Research on the Impact of Data Factors on Corporate Supply Chain Resilience

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Abstract. Against growing global geopolitical risks, stable industrial and supply chains are vital to China's high-quality development. Based on 2007–2024 A-share listed firms, this paper investigates data factors' influence on supply chain resilience and its mechanisms. Data significantly strengthen supply chain resilience by boosting internal control, supply chain finance and operational efficiency; the effect is more evident in private and innovative enterprises. Digital governance support and industrial chain pilot policies amplify this effect. Data improves both pre-crisis risk defense and post-crisis recovery, with greater efficacy in risk prevention. The research supplements relevant theories and provides empirical evidence for digital-driven supply chain security.

Keywords: Data Factors; Supply Chain Resilience; Supply Chain Finance; Supply Chain Efficiency; Industrial Chain Leader System.

1. Introduction

Escalating geopolitical frictions, recurrent COVID-19 shocks and rampant trade protectionism have severely disrupted global industrial and supply chains and heightened external uncertainty worldwide. Stabilizing supply chains has thus become a top economic priority for all nations. The report to the 20th CPC National Congress set a clear goal of boosting supply chain resilience and security, making supply chain resilience a national strategy and a core mission for China's high-quality growth and new development paradigm.

Frequent external shocks compel firms to build supply chain resilience, as stable operation amid crises and rapid post-disruption recovery are vital for corporate survival and expansion. Scholars have widely examined determinants of supply chain resilience, including supply chain network structure, financial marketization and macro policies. Yet most existing research ignores data factors—the new production factor of the digital economy—and their capacity to empower supply chain resilience.

The booming digital economy is restructuring China's economy, and data factors have become a new growth driver. The report to the 20th CPC National Congress advances digital economy expansion, deeper integration with the real economy, and a unified data factor market. Prior studies prove data factors lift enterprises' total factor productivity, technological innovation and resource allocation to advance high-quality development. However, relevant research mostly centers on productivity and innovation, rarely exploring their role in supply chain risk resistance. Several key questions remain underexplored: Can data factors strengthen corporate supply chain resilience? What transmission channels underpin this effect? Does the impact differ across heterogeneous firms? How do external policies moderate data factors' empower function?

To resolve the above research questions, this paper adopts 2007–2024 China A-share listed firms as samples to analyze how data factors affect corporate supply chain resilience, together with its internal mechanisms and heterogeneous boundaries. The main results are summarized below.

Baseline regressions demonstrate that data factors significantly enhance supply chain resilience. This conclusion holds after multiple robustness checks: instrumental variable estimation, one-period lagged regressions, exclusion of samples hit by the 2015 stock market crash, replacement of core explanatory variables, high-dimensional fixed effects and adjusted clustering standards, which verifies the stable enabling effect of data factors.

Mechanism analysis reveals three core indirect channels through which data factors improve supply chain resilience. First, data factors strengthen firms' internal control and risk management

capabilities. Second, they facilitate supply chain finance, alleviating financing constraints for small and medium-sized enterprises in supply chain networks. Third, they optimize supply chain operational efficiency, thereby improving supply chain flexibility and responsiveness. These findings clarify the internal influencing mechanism and open the black box between data factors and supply chain resilience.

Heterogeneity analysis shows that the empowering effect of data factors is more prominent in non-state-owned enterprises and highly innovative firms. This suggests that data factors effectively alleviate the operational drawbacks of non-state-owned enterprises, and their value creation is contingent on firms' technological absorption capabilities.

Moderation analysis indicates that external policy environments significantly strengthen the empowering effect of data factors. Both governmental attention to digital development and the industrial chain leader pilot policy generate positive moderating effects, realizing synergistic empowerment between policies and factor endowments.

Dimensional decomposition reveals that data factors comprehensively improve supply chain resilience by enhancing both pre-shock risk resistance and post-shock recovery capability, with a more salient effect on ex-ante risk prevention. This demonstrates that data factors primarily function as a risk-mitigation tool that reduces supply chain disruption risks at the source.

This paper makes marginal contributions to existing literature in three aspects:

This paper makes three key contributions. First, it innovatively investigates the impact of data factors on corporate supply chain resilience, enriching research on the economic consequences of data factors. Unlike existing studies that mainly focus on firms' productivity and innovation, this study extends the research scope to supply chain risk resistance, providing fresh empirical evidence for the economic value of data factors. Second, it expands the driving factors of supply chain resilience from the novel perspective of data factors. While prior literature centers on traditional structural, financial and policy determinants, this study verifies the empowering role of data as a new production factor, offering a new approach to improve supply chain resilience. Third, it clarifies the internal transmission mechanism of data factors via three core channels and further explores firm heterogeneity and policy moderating effects. This study clarifies the causal link between data factors and supply chain resilience, and provides targeted empirical references for policy formulation, with practical significance for securing industrial and supply chain stability through digital economy development.

