Supply Chain Resilience Impact on Enterprise Digital Technology Innovation: Dual Perspectives of Absorptive Capacity and Adaptability

Ouze Yang, Qiannan Du *

School of Management Engineering and Business, Hebei University of Engineering, Handan, China, 056009

* Corresponding Author Email: dqn1111@163.com

Abstract. Under the impact of multiple uncertainties such as geopolitical conflicts and financial risks, the construction of supply chain resilience has become a primary strategic goal for the survival of enterprises, but an acute paradox is increasingly prominent: when enterprises strive to build a risk-resistant "resilient armor", this protection system may become a hidden shackle that stifles digital technology innovation. Utilizing panel data from Chinese listed firms (2013-2023), this research examines how supply chain resilience (SCR) shapes enterprise digital innovation through the integrated lens of dynamic capability theory, dissecting transmission mechanisms at the capability-microstructure nexus. The study finds that supply chain resilience enhances the enterprise's digital technology innovation level by improving its absorption capacity and adaptive capacity, thereby strengthening the enterprise's ability to respond quickly to environmental changes and coordinate the configuration of resources. Behaviorally, patient capital holders exhibit a neglect of innovation risk premium and demand excessive returns for digital innovation exposures, leading to an equilibrium of underfunding. When enterprises obtain more patient capital, they tend to invest in projects with stable returns, thereby reducing the enterprise's firm digital innovation capability. In addition, this study breaks through the limitations of traditional single-dimensional indicators and constructs a comprehensive index through resistance, recovery, operations, supply and demand matching, and renewal capabilities to more accurately capture supply chain resilience, while also revealing the influencing factors of innovation and development in the manufacturing industry.

Keywords: Supply chain resilience, Digital technology innovation, Absorptive capacity, Adaptability, Patient capital.

1. Introduction

In the face of multiple uncertainties such as the restructuring of global value chains, geopolitical conflicts, and extreme weather events, supply chain disruptions have become a routine crisis for businesses. Enhancing supply chain resilience has thus been identified as a lifeline for business survival. This can be achieved through optimized resource allocation and information coordination, thereby strengthening a company's ability to adapt to and recover from shocks, and helping it gain a competitive edge in digital transformation [1]. However, a significant paradox exists: while companies strive to build a “resilience armor” to withstand external shocks, this protective system designed for survival may inadvertently evolve into a barrier that stifles future growth, becoming an invisible shackle on digital technology innovation. Traditional resilience strategies adopted by enterprises to withstand shocks, such as simplifying supply chains and increasing buffer inventories, may stabilize operations in the short term but are prone to path dependence and rigid optimization, which weaken exploratory learning and suppress investment in digital technology innovation. For enterprises in emerging economies, this may also exacerbate the risk of being locked into low-end markets. Therefore, elucidating the intrinsic mechanisms through which supply chain resilience influences corporate digital technology innovation is of urgent practical importance for balancing corporate survival pressures with long-term competitiveness and addressing bottlenecks in high-quality economic development [2].

Supply chain resilience refers to the comprehensive ability of an enterprise to maintain the stability of the supply chain and recover quickly when facing external shocks [3]. A robust supply chain resilience equips enterprises to navigate volatile market conditions and safeguards industrial and supply chains by bolstering their autonomy and risk mitigation capabilities. Current literature primarily employs both quantitative and qualitative approaches to explore how resilience influences various outcomes, including enterprise performance and risk reduction. The partial least squares structural equation modeling (PLS-SEM) approach was applied by Rahman et al. to assess the effect of supply chain resilience orientation on sustainable performance in a B2B context [4]. Employing a case study approach, Makaci & Zouaghi examined the contribution of collaborative logistics pools to enhanced supply chain resilience within the retail sector. [5]. In addition, a mixed research design combining quantitative and qualitative methods has also been applied to the study of the impact of supply chain resilience. Ganesh Kumar R used a hybrid method SEM analysis with smart PLS to evaluate the impact of technological progress on supply chain management performance [6].

