Research on the Impact Mechanism of IoT Technology on Enterprise Supply Chain Resilience

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Abstract. Against the backdrop of escalating global supply chain risks and uncertainties, enhancing supply chain resilience has become a core strategic priority for enterprises and national industrial development. This paper focuses on the impact of IoT technology on enterprise supply chain resilience, using panel data of A-share listed companies from 2014 to 2024 to conduct an empirical analysis. The study reveals that IoT technology can significantly improve enterprise supply chain resilience through two key transmission mechanisms: promoting technological innovation and alleviating financing constraints. Heterogeneity analysis further shows that this effect is more pronounced in non-state-owned enterprises, enterprises in eastern regions, and technology-intensive enterprises. This research enriches the theoretical framework of IoT applications and supply chain resilience, and provides empirical evidence and decision-making references for enterprises to build resilient supply chains and for governments to formulate targeted industrial policies.

Keywords: IoT Technology, Supply Chain Resilience,Technological Innovation Introduction ,Literature Review

1 Introduction

Against the background of economic globalization and intensified geopolitical competition, global industrial and supply chains are facing severe risks and uncertainties. Improving supply chain resilience has become crucial for enterprises and countries. As a major manufacturing country, China regards supply chain resilience as a cornerstone of stable economic growth, high-quality development, national security, and the transition toward a manufacturing powerhouse.

The IoT strategy is a systematic management approach that uses IoT technology to realize data collection, transmission, and intelligent analysis throughout the supply chain, achieving end-to-end visibility, automated decision-making, and coordinated response. It can improve supply chain transparency, real-time responsiveness, agility, and collaboration efficiency, enabling enterprises to better cope with external shocks and disruptions, thereby effectively enhancing supply chain resilience.

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Currently, both academia and practice are paying close attention to enterprise supply chains and the resilience of IoT technology. In the field of supply chain resilience, research focuses include mechanism research[1], influencing factors[2], optimization paths[3], and policy orientations[4]. In the field of IoT technology, research focuses include development paths[5], application research[6], technical principles[7], and ecological value[8]. However, systematic research integrating both within the same analytical framework is still relatively rare. Therefore, in-depth study of the impact effects and mechanisms of IoT technology on supply chain resilience is of great significance.

Against this background, this paper addresses several key theoretical and practical issues: What is the specific impact of IoT technology on enterprise supply chain resilience? Do heterogeneous effects exist across different regions and enterprise characteristics? What are the underlying mechanisms? Answering these questions helps enrich the research system of IoT, supply chain management and resilience, and provides empirical evidence and implications for policymakers and enterprises.

Using panel data of Chinese A-share listed firms from 2014 to 2024, this study combines theoretical analysis and empirical tests to examine the impact and mechanisms of IoT technology on supply chain resilience. The marginal contributions are twofold: First, it integrates IoT strategy and micro-level supply chain resilience into a unified framework, enriching relevant literature. Second, it identifies the channels through which IoT strategy enhances supply chain resilience, extending the research boundary of supply chain resilience. Heterogeneity analyses further provide a theoretical and empirical basis for targeted policies to strengthen supply chain security.

2 Theoretical Analysis and Research Hypotheses

2.1 IoT Technology and Supply Chain Resilience

In the relationship between IoT and enterprise supply chain resilience, four key effects exist.First, IoT strategy improves supply chain transparency, eliminates information silos, and strengthens collaboration in logistics, capital flow and information flow, thus enhancing risk warning and market responsiveness.Second, IoT applications drive the supply chain to evolve from a linear structure to an intelligent ecosystem. IoT terminals such as sensors and RFID enable data sharing and dynamic coordination, helping firms quickly identify risks and adjust resource allocation to improve resistance to disruptions.Third, IoT provides real-time data and end-to-end visibility, supporting optimized inventory and production scheduling. With real-time monitoring and intelligent analysis, enterprises can better forecast supply and demand, track operations, and issue early warnings, thus strengthening risk response capabilities.Finally, IoT creates a transparent and efficient operational environment and forms a data-driven intelligent decision-making loop. It accelerates the digital transformation of supply chain management and comprehensively improves supply chain resilience.

Accordingly, this paper proposes H_1 is proposed: IoT technology can promote the improvement of supply chain resilience.