The remainder of this paper proceeds as follows. Section 2 reviews relevant literature and develops research hypotheses. Section 3 specifies the research design, including sample selection, variable definitions and empirical models. Section 4 presents the baseline regression results and robustness tests. Section 5 conducts extended analyses covering mechanisms, heterogeneity, moderation effects and dimensional decomposition. Section 6 concludes the study and offers policy implications.

2. Literature Review and Research Hypotheses

2.1. Research on Data Factors.

At the macro level, Huang Yanghua et al. (2026) constructed a theoretical framework for digital economic growth based on the technical and economic characteristics of data factors, analyzing internal mechanisms through which data factors influence micro-firm production activities and further extending to macroeconomic growth paths, offering systematic theoretical support for understanding the macroeconomic value of data factors.

At the micro-firm level, existing literature explores the economic consequences of data factors across multiple dimensions. Dai Kuizao et al. (2024) focused on manufacturing transformation and upgrading, empirically verifying that data factors drive service-oriented manufacturing via three channels: boosting R&D and design, optimizing production management, and upgrading marketing services, while data governance significantly shapes this enabling effect. Chen Rongda et al. (2025) constructed measurement indicators for data factor marketization from the perspective of factor

market development, finding that data factor marketization substantially improves corporate performance through optimizing internal governance and external environments, specifically mitigating agency conflicts, cutting administrative costs, optimizing customer structures and alleviating financing constraints. Wang Guihu et al. (2025) further extended research to the impact of data factors on corporate financial resilience. Using quasi-natural experiments of national big data comprehensive pilot zones, they found data factors significantly strengthen the balance sheet resilience of private enterprises via efficiency empowerment and structural optimization channels.

Against rising concerns over supply chain security, academia has begun to explore the link between data factors and supply chain-related fields. Zhao Chunming et al. (2025) studied the impact of data factor input on industrial chain resilience, confirming data factors lift industrial chain resilience through boosting corporate digital transformation and strengthening corporate governance, with a polarized effect. Shi Benye et al. (2026) focused on supply chain disruption risks, empirically testing that data factors mitigate disruption risks by easing financing constraints, improving supply chain transparency and fostering inter-firm collaboration. Wang Yu (2024) explored the impact of data factors on supply chain quality, discovering data factors significantly boost supply chain diversification and efficiency, exerting a stronger effect on upstream diversification, with amplified impacts in highly competitive industries.

Several studies further investigate the direct empowering effect of data factors on supply chain resilience. Li Xiaomei et al. (2025) constructed measurement indicators for supply chain resilience covering subject and relational dimensions, empirically proving data factors enhance both subject and relational resilience via innovation and information effects. Wu Qiang et al. (2026) further divided corporate data factor application into breadth and depth dimensions, finding deep application exerts a stronger boosting effect on supply chain resilience than broad application: deep application strengthens internal control, while broad application reduces transaction costs.

2.2. Research on Corporate Supply Chain Resilience.

Early studies adopted internal operational and structural perspectives. Ma Xiaoyu et al. (2023) systematically identified drivers of supply chain resilience via SEM and fsQCA methods, confirming flexibility, agility, restructure capacity, visibility and supply chain collaboration all exert significant positive impacts, and high-resilience supply chains arise from multi-factor synergy with multiple factor combinations yielding equivalent outcomes. Wei Qi et al. (2025) adopted a social capital perspective, finding intra-chain and extra-chain social capital both lift supply chain resilience: intra-chain social capital reduces credit risks, while extra-chain social capital improves financing capacity, with digital transformation amplifying this enabling effect.

As the digital economy advances, research on digital factors' impact on supply chain resilience has become a mainstream focus. Zhang Shushan et al. (2024) pioneered empirical tests on corporate digital transformation's effect on supply chain resilience, verifying digital transformation significantly boosts both pre-shock resistance and post-shock recovery capacity, with a stronger impact on recovery. Mechanistically, digital transformation enhances supply chain diversification and optimizes supply-demand matching. Wu Qiang et al. (2024) explored supply chain restructuring driven by digital transformation, identifying resilience enhancement as a core outcome: digital transformation lifts supply chain resilience by promoting diversified supply chain structures and improving flexibility, enabling firms to better withstand external shocks.

Other studies have examined additional determinants of supply chain resilience such as policy support and external environments. Pei Jiansuo et al. (2025) systematically sorted transmission mechanisms of industrial and supply chain resilience, pointing out external shocks spread across entire industrial chains via core leading firms, while digital technologies effectively mitigate shock spillovers. Other literature has explored climate risks, social capital and other external drivers, enriching the analytical framework for supply chain resilience determinants.

2.3. Research Commentary.

First, existing studies on data factors in supply chain contexts lack in-depth mechanism analysis. While prior research predominantly focuses on corporate performance, manufacturing upgrading and innovation, emerging supply chain-related studies remain at the macroscopic industrial level. Limited literature linking data factors and supply chain resilience only examines general mechanisms, without dissecting the micro transmission channels of internal control optimization, supply chain finance empowerment and operational efficiency improvement, nor distinguishing the dimensional heterogeneity of supply chain resilience.

Second, current supply chain resilience research generally adopts digital transformation as a comprehensive indicator, failing to isolate the independent net effect of data factors as a core production factor. As digital transformation involves systematic technological, organizational and institutional changes, extant studies cannot accurately identify the unique value of data factors, leaving unanswered how standalone data factor endowments shape supply chain resilience and lacking empirical support for data factor marketization reform.

Third, relevant research lacks comprehensive heterogeneity and moderating effect investigations. Existing studies mainly discuss firm-level heterogeneity while neglecting the moderating role of external institutional environments, including government digital development attention and industrial chain leader pilot policies. Furthermore, few studies decompose supply chain resilience into pre-shock resistance and post-shock recovery dimensions, which obscures the differentiated empowerment logic of data factors.

Against this backdrop, this paper takes China's A-share listed companies from 2007 to 2024 as samples to empirically test the impact of data factors on corporate supply chain resilience, excavate internal transmission mechanisms, analyze multi-dimensional heterogeneity and policy moderation effects, fill gaps in existing literature, and deliver empirical evidence for data factor-driven supply chain resilience.

3. Theoretical Analysis and Research Hypotheses

As a novel production factor in the digital economy, data features non-rivalry, replicability and increasing marginal returns, overcoming the resource limitations of traditional factors and providing new impetus for stable supply chain operation. In an increasingly uncertain external environment, global supply chains suffer from heightened disruption risks and inadequate recovery capacity, while data factors can optimize supply chain operations in multiple dimensions. On the one hand, data penetration mitigates information asymmetry among supply chain participants, enhances supply chain transparency, enables firms to foresee market volatility and potential shocks, and supports proactive operational adjustments, thereby strengthening supply chain risk resistance. On the other hand, data application promotes coordinated linkage among supply chain nodes. When external shocks occur, firms can rely on data to optimize supply-demand matching, restructure cooperative networks and restore operational stability, and even improve overall efficiency through structural adjustment. Therefore, data factors comprehensively improve corporate supply chain resilience by boosting both pre-shock resistance and post-shock recovery capabilities. This paper thus proposes the core research hypothesis:

H1: Data factors improve corporate supply chain resilience.

From the perspective of corporate internal governance, internal control serves as a core institutional arrangement for risk prevention and standardized operational management. Data factor development strengthens corporate internal control, thereby underpinning the improvement of supply chain resilience. Specifically, data application breaks internal information barriers, accelerates intra-firm information circulation and sharing, and enables management to timely and comprehensively monitor corporate operating conditions, which alleviates agency conflicts and restrains managerial opportunism. Meanwhile, data analytics realize real-time supervision of business processes, facilitates early identification of operational risks, and promotes refined risk control. Improved

internal control empowers firms to better cope with external volatility, rapidly adjust operations through standardized internal procedures amid supply chain shocks, and avoid supply chain disruptions caused by internal governance deficiencies, ultimately enhancing supply chain resilience. We thus propose:

H2: Data factors strengthen internal control, thereby improving corporate supply chain resilience.

From the perspective of supply chain capital flows, data factor development facilitates supply chain finance, providing solid capital guarantees for supply chain resilience. Traditional supply chain financing leaves upstream and downstream SMEs with severe financing constraints stemming from insufficient collateral and opaque credit information, easily triggering capital chain fractures and supply chain disruptions under external shocks. Data factors effectively mitigate information asymmetry in supply chain financial services. By leveraging multi-dimensional transaction and operational data, financial institutions and core enterprises can accurately evaluate SMEs' credit and repayment capacity, reduce financing risks and costs while expand financing coverage. Optimized supply chain finance eases SMEs' financing dilemmas, ensures smooth capital circulation, and accumulates sufficient capital buffers for firms to withstand shock pressures. It further avoids capital-induced supply chain disruptions and effectively improves overall supply chain resilience. We therefore propose:

H3: Data factors advance supply chain finance, thereby improving corporate supply chain resilience.

From the perspective of supply chain operational efficiency, efficient operational systems constitute the foundation of flexible shock response and resilient supply chains. Traditional supply chains are plagued by delayed and distorted information transmission, which leads to inaccurate demand forecasting, supply-demand mismatches, inventory backlogs and slow product circulation, hindering operational efficiency. Data factors address these deficiencies by enabling precise demand identification, optimized supply-demand allocation, reduced inventory and capital occupation, and accelerated product turnover. Additionally, data applications lower inter-firm transaction costs and strengthen collaborative interaction across supply chain nodes, thereby improving overall operational efficiency. Enhanced operational efficiency allows supply chains to adapt swiftly to external changes, dynamically adjust supply-demand structures during shocks, and accelerate operational recovery, which substantially improves supply chain resilience. We propose:

H4: Data factors improve supply chain efficiency, thereby lifting corporate supply chain resilience.

4. Research Design

4.1. Sample Selection and Data Sources.

This paper selects China's A-share listed companies from 2007 to 2024 as initial samples, processed as follows: (1) exclude financial and insurance industry samples; (2) eliminate observations with missing variable data; (3) remove ST, *ST and PT listed firms; (4) winsorize all continuous variables at the 1st and 99th percentiles to mitigate outlier bias. Corporate financial data are sourced from the China Stock Market & Accounting Research Database (CSMAR); internal control index from the Dibo Internal Control Database; textual data from CNINFO (China Listed Company Information Disclosure Platform).

4.2. Definition of Main Variables.

4.2.1. Dependent Variable: Corporate Supply Chain Resilience (SCR).

Following Zhang Shushan and Gu Cheng (2024), this paper constructs a composite supply chain resilience index via the entropy weight method, decomposed into two core dimensions: supply chain resistance and supply chain recovery capacity.

Supply chain resistance. Captured by two indicators: (a) natural logarithm of accounts receivable-to-operating income ratio (smaller values indicate more stable capital linkages); (b)

proportion of long-term top-five customers (ratio of non-new top-five customers to total top-five customers, higher values reflect stable long-term supply-demand partnerships).

Supply chain recovery capacity. Captured by two indicators: (a) inventory turnover ratio (higher values denote faster product circulation and stronger post-shock recovery); (b) economic performance sensitivity index, measuring relative gaps between corporate performance volatility and industry-wide performance volatility (higher values reflect stronger operational rebound elasticity after shocks).

The four underlying indicators are weighted via entropy weighting to synthesize the composite SCR index, comprehensively reflecting supply chains' capacity to withstand external shocks and restore stable operations.

4.2.2. Core Explanatory Variable: Data Factors (DF).

Following the research framework of Dai et al. (2024), this study constructs a comprehensive firm-level data factor index that integrates macro regional and micro firm-level information. Macroscopically, it adopts the big data development index to reflect regional data factor development. Microscopically, it selects keywords from four dimensions—data factor stock, data development capability, data-driven business application, and data value monetization—based on relevant policies and research. By conducting text segmentation and keyword matching on listed firms' annual reports and excluding negative and invalid entries, this study summarizes valid keyword frequencies. The firm-level data factor development index is finally obtained by taking the natural logarithm of one plus the effective word frequency. After standardizing the macro and micro indicators to eliminate dimensional differences, this study synthesizes a comprehensive data factor index via arithmetic averaging. The integrated index systematically reflects both the regional institutional foundation and firms' independent capabilities of data development and utilization.

4.2.3. Mediating Variables.

Based on the foregoing theoretical analysis and research hypotheses, this paper selects three mechanism variables to examine the underlying transmission channels.

First, corporate internal control (IC). This study adopts the Dibo Internal Control Index to measure firms' internal control quality. A higher index value indicates a more sound internal control system and stronger capabilities to prevent compliance and operational risks.

Second, supply chain finance (SCF). Text mining technology is applied to quantify corporate supply chain finance development. This paper captures and counts supply chain finance-related keyword frequencies from listed firms' annual reports. Given the right-skewed distribution of word frequency data, the original frequency is added by one and logarithmically transformed for standardization. A higher value signifies more intensive adoption of supply chain finance tools and deeper participation in supply chain financial activities.

Third, supply chain efficiency (SCE). Inventory turnover ratio is adopted to reflect firms' physical supