limitations. First, most research focuses on the industry or supply chain network level, with relatively little attention to the micro-level behaviors and organizational capabilities of individual firms; thus, large-sample, firm-level evidence remains scarce (Wiedmer and Griffis, 2021^[7]). Second, much of the literature relies on surveys or case studies, which, although helpful in revealing underlying mechanisms, are insufficient for verifying the actual effects of digitalization on a broader scale (Tan et al., 2023^[8]). Third, measurement of digital transformation remains underdeveloped, as many studies lack indicators that accurately capture firms' strategic orientation and digital capability deployment, leading to limitations in measurement precision (Gradillas and Thomas, 2025^[9]). Therefore, it is necessary to combine real operational and textual data to construct more representative digitalization indicators and systematically examine the actual impact of digital transformation on supply chain resilience.

Against this backdrop, this study uses Chinese A-share listed firms from 2009 to 2024 as the research sample and adopts widely used textual analysis methods to extract digitalization-related keywords from annual reports to construct a firm-level digital transformation indicator. Meanwhile, days of inventory outstanding are employed as an observable proxy for supply chain resilience. This study empirically investigates

whether and to what extent digital transformation affects supply chain resilience. Compared with existing literature, the contributions of this study are threefold. First, it adopts a large-scale, long-span micro-level dataset to improve measurement accuracy and empirical reliability in digitalization research within the supply chain domain. Second, it introduces supply chain resilience into the digital transformation research framework, enriching the understanding of how digitalization influences firms' operational quality and risk management capabilities. Third, through multiple robustness checks and contextual heterogeneity analyses, the study reveals substantial differences in the effects of digital transformation across firms with varying resource endowments, industry characteristics, and regional environments, offering targeted policy implications for promoting differentiated digital strategies and improving digital governance in supply chain systems.

2 Theoretical Analysis

Supply chain resilience reflects the stability, flexibility, and efficiency of a firm's supply chain operations, and is largely manifested through its inventory efficiency, coordination capacity, and resource allocation capability. A resilient supply chain maintains stable operations under normal conditions and exhibits strong adaptability when confronted with variability in demand, supply fluctuations, or process uncertainties. Inventory turnover, as captured by days of inventory outstanding (DIO), is one of the most direct and observable indicators of supply chain performance. Lower DIO implies higher inventory efficiency and, consequently, greater supply chain resilience. With the advancement of digital technologies, firms increasingly rely on digital transformation to improve data processing capability, enhance coordination, optimize inventory decisions, and streamline operational processes, thereby strengthening their supply chain resilience.

To formally illustrate the relationship between digital transformation and supply chain resilience, this study develops a simplified theoretical model grounded in inventory efficiency. Let supply chain resilience be denoted by SCR, inventory efficiency by DIO, and the firm's digital transformation level by D . Digital transformation is assumed to enhance the firm's coordination capability, forecasting accuracy, and operational visibility, all of which help reduce inventory days and improve supply chain performance.

Let the firm's inventory days be represented as:

$$DIO = g(C) \quad (1)$$

where C denotes the firm's overall capability in supply chain coordination and inventory management. Digital transformation strengthens this capability, such that:

$$C = C_0 + \beta D \quad (2)$$

where $\beta > 0$ captures the positive effect of digital transformation on operational capability. Substituting Equation (2) into Equation (1) yields:

$$DIO = g(C_0 + \beta D) \quad (3)$$

Assuming that improved inventory management reduces inventory days and that the marginal effect diminishes over time, we have $g'(\cdot) < 0$. Therefore, the effect of digital transformation on inventory days is:

$$\frac{\partial DIO}{\partial D} = g'(C_0 + \beta D) \cdot \beta < 0 \quad (4)$$

Equation (4) shows that a higher level of digital transformation reduces inventory days, meaning that inventory efficiency improves.

Supply chain resilience is defined as the inverse of inventory days, reflecting that lower DIO corresponds to stronger resilience:

$$SCR = \frac{1}{DIO} \quad (5)$$

Differentiating with respect to D yields:

$$\frac{\partial SCR}{\partial D} = -\frac{1}{DIO^2} \cdot \frac{\partial DIO}{\partial D} > 0 \quad (6)$$

Equation (6) demonstrates that digital transformation enhances supply chain resilience through its effect on inventory efficiency.

Based on this theoretical foundation, the study proposes the following hypothesis:

Hypothesis: Digital transformation significantly enhances firms' supply chain resilience.

3 Study Design

3.1 Samples and Data

This study selects Chinese A-share firms listed on the Shanghai and Shenzhen stock exchanges from 2009 to 2024 as the research sample, with the initial data obtained from the China Stock Market and Accounting Research (CSMAR) database. To ensure the reliability, continuity, and comparability of the sample, the following screening procedures are implemented: (1) firms in the financial industry and those designated as ST, *ST, or PT are excluded; (2) observations with missing values in key variables or evidently abnormal data are removed; and (3) all continuous variables are winsorized at the 1% level in both tails to mitigate the influence of extreme values. After applying these criteria, the final dataset consists of 22,241 firm-year observations.

3.2 Definition of Variables

Dependent Variable.

Supply chain resilience (SCR) refers to a firm's ability to maintain operations or rapidly restore normal functioning when confronted with supply disruptions, demand fluctuations, or other internal and external uncertainties. Common managerial practices

that enhance resilience include building redundant inventory, developing backup suppliers, cultivating alternative markets, maintaining production flexibility, and optimizing the allocation of resources. In exploring quantitative approaches, existing studies generally acknowledge that performance indicators are important tools for evaluating the effectiveness of managerial actions. Consequently, a growing body of literature attempts to link supply chain resilience to observable performance metrics. Specifically, indicators such as days of inventory outstanding (DIO) directly reflect the efficiency of inventory turnover and the speed of inventory monetization, thereby providing intuitive insight into the daily operational performance of the supply chain and its inherent capability to respond to uncertainty. Numerous studies have shown that horizontal or longitudinal comparisons of inventory cycles can effectively assess the overall capacity and robustness of a supply chain (Al-Hakimi et al., 2022^[10]; Dubey et al., 2023^[11]; Sharma et al., 2025^[12]). Based on this rationale, this study adopts DIO as the core proxy measure for firm-level supply chain resilience.

Independent Variable.

Digital transformation represents a key strategic initiative for firms to adapt to the new era and achieve high-quality development. Such strategic intentions and implementation characteristics are typically reflected in annual reports, which serve as comprehensive documents summarizing a firm's operations, outlining future plans, and conveying managerial priorities. The textual content and linguistic patterns of annual reports can reveal a firm's strategic focus, forward-looking orientation, and underlying managerial philosophy, thereby mapping the development path shaped by its strategic intent. Accordingly, extracting the frequency of keywords related to "digital transformation" from listed firms' annual reports provides a theoretically sound and methodologically feasible proxy for measuring the degree of digital transformation. Following existing studies (Chwiłkowska et al., 2023^[13]; Fang and Liu, 2024^[14]), this paper constructs the digital transformation indicator (Digital) based on the total frequency of digitalization-related keywords identified in annual reports, and applies a log-transformation after adding one to the raw frequency.

Control Variables.

To account for firm heterogeneity and mitigate potential omitted variable bias, this study incorporates a comprehensive set of control variables into the regression model. In terms of firm characteristics, we include firm size (Size), firm age (Age), leverage (Lev), asset tangibility (Tang), and capital intensity (CapInt). Regarding operating performance, we control for return on assets (Roa), Tobin's Q (TobinQ), and revenue growth (Growth). For corporate governance, the largest shareholder's ownership (Top1), board size (Board), managerial ownership (ManHold), and CEO duality (DUAL) are included. With respect to external monitoring, we incorporate an indicator for Big Four audits (AUDIT) and the institutional ownership ratio (InsHold). Together, these variables capture differences in firms' fundamentals, financial performance, internal governance structures, and external oversight environments, thereby reducing

confounding effects on the relationship between digital transformation and supply chain resilience.

3.3 Model Setting and Descriptive Statistics

Model Setting.

To examine the impact of digital transformation on firms' supply chain resilience, this study constructs the following two-way fixed effects regression model:

$$SCR_{i,t} = \alpha + \beta DIGI_{i,t} + \gamma X_{i,t} + \delta_i + \theta_t + \varepsilon_{i,t} \quad (7)$$

where $SCR_{i,t}$ denotes the supply chain resilience of firm i in year t ; $DIGI_{i,t}$ represents the level of digital transformation; $X_{i,t}$ is a vector of control variables; δ_i captures firm fixed effects to control for unobservable time-invariant firm characteristics; θ_t represents year fixed effects to account for macroeconomic fluctuations and time trends; and $\varepsilon_{i,t}$ is the error term. The key coefficient, β , reflects the marginal impact of digital transformation on supply chain resilience. This model allows for the simultaneous control of time and individual heterogeneity, thereby reducing estimation bias arising from omitted variables.