2.2 IoT Technology, Enterprise Innovation Level, and Supply Chain Resilience

Technological innovation is vital for enterprises to maintain core competitiveness under uncertainty, and IoT strategy effectively promotes technological innovation. IoT helps enterprises better identify market demand, optimize innovation resource allocation, and accelerate knowledge sharing and transformation both internally and across industry-university-research cooperation.By applying new technologies, enterprises can upgrade production and management models, optimize supply chain processes, and reduce operational risks. IoT-driven intelligent forecasting and dynamic scheduling enhance the ability to anticipate risks and respond flexibly to external shocks. This innovation-enabled agility significantly strengthens enterprise supply chain resilience.

Accordingly, this paper proposes H_2: The implementation of the IoT strategy can promote enterprise technological innovation, thereby enhancing enterprise supply chain resilience.

2.3 IoT Technology, Financing Constraints, and Supply Chain Resilience

Capital flow is essential for maintaining supply chain operations. Stable financial support is critical for supply chain stability under external shocks. Traditional corporate financing often suffers from information asymmetry and adverse selection, as financial institutions struggle to assess corporate risks, leading to tight credit and high financing costs. The IoT strategy can alleviate such financing constraints both internally and externally.Externally,IoT provides reliable real-time operational data for financial institutions, improving credit evaluation, supporting customized financial services, and reducing financing costs. Internally, IoT integrated with intelligent finance and ERP systems enables refined cash flow management, enhances capital turnover, and lowers dependence on expensive external financing.The mitigation of financing constraints strongly supports supply chain resilience. Adequate capital enables stable investment and rapid resource reallocation under shocks, thus strengthening risk resistance and recovery capacity.

Accordingly, this paper proposes H_3: The implementation of the IoT strategy can alleviate enterprise financing constraints, thereby enhancing enterprise supply chain resilience

3 Data Description and Model Specification

3.1 Data Sources

Considering data availability and following common practices in existing research, this paper takes Chinese A-share listed companies from 2014 to 2024 as the research object. The regional and enterprise-level data involved are all sourced from the CNRDS, CSMAR, and Wind databases. The raw data were processed as follows: samples of PT, ST, *ST, delisted, and financial industry enterprises during the sample period were excluded; observations with severely missing key variables were deleted. Finally, an unbalanced panel dataset of 19,020 firm-year observations was obtained.

3.2 Dependent Variable

The dependent variable of this paper is the degree of supply chain resilience of each listed company. Referring to the research of Zhang Shushan[9], this paper selects relevant indicators, assigns weights to the variables using the entropy method, and constructs the supply chain resilience level for each company in each year through the weighted method. In the robustness test section, referring to the research of Yao Zhenghai[10], the measurement indicators are changed, and the comprehensive score is recalculated using the entropy weight method.

Table 1. Measurement Indicators for Supply Chain Resilience

Primary Dimension	Secondary Dimension	Specific Indicators
Supply Chain Resistance	Capital Relationship	Natural logarithm of the ratio of accounts receivable to revenue
	Supply-Demand Stability	Number of non-newly appearing customers among the top five customers of the enterprise / 5
Supply Chain Recovery	Product Flow	Enterprise inventory turnover rate
	Performance Volatility	Economic performance sensitivity index

3.3 Independent Variable

The core independent variable of this paper is the IoT technology level of each listed company. Referring to the research of Wu Fei[11], this paper conducts content analysis on the public texts of enterprises. Each occurrence of a relevant keyword is scored as 1 point, and the final data is obtained by cumulative counting. In the robustness test section, to avoid the influence of the length of the annual report text, referring to the approach of Yuan Chun[12], a new independent variable is generated using the ratio of the total word frequency of IoT terms to the total number of sentences in the annual report.

3.4 Control Variables

Referring to the research of Zhang Shushan[9], this paper selects the following variables as control variables: Size, measured by the natural logarithm of total assets; Lev, measured by the ratio of total liabilities to total assets; Cashflow , measured by the ratio of net cash flow from operating activities to current liabilities at year-end; Indep, measured by the ratio of the number of independent directors to the size of the board; Top1, measured by the shareholding ratio of the largest shareholder; REC, measured by the ratio of accounts receivable to total assets. Specifically, this paper also controls for year and industry fixed effects. Descriptive statistical analysis was conducted on all variables.