Building on this, the present research endeavors to examine the influence, transmission mechanisms, and boundary conditions through which resilience within supply networks shapes digital technology innovation in firms. From a theoretical perspective, it attempts to bridge the gap between resilience studies and innovation theory by drawing upon the resource-based view and dynamic capability perspective, thereby constructing an analytical model that illustrates how resilient supply networks can stimulate digital innovation by reconfiguring resources and dynamic structures, offering empirical evidence for advancing existing theoretical discourse. On the practical front, the findings are expected to provide enterprises with concrete guidance for addressing the "resilience–innovation" paradox in a turbulent environment. Specifically, the study sheds light on how organizations can strategically cultivate resilient supply networks that minimize disruption risks, enhance innovation vitality, and inform policy makers in designing mechanisms to strengthen industrial system security and foster the prosperity of the broader innovation ecosystem, highlighting significant managerial implications.

2. Research Hypotheses

Supply chain resilience helps enterprises better cope with changes in the external environment, reducing the uncertainty in the process of digital technology innovation. By establishing an effective risk warning and response mechanism, enterprises can carry out technology R&D and innovation experiments more calmly, reducing resource waste and project delays caused by emergencies, and thus improving the enterprise's digital technology innovation capability. A resilient supply chain can optimize the allocation of resources within and outside the enterprise, improve resource utilization efficiency, which enables enterprises to more effectively invest capital, talent and technology into digital technology innovation, and promote the smooth progress of innovation activities. In addition, supply chain resilience promotes information sharing and integration within and outside the enterprise, improves information transparency and response speed, which helps enterprises to grasp the market demand and technology development trends more accurately, and make wiser innovation decisions [7]. Supply chain resilience enhances the enterprise's ability to absorb external knowledge and technology. Enterprises can establish closer cooperation with suppliers, customers and other partners, and obtain more innovation resources and information, promoting the renewal of internal knowledge and the improvement of technological capabilities.

Dynamic capabilities, such as absorptive capacity and adaptability, can strengthen the positive influence of resilient supply networks on technological advancement by enhancing firms'agility in dealing with environmental uncertainty and improving the effectiveness of knowledge transformation. Organizations may establish broader information-sharing channels and employ advanced data analytics to promptly capture signals of market shifts, emerging technologies, and potential supply disruptions, thereby offering more precise guidance for digital innovation. Resilience within supply networks further allows enterprises to reorganize resources and adjust operating models more flexibly to remain competitive in volatile environments [8]. In this context, firms leverage digital tools to enhance supply chain operations, boost productivity, and explore new business models. Accordingly, Hypothesis 1 is formulated.

H1: Supply chain resilience has a significant positive promoting effect on the digital technology innovation of enterprises.

Patient capital usually denotes funds invested with a focus on creating long-term value rather than immediate returns. While such capital relieves short-term cash flow pressures, debt repayment obligations often reduce enterprises'risk appetite. Firms with access to long-term credit tend to preserve the status quo, which diminishes their responsiveness to supply fluctuations and lowers theurgency for innovation-driven exploration. In particular, when resilience within supply networks provides additional buffer capacity, organizations are more inclined to allocate resources toward expanding low-risk, conventional operations instead of investing in high-uncertainty technological innovation. This tendency undermines environmental scanning and weakens dynamic capabilities, ultimately restraining the vitality of innovation. Accordingly, Hypothesis 2 is proposed.

H2: Patience capital as a regulating variable negatively regulates the role of supply chain resilience on the digital technology innovation of enterprises.

3. Methodology/ empirical framework

3.1. Data description

This study takes the listed companies in the manufacturing industry of China's A-share market from 2013 to 2023 as the research object, and the data comes from CSMAR database, covering multi-dimensional information such as supply chain resilience, financial data and institutional shareholding. The sample selection follows the following principles: first, companies marked as ST/*ST with abnormal operations are excluded; second, financial industry companies are excluded; third, observations with missing core variables are excluded, and finally a unbalanced panel data is obtained. The supply chain resilience data comes from the company's annual report and supply chain management database, and is synthesized into a comprehensive indicator through five dimensions: recovery capability, operational capability, update capability, resistance capability and supply-demand matching capability; the digital technology innovation data is constructed through indicators such as R&D expenditure and patent authorization, among which the institutional shareholding data is used to measure patient capital, and the financial data extracts information on long-term liabilities such as notes payable and long-term borrowings to reflect the investment of innovation resources. All continuous variables are trimmed at the 1% level to control the interference of extreme values.

3.2. Variable definitions and assessment

This paper takes enterprise digital technology innovation (EDTI) as the dependent variable. Referencing the research of Tao Feng et al., and based on the "Digital Economy Core Industry Classification and International Patent Classification Reference Table (2023)" which provides patent IPC information in the field of digital technology, the IPC classification numbers of listed companies' invention patents are identified and matched [9]. If the IPC classification number belongs to the digital technology field IPC, it is considered a digital technology patent. Enterprise digitalization is measured using the average number of citations of digital invention patents. In the empirical analysis, the indicator data is reduced before regression.

The dependent variable of this research is supply chain resilience (SCR), which is evaluated based on the framework established by Su Zhifang et al. SCR is assessed across five key dimensions: resistance capability, recovery capability, operational capability, supply–demand matching capability, and renewal capability. The entropy weight method is employed to compute an overall measure of supply chain resilience for manufacturing firms. Specifically, resistance capability is quantified as the natural logarithm of the ratio of accounts receivable to core business revenue. Recovery capability is derived from residuals that reflect changes in corporate performance attributable to external influences [10]. Operational capability incorporates both accounts receivable and accounts payable turnover ratios; the latter is defined as the ratio of operating costs to the average accounts payable over the period, while the former is calculated as operating income divided by the average accounts receivable. Supply–demand matching capability is gauged by taking the natural logarithm of the absolute change in net inventory value relative to the prior period, serving as an indicator of inventory adjustment intensity. Renewal capability is measured as the natural logarithm of one plus the number of authorized invention patents. Finally, the entropy weight method is applied to integrate these five dimensions—resistance, recovery, operational, supply–demand matching, and renewal capabilities—to produce a comprehensive supply chain resilience score for manufacturing enterprises.

The adjusting variable is patient capital (DO). This article treats all bank loans as relationship-based debt, measuring patient capital by the proportion of relationship-based debt, while considering the long-term nature of relationship-based debt, and viewing the proportion of relationship-based debt as the share of bank long-term loans in total debt.

This study employs absorption capacity (Abs Cap) and adaptive capacity (Adap Cap) as its mediating variables. Absorption capacity is quantified using R&D expenditure intensity, which is defined as the ratio of a firm's annual R&D spending to its operating income. Adaptive capacity, on the other hand, is gauged by the coefficient of variation of the company's yearly expenditures in R&D, capital, and advertising. This metric reflects the flexibility of resource allocation, thereby serving as an indicator of adaptive capability. To ensure interpretive consistency—where higher values correspond to greater adaptive capacity—the coefficient of variation is negated. Thus, a larger adjusted value indicates stronger adaptive ability.

3.3. Model

This study uses a time-fixed effect regression model to verify the theoretical hypothesis, gradually introducing variables to construct a progressive testing framework:

$$DTI_{it}=\alpha_0+\alpha_1 SCR_{it}+\sum\gamma_k Controls_{it}+\varepsilon_{it}+\lambda_t \quad (1)$$

where i denotes an individual, t denotes the year, denotes the digital technology innovation of firm i in period t, denotes the supply chain resilience index of firm i in period t, denotes the set of control variables, the expected coefficient is significantly positive, denotes the constant term, denotes the random disturbance term, and k denotes the number of control variables.

Referring to existing literature on digital technology innovation in enterprises, the following control variables were introduced into the model: enterprise size (Size), debt-to-equity ratio (Lev), profitability (Roa), cash flow ratio (CF), and board size (Board).

4. Empirical analysis

4.1. Descriptive statistic analysis

Table 1 reports the descriptive statistics for the main variables. The mean value of supply chain resilience (SCR) is 0.169, with a range of 0.077 to 0.532, indicating that there are significant differences in the ability of enterprises to withstand supply chain disruptions, but the overall level still needs to be improved. Enterprise Digital Technology Innovation (EDTI) exhibits a highly right-skewed distribution: the mean of 65.144 contrasts sharply with the standard deviation of 376.507, and the difference between the maximum and minimum values is substantial. This aligns with the long-tail distribution pattern of digital technology innovation, where a small number of companies dominate core technological innovation activities.

Table 1. Descriptive statistical analysis

Variable	Obs	Mean	Std.Dev.	Min	Max
SCR	20265	0.169	0.042	0.077	0.532
EDTI	10666	65.144	376.507	0.000	13922.000
Size	21932	22.032	1.178	19.585	26.452
Lev	21932	0.380	0.190	0.035	0.908
ROA1	20363	0.045	0.066	-0.373	0.247
Cashflow	21932	0.052	0.066	-0.196	0.267
Board	21903	2.103	0.189	1.609	2.708

4.2. Baseline Estimate

The benchmark regression results in Table 2 systematically validate the promotional effect of supply chain resilience (SCR) on enterprise digital technology innovation (EDTI). In the base model without control variables, the SCR coefficient is 3.1211. After introducing firm-level variables, the coefficient stabilizes at 2.4157. Further controlling for annual fixed effects, the coefficient remains at 2.4957. This result indicates that even after controlling for firm heterogeneity and time trend interference, a 1-unit increase in SCR can sustainably drive approximately 2.50 units of EDTI growth, validating the theoretical expectation of Hypothesis H1. From the perspective of control variables, the coefficient for firm size is significantly positive, consistent with the resource-based theory's explanation of how economies of scale empower innovation. Meanwhile, the negative effect of board size suggests that governance structure complexity may inhibit innovation, aligning with agency cost theory—as decision-making chains lengthen, firms may become less willing to explore high-risk digital technologies.

Table 2. Benchmark regression results

	(1)	(2)	(3)	(4)
	EDTI1	EDTI1	EDTI1	EDTI1
SCR	3.1211***	2.4157***	3.2034***	2.4957***
	(0.09)	(0.11)	(0.09)	(0.11)
Size		0.0491***		0.0513***
		(0.00)		(0.00)
Lev		-0.0326		-0.0390
		(0.03)		(0.03)
ROA1		-0.1197		-0.0934
		(0.07)		(0.07)
Cashflow		-0.0442		-0.0613
		(0.07)		(0.07)
Board		-0.0750***		-0.1117***
		(0.02)		(0.02)
_cons	-0.4772***	-1.2642***	-0.4375***	-1.1809***
	(0.02)	(0.09)	(0.02)	(0.09)
N	9820	9819	9820	9819
R^2	0.111	0.126	0.123	0.139
adj. R^2	0.111	0.125	0.122	0.138
year	NO	NO	YES	YES

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.3. Mediation analysis

Table 3 presents the results of the mediation effect analysis. According to the findings, dynamic capability plays a significant mediating role between supply chain resilience and corporate digital technology innovation. The correlation coefficient between absorptive capacity and supply chain resilience is 10.1886, and it is significant at the 0.01 significance level, indicating that the absorptive capacity of dynamic capability enhances the positive impact of supply chain resilience on digital technology innovation. Adaptive capacity also exhibits a statistically significant positive relationship, with a coefficient of 1.1690, significant at $p < 0.01$, further confirming the important mediating role of adaptive capacity in this process.