Descriptive Statistics.

To gain a comprehensive understanding of the basic relationships between digital transformation and supply chain resilience, this study conducts descriptive statistical analyses of the main variables, as presented in Table 1. Overall, the dependent variable—days of inventory outstanding (SCR)—has a mean of 4.3874 and a standard deviation of 1.0871, with values ranging from 0.3787 to 7.2440. This indicates substantial variation in supply chain efficiency and operational robustness across firms. Such differences reflect variations in industry characteristics and strategic choices, as well as heterogeneity in digital capabilities, operational models, and supply chain structures, thereby providing a meaningful foundation for the subsequent empirical analysis.

The digital transformation indicator (DIGI) has a mean of 1.0897 and a standard deviation of 1.2090, with values ranging from 0 to 4.7536, suggesting significant disparities in digital development levels among firms. While some firms have advanced substantially in their digital initiatives and mention related concepts frequently in their annual reports, others remain at the early stages of digitalization. This variation offers an appropriate basis for identifying the impact of digital transformation on supply chain resilience.

Table 1. Descriptive statistics

	N	Mean	Sd	Min	P50	Max
SCR	22241	4.3874	1.0871	0.3787	4.4892	7.2440
DIGI	22241	1.0897	1.2090	0.0000	0.6931	4.7536
Size	22241	22.5392	1.2610	19.8980	22.3551	26.6814
Roa	22241	0.0402	0.0520	-0.2152	0.0366	0.2225

Age	22241	2.9861	0.3226	1.3863	3.0445	3.7136
Lev	22241	0.4358	0.1844	0.0518	0.4349	0.9092
Tang	22241	0.9309	0.0757	0.5058	0.9547	1.0000
TobinQ	22241	1.8990	1.1100	0.7656	1.5460	9.5402
Growth	22241	0.1246	0.2928	-0.6535	0.0865	2.2755
CapInt	22241	2.1891	1.6946	0.3212	1.7369	13.1931
Top1	22241	34.7150	14.9620	8.0200	32.5900	76.4400
Board	22241	2.2204	0.2327	1.6094	2.1972	2.8904
ManHold	22241	0.1097	0.1778	0.0000	0.0033	0.6867
DUAL	22241	0.2499	0.4329	0.0000	0.0000	1.0000
AUDIT	22241	0.0737	0.2613	0.0000	0.0000	1.0000
InsHold	22241	45.9374	24.4349	0.0485	48.1125	93.0852

Notes: Table 1 provides the descriptive statistics for all variables, including explanatory variables, dependent variables, and control variables.

4 Empirical Results

4.1 Benchmark Regression

To examine the overall impact of digital transformation on supply chain resilience, this study employs a two-way fixed effects model and sequentially incorporates firm characteristics, operating performance, corporate governance, and external monitoring variables. Table 2 reports the benchmark regression results. Across all model specifications, the coefficient of the key explanatory variable DIGI remains significantly negative. Since this study uses days of inventory outstanding (DIO) as a reverse indicator of supply chain resilience—where a lower value indicates higher supply chain efficiency and stronger resilience—a negative coefficient implies that digital transformation significantly improves firms' supply chain resilience.

In Model (1), without any control variables, the coefficient of DIGI is already significantly negative, suggesting that digitalization itself exerts a direct influence on supply chain operational efficiency. After adding firm and year fixed effects in Model (2), the coefficient remains stable and significant, indicating that the effect is not driven by time-invariant firm characteristics or macroeconomic trends.

Models (3) through (5) further include controls for firm size, leverage, asset structure, profitability, growth, governance characteristics, and external monitoring. The coefficient of DIGI consistently remains negative at the 1% significance level, with only minor changes in magnitude. This demonstrates that digital transformation enhances supply chain resilience independently of firms' fundamental attributes and exhibits strong robustness. In other words, even after accounting for a wide range of factors that may affect supply chain operations, the increased information transparency, process optimization, and cross-organizational coordination enabled by digitalization continue to significantly reduce inventory cycles and strengthen firms' supply chain responsiveness and buffering capacity.

Table 2. Benchmark regression results

Variables	(1)	(2)	(3)	(4)	(5)
	SCR	SCR	SCR	SCR	SCR
DIGI	-0.027*** (-4.42)	-0.026*** (-5.03)	-0.023*** (-4.34)	-0.019*** (-3.80)	-0.020*** (-3.98)
Size			-0.022** (-2.09)	-0.069*** (-6.65)	-0.053*** (-4.89)
Roa			-0.528*** (-5.25)	0.236** (2.36)	0.290*** (2.89)
Age			-0.037 (-0.61)	0.126** (2.09)	0.089 (1.47)
Lev			0.264*** (6.21)	0.398*** (9.64)	0.379*** (9.16)
Tang			0.565*** (6.98)	0.653*** (8.34)	0.633*** (8.09)
TobinQ			-0.026*** (-5.14)	-0.015*** (-3.09)	-0.008 (-1.63)
Growth			-0.122*** (-9.33)	-0.045*** (-3.53)	-0.039*** (-3.07)
CapInt				0.150*** (36.87)	0.150*** (37.01)
Top1				-0.000 (-0.11)	0.002** (2.39)
Board				-0.002 (-0.11)	0.004 (0.19)
ManHold				0.355*** (6.80)	0.239*** (4.35)
DUAL					-0.009 (-0.75)
AUDIT					0.133*** (4.64)
InsHold					-0.003*** (-6.87)
Constant	4.416*** (450.23)	4.416*** (674.46)	4.464*** (14.60)	4.465*** (14.61)	4.301*** (13.99)
Firm FE	No	Yes	Yes	Yes	Yes
Year FE	No	Yes	Yes	Yes	Yes
Observations	22,241	22,241	22,241	22,241	22,241
R-squared	0.00	0.82	0.82	0.83	0.83

Notes: ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively. t-statistics are reported in parentheses beneath each coefficient.

4.2 Robustness Test

To ensure the reliability of the benchmark regression results, this study conducts robustness tests from three perspectives: sample structure, regional characteristics, and panel settings. The results are presented in Table 3. Overall, the sign and significance of the digital transformation variable (DIGI) remain consistent across the different tests, further confirming that digital transformation significantly enhances firms' supply chain resilience.

First, recognizing that major macroeconomic events may introduce systematic shocks to firms' operations and supply chain performance—such as the stock market volatility in 2015, the escalation of China–U.S. trade tensions in 2018, and the outbreak of COVID-19 in 2020—this study excludes these years and re-estimates the model. The coefficient of DIGI remains significantly negative, indicating that the positive effect of digital transformation on supply chain resilience is not driven by specific macro events but exhibits strong generalizability and structural stability.

Second, municipalities such as Beijing, Shanghai, Tianjin, and Chongqing possess distinct advantages in economic structure, digital infrastructure, policy environments, and access to supply chain resources, which may lead their firms to systematically differ in digital investment and supply chain performance. To eliminate such regional structural biases, the study excludes firms located in these municipalities. The coefficient of DIGI continues to be significantly negative, suggesting that the benchmark findings are not affected by regional exceptionalism.

Finally, a balanced panel is constructed to address potential bias arising from non-random sample entry and exit. For example, firms may enter the market in different years or have missing observations, resulting in an unbalanced panel that could influence the stability of the estimates. Even under the stricter balanced panel setting, the coefficient of DIGI remains significantly negative, despite the reduction in sample size, indicating that the results are robust to concerns regarding sample structure.

Taken together, the three robustness tests consistently support the benchmark regression findings: digital transformation significantly enhances firms' supply chain resilience. Regardless of sample period adjustments, regional exclusions, or balanced panel construction, the role of digitalization in improving supply chain efficiency and strengthening resilience remains stable and credible.

Table 3. Robustness test

Variables	(1)	(2)	(3)
	SCR	SCR	SCR
DIGI	-0.023*** (-3.96)	-0.012** (-2.20)	-0.027** (-2.51)
Constant	4.121*** (12.15)	4.269*** (12.74)	5.344*** (7.14)
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	17,900	18,067	4,576
R-squared	0.83	0.83	0.79

4.3 Heterogeneity Analysis

To further investigate whether the impact of digital transformation on supply chain resilience differs across firms with varying internal characteristics and external environments, this study conducts heterogeneity analyses along four key dimensions: financial constraints, firm size, industry technological intensity, and regional development level. As reported in Table 4, the results reveal notable cross-group differences, indicating that firms' resource endowments, digital infrastructure foundations, managerial capabilities, and market conditions systematically shape the extent to which digital transformation strengthens supply chain resilience.

First, the effects vary markedly with financial constraints. Among firms with low financing frictions, the coefficient of DIGI is significantly negative, suggesting that these firms are better positioned to invest in digital infrastructure and adopt digital tools that enhance supply chain visibility and operational flexibility. In contrast, the effect becomes insignificant for highly constrained firms, where limited capital and managerial resources reduce the likelihood of substantive digitalization efforts.

Second, firm size produces another clear pattern of heterogeneity. Digital transformation significantly improves supply chain resilience for large firms, which typically possess stronger digital foundations, superior absorptive capacity for new technologies, and more sophisticated supply chain management systems. Conversely, smaller firms frequently encounter constraints in capital, digital talent, and organizational routines, limiting the potential for digitalization to generate measurable improvements in supply chain performance.

Third, digital transformation exhibits differentiated effects across industries. In high-tech industries, where supply chains are more complex, data-intensive, and sensitive to technological changes, digital tools provide greater marginal benefits by enabling real-time monitoring and rapid response capabilities. However, the effect is not significant among low-tech industries, whose production processes tend to be more stable, less digitalized, and less dependent on advanced information systems.

Finally, regional development levels further condition the effectiveness of digital transformation. Firms located in the eastern region benefit from superior digital infrastructure, denser supply chain networks, and more supportive institutional environments, resulting in a significant improvement in supply chain resilience. In contrast, firms in western regions may face infrastructural and ecosystem limitations that hinder the effective utilization of digital technologies.

Although the heterogeneity analysis covers multiple firm- and region-level dimensions, the current findings primarily reflect separate subgroup comparisons. Future research could refine these insights by examining joint heterogeneity patterns and testing for interaction effects across key firm characteristics. For instance, the interplay between firm size and industry technological intensity may jointly influence the returns to digital transformation: large firms in high-tech industries may experience reinforcing advantages in digital capability building, ecosystem connectivity, and operational flexibility, whereas small firms in low-tech industries may encounter layered constraints that diminish the benefits of digitalization. Incorporating interaction-term models or

multi-dimensional heterogeneity frameworks would therefore provide a more comprehensive understanding of how internal capabilities and external technological contexts jointly shape the resilience-enhancing effects of digital transformation.

Table 4. Heterogeneity analysis

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	SCR	SCR	SCR	SCR	SCR	SCR	SCR	SCR
	High FC	Low FC	Large Size	Small Size	High Tech	Low Tech	West	East
DIGI	-0.002 (-0.27)	-0.035*** (-4.81)	- 0.025*** (-3.51)	-0.006 (-0.97)	-0.013** (-2.20)	0.004 (0.51)	0.009 (0.92)	- 0.032*** (-5.38)
Constant	4.005*** (9.64)	5.290*** (4.56)	2.964*** (5.37)	1.186** (2.40)	3.562*** (9.51)	3.286*** (3.74)	4.235*** (7.73)	3.938*** (10.44)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11,262	10,979	9,775	12,466	14,638	7,603	6,872	15,369
R-squared	0.89	0.87	0.88	0.85	0.86	0.91	0.84	0.83

5 Conclusions and Suggestions

Based on panel data of Chinese A-share listed firms from 2009 to 2024, this study systematically examines the impact of digital transformation on supply chain resilience. The empirical results indicate that digital transformation significantly reduces days of inventory outstanding, suggesting that digitalization helps improve supply chain efficiency and firms' ability to manage risks. The negative and significant coefficient of the digitalization variable remains stable across specifications, regardless of whether firm characteristics, operating performance, and corporate governance controls are included. This conclusion is further supported by robustness tests that exclude major event years, remove municipality samples, and construct a balanced panel.

The heterogeneity analysis shows that the effect of digital transformation is not uniform across firms and regions. Digitalization significantly enhances supply chain resilience among firms with low financial constraints, large firm size, high technological intensity, and those located in the eastern region with more advanced digital infrastructure. However, the effect is relatively limited for financially constrained firms, small firms, and those in regions with weaker infrastructure. These findings suggest that the value of digital transformation depends on firms' resource endowments, technological conditions, and external environments.

Based on these results, firms should regard digital transformation as a key approach to strengthening supply chain stability and flexibility. Efforts should be made to improve data governance, promote process digitalization, enhance supplier coordination, and develop risk monitoring mechanisms. Small and resource-constrained firms, in particular, should prioritize digitalization in critical supply chain processes to maximize the benefits of limited investments. At the policy level, governments should further

improve digital infrastructure and provide differentiated support measures based on firm size, industry characteristics, and regional development conditions. Such efforts will help create a more favorable environment for building resilient supply chain systems.

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