Table 2. Descriptive Statistical Analysis of Variables

Variable	Observation	Mean	Median	Std.Dev.	Min	Max
Scr	19022	46.894	56.073	12.310	30.170	59.785
LW	19022	1.956	0.000	5.801	0.000	40.000
Size	19022	22.596	22.410	1.278	20.249	26.410
Lev	19022	0.435	0.429	0.193	0.069	0.872
Cashflow	19022	0.052	0.049	0.063	-0.122	0.241
Indep	19022	0.383	0.375	0.075	0.250	0.600
Top1	19022	0.330	0.304	0.144	0.089	0.726
REC	19022	0.124	0.103	0.101	0.001	0.461

3.5 Baseline Regression Analysis

This paper uses the following regression model to examine the impact of IoT development on supply chain resilience. In this model, Scr represents enterprise supply chain resilience, LW represents the IoT strategy, X represents the set of control variables, μ represents industry fixed effects, λ represents year fixed effects, and ε is the random disturbance term.

$$Scr_{it} = \alpha_0 + \alpha_0 LW_{it} + \alpha_2 X_{it} + \mu_j + \lambda_h + \varepsilon_{it}$$

3.6 Mediation Effect Model

To test whether H_2 and H_3 hold, a two-step mediation effect model is constructed. In this model, Inno represents the degree of enterprise technological innovation, and KZ represents the financing constraint index.

$$Scr_{it} = \alpha_0 + \alpha_0 LW_{it} + \alpha_2 X_{it} + \mu_j + \lambda_h + \varepsilon_{it}$$

$$Inno_{it} = \beta_0 + \beta_0 LW_{it} + \beta_2 X_{it} + \mu_j + \lambda_h + \varepsilon_{it}$$

$$Scr_{it} = \gamma_0 + \gamma_0 LW_{it} + \gamma_2 X_{it} + \gamma_3 Inno_{it} + \mu_j + \lambda_h + \varepsilon_{it}$$

$$Scr_{it} = \alpha_0 + \alpha_0 LW_{it} + \alpha_2 X_{it} + \mu_j + \lambda_h + \varepsilon_{it}$$

$$KZ_{it} = \beta_0 + \beta_0 LW_{it} + \beta_2 X_{it} + \mu_j + \lambda_h + \varepsilon_{it}$$

$$Scr_{it} = \gamma_0 + \gamma_0 LW_{it} + \gamma_2 X_{it} + \gamma_3 KZ_{it} + \mu_j + \lambda_h + \varepsilon_{it}$$

4 Empirical Results Analysis

4.1 Baseline Regression Analysis

To examine the impact of IoT on supply chain resilience, this paper incorporates the relevant variables into the regression model based on the principles in 3.3. Table 3 displays the results. Columns (1) through (4) progressively include control variables, year fixed effects, and industry fixed effects. Under these different specifications, the regression coefficients of IoT technology are all significantly positive at the 1% level. Taking Column (5) as an example, ceteris paribus, a one-unit increase in IoT technology leads to an average increase of 0.121 units in supply chain resilience. This confirms that IoT development significantly promotes supply chain resilience, thus verifying Hypothesis H_1.

Table 3. Baseline Regression Results

Variable	(1)	(2)	(3)	(4)
LW	0.123***	0.111***	0.129***	0.121***
	(8.11)	(8.42)	(8.57)	(8.10)
Size		-0.910***	-0.599***	-0.707***
		(-10.87)	(-6.89)	(-8.08)
Lev		-1.673***	-1.222**	-0.961*
		(-3.16)	(-2.20)	(-1.73)
Cashflow		11.674***	10.573***	9.993***
		(8.02)	(7.27)	(6.84)
Indep		6.787***	4.012***	4.608***
		(5.82)	(3.44)	(3.96)
Top1		-7.932***	-6.725***	-6.212***
		(-12.36)	(-10.29)	(-9.49)
REC		9.987***	5.928***	5.618***
		(10.85)	(5.63)	(5.36)
N	19022	19022	19022	19022
R^2	0.075	0.053	0.082	0.089
IND FE	YES	NO	YES	YES
YEAR FE	YES	YES	NO	YES

*Note: Values in parentheses are robust standard errors; ***, *, * indicate significance at the 1%, 5% and 10% levels, respectively. The same applies to the following tables.

4.2 Robustness Tests

This paper conducts robustness tests on the above analysis from the following aspects. First, referring to the research of [Song Donglin[13], to eliminate the interference of superior digital infrastructure in first-tier cities, we exclude these samples and re-regress, with results in Column (1) of Table 4. Second, to mitigate reverse causality, the explained variable is lagged by one period. Third, we replace the measures of both IoT technology and the explained variable. To address endogeneity, we conduct instrumental variable regression using the average IoT level of other listed firms in the same city as the instrument. Columns (5) and (6) report the first- and second-stage results, with the IV coefficient 0.585 and significant at 1%. In all specifications, the key explanatory variable remains significantly positive at 1%, consistent with the baseline regression and confirming the robustness of the core conclusion.

Table 4. Robustness Tests

Variable	(1)	(2)	(3)	(4)	(5)	
	Excluding first-tier cities	Lags of explained variable by one period	Replacing explanatory variable	Replacing explanatory variable	Instrumental Variable Test	
					First Stage	Second Stage
LW_2			0.121***			
			(8.10)			
iv1					0.585***	
					(22.08)	
LW	0.133***	0.150***		3.106***		0.556***
	(6.38)	(6.82)		(29.35)		(6.22)
Size	-0.438***	-0.581***	-0.707***	26.059***	0.230***	-0.829***
	(-4.06)	(-4.80)	(-8.08)	(50.01)	(6.52)	(-9.14)
Lev	-1.906***	-2.314***	-0.961*	-42.353***	-0.849***	-0.528
	(-2.95)	(-3.19)	(-1.73)	(-16.02)	(-3.60)	(-0.94)
Cashflow	10.865***	11.973***	9.993***	-18.969***	-2.394***	11.003***
	(6.38)	(6.36)	(6.84)	(-2.73)	(-4.13)	(7.45)
Indep	3.111**	2.967*	4.608***	35.209***	0.418	4.325***
	(2.25)	(1.94)	(3.96)	(6.13)	(0.86)	(3.72)
Top1	-6.109***	-5.208***	-6.212***	5.914*	-2.037***	-5.456***
	(-7.84)	(-6.07)	(-9.49)	(1.89)	(-8.72)	(-8.12)
REC	7.174***	8.499***	5.618***	60.096***	1.752***	4.564***
	(5.70)	(6.12)	(5.36)	(11.58)	(3.32)	(4.25)
N	13922	11378	19022	19022	19022	19022
R^2	0.088	0.092	0.089	0.586	0.286	0.089

To test the mechanism, this paper conducts a mediation effect analysis. Enterprise innovation level (inno) and financing constraint (fus) are measured by the logarithm of patents plus one and the KZ index, respectively, with data from CSMAR. The results are shown in Table 5. Column (2) shows that IoT significantly promotes innovation, with a coefficient of 0.017 at the 1% level. When both innovation and IoT are included, innovation also has a significant positive impact on supply chain resilience. This indicates that IoT enhances supply chain resilience by improving enterprise innovation, supporting Hypothesis H_2.

Table 5. Test on the Mechanism of IoT Development on Supply Chain Resilience

	(1)	(2)	(3)	(4)	(5)
Variable	Scr	inno	Scr	Fus	Scr
inno			0.002***		
			(2.99)		
KZ					-0.002**
					(-2.07)
LW	0.121***	0.017***	0.001***	-0.004***	0.001***
	(8.10)	(8.78)	(7.89)	(-2.94)	(8.04)

Size	-0.707***	0.406***	-0.008***	-0.274***	-0.008***
	(-8.08)	(35.36)	(-8.60)	(-36.79)	(-8.32)
Lev	-0.961*	-0.546***	-0.009	6.721***	0.003
	(-1.73)	(-8.90)	(-1.56)	(142.00)	(0.37)
Cashflow	9.993***	2.037***	0.096***	-15.659***	0.070***
	(6.84)	(12.15)	(6.56)	(-110.82)	(3.44)
Indep	4.608***	0.609***	0.045***	-0.017	0.046***
	(3.96)	(4.57)	(3.86)	(-0.18)	(3.96)
Top1	-6.212***	0.154**	-0.063***	-0.512***	-0.063***
	(-9.49)	(2.02)	(-9.55)	(-9.66)	(-9.61)
REC	5.618***	0.866***	0.055***	0.796***	0.058***
	(5.36)	(7.19)	(5.25)	(9.37)	(5.49)
N	19022	19020	19020	19022	19022
R^2	0.089	0.358	0.090	0.770	0.089

4.3 Heterogeneity Analysis

This paper conducts heterogeneity analysis from three dimensions: enterprise property right nature, geographical location and factor intensity of production, to examine the differences in the impact of IoT technology on supply chain resilience under different scenarios.

(1) Property right nature

First, enterprises are divided into state-owned and non-state-owned subsamples according to property rights. Regression results show that the coefficient of IoT technology (LW) is 0.159 and significant at 1% for state-owned enterprises, and 0.091 and significant at 1% for non-state-owned enterprises, indicating that IoT has a stronger promoting effect on supply chain resilience in state-owned enterprises. This may be because state-owned enterprises have advantages in resources, policy support and technology investment, and they emphasize supply chain security and systematic IoT application.

(2) Geographical location

Enterprises are divided into eastern region and central/western region subsamples according to geographical location. The regression coefficient of IoT technology is 0.129 and significant at 1% in the eastern region, and 0.092 and significant at 5% in central and western regions, indicating that IoT improves supply chain resilience more strongly in eastern enterprises. This is mainly because the eastern region has more developed digital infrastructure, richer application scenarios, higher supply chain globalization, and stronger efficiency in technology application and transformation.

(3) Enterprise production factors

Enterprises are classified into technology-intensive, capital-intensive, and labor-intensive subsamples based on production factor intensity. Regression results show that the coefficient of IoT technology is largest in capital-intensive enterprises (0.433, 1% significance), followed by technology-intensive enterprises (0.116, 1% significance) and labor-intensive enterprises (0.090, 5% significance). This indicates that IoT enhances supply chain resilience most strongly in capital-intensive enterprises. Capital-intensive industries such as manufacturing and energy involve heavy assets and longcycle operations, where IoT effectively reduces disruption risks through real-time monitoring and inventory optimization. Technology-intensive firms can better integrate IoT via their technological strengths, whereas labor-intensive enterprises rely more on human resources, leaving relatively limited room for IoT application.

Table 6. Heterogeneity Analysis

Variable	State-owned Enterprises	Non-state-owned Enterprises	Eastern Region	Central and Western Regions	Technology-intensive	Capital-intensive	Labor-intensive
LW	0.159***	0.091***	0.129***	0.092**	0.116***	0.433***	0.090**
	(4.67)	(5.47)	(7.91)	(2.38)	(7.19)	(3.38)	(2.09)
Size	-0.149	-0.723***	-0.967***	-0.072	-0.899***	-0.403**	-0.558***
	(-1.15)	(-5.76)	(-9.35)	(-0.42)	(-6.91)	(-2.17)	(-3.60)
Lev	-1.544*	0.788	-0.067	-3.548***	-2.867***	-0.088	1.285
	(-1.74)	(1.10)	(-0.10)	(-3.42)	(-3.51)	(-0.07)	(1.30)
Cashflow	10.239***	5.981***	8.739***	10.992***	15.474***	7.193**	7.206***
	(4.27)	(3.30)	(5.02)	(4.11)	(6.97)	(2.11)	(3.06)
Indep	-2.729	3.934***	5.571***	-0.023	6.525***	5.738**	0.950
	(-1.44)	(2.64)	(4.02)	(-0.01)	(3.88)	(2.14)	(0.47)
Top1	-5.226***	-4.291***	-6.579***	-5.213***	-9.020***	-2.091	-5.052***
	(-5.05)	(-4.91)	(-8.33)	(-4.29)	(-9.21)	(-1.42)	(-4.54)
REC	8.083***	3.152**	5.844***	5.883***	1.106	26.839***	6.770***
	(4.49)	(2.44)	(4.81)	(2.76)	(0.76)	(10.08)	(3.59)
N	7501	11521	13484	5436	8905	3691	6242
R^2	0.089	0.067	0.099	0.120	0.070	0.115	0.088

5 Conclusion and Policy Implications

IoT technology is critical for removing supply chain information barriers, accelerating intelligent transformation and building a modern supply chain system in China. Based on 2014–2024 panel data of A-share listed firms and a fixed-effects model, this paper draws the following conclusions:First, IoT development significantly improves enterprise supply chain resilience, which is verified by robustness tests.Second, IoT enhances supply chain resilience mainly by promoting technological innovation and easing financing constraints.Third, the positive effect is more significant for SOEs, eastern-region enterprises, asset-intensive firms and regions with better market environments.

This paper proposes three policy suggestions:First, deepen the integrated application of IoT in the whole supply chain, build a full-chain sensing system and break information barriers.Second, stimulate technological innovation via IoT applications with policy support and industry-university-research cooperation.Third, implement differentiated IoT strategies to carry out pilots in advantageous industries and narrow the digital divide for underdeveloped regions.

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