Table 3. Intermediary mechanism test results

	(1)	(2)	(3)
	EDTI11	lnAbsCap	AdapCap
SCR	0.1917***	10.1886***	1.1690***
	(0.01)	(0.21)	(0.07)
Size	0.0045***	-0.2998***	-0.0222***
	(0.00)	(0.01)	(0.00)
Lev	-0.0041*	-1.0472***	-0.1586***
	(0.00)	(0.05)	(0.02)
ROA1	-0.0137**	-1.1689***	-0.0096
	(0.01)	(0.13)	(0.04)
Cashflow	-0.0065	-1.3371***	0.1351***
	(0.01)	(0.13)	(0.04)
Board	-0.0069***	-0.2915***	0.0101
	(0.00)	(0.04)	(0.01)
_cons	-0.1052***	2.3409***	-0.8072***
	(0.01)	(0.17)	(0.05)
N	8455	16956	17341
R^2	0.158	0.230	0.046
adj. R^2	0.156	0.230	0.045
year	YES	YES	YES

Standard errors in parentheses
*** $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$**

4.4. Moderation analysis

Based on the results of the moderation effect test in Table 4, this study introduces the interaction term between supply chain resilience and patient capital (SCR×DO) to examine the moderating effect of long-term capital structure. Empirical findings: The interaction term coefficient is -0.1563*, indicating that patient capital shows a statistically significant negative moderation effect on the "supply chain resilience—digital innovation" pathway. Specifically, in firms with high patient capital, the promotional effect of supply chain resilience on digital technology innovation is significantly weakened, while in firms with low patient capital, this effect is significantly enhanced. This phenomenon stems from the dual nature of patient capital: on the one hand, while long-term capital investment enhances risk-resilience, it may also suppress firms' motivation to convert resilience into short-term digital innovation due to rigid investment cycles and reduced tolerance for innovation returns; on the other hand, firms with low patient capital, which need to respond quickly to market changes, are more efficient at converting resilience capabilities into innovation outcomes. After controlling for variables such as firm size, financial leverage, cash flow, and governance structure, the moderating effect remains robust. The findings indicate that the composition of patient capital constitutes a critical boundary condition influencing the relationship between supply chain resilience and innovation efficiency. Its negative moderating effect reveals the inherent tension between long-term capital allocation and short-term innovation incentives, deepening our understanding of the institutional context for resilience transformation.

Table 4. Regression results of the adjustment mechanism

	(1)	(2)
	EDTI1	EDTI1
SCR	2.4674***	2.5062***
	(0.11)	(0.11)
Size	0.0554***	0.0560***
	(0.00)	(0.00)
Lev	-0.0133	-0.0169
	(0.03)	(0.03)
ROA1	-0.1090	-0.1130
	(0.07)	(0.07)
Cashflow	-0.0621	-0.0625
	(0.07)	(0.07)
Board	-0.1183***	-0.1202***
	(0.02)	(0.02)
DO	-0.1722***	-0.1563***
	(0.03)	(0.03)
SCR_DO		-3.0543***
		(0.67)
_cons	-1.2458***	-1.2569***
	(0.09)	(0.09)
N	9819	9819
R^2	0.142	0.144
adj. R^2	0.141	0.142

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5. Conclusions

This study shows that supply chain resilience significantly enhances a company's digital technology innovation capabilities by optimizing resource allocation. However, when relying on patient capital, it may trigger the paradox of “the armor becoming a shackle”—the constraints of long-term debt suppress innovation vitality, knowledge absorption capacity becomes the core transmission path, and environmental adaptability is inhibited due to the transfer of R&D resources. To address this paradox, companies should strengthen the transmission effects of absorption and adaptability, transforming supply chain resilience into an innovation driver. It is recommended that companies enhance their ability to identify and absorb high-value resources and respond to environmental changes to improve their supply chain's risk-response capabilities and drive technological innovation. At the same time, they should be vigilant about the inhibitory effects of patient capital, ensuring that long-term capital is directed toward supporting innovation. Furthermore, this study has limitations in terms of sample selection. The current sample does not include non-manufacturing enterprises. Future research could expand the sample scope to include non-manufacturing enterprises in the analytical framework, thereby enhancing the generalizability and external validity of the research conclusions.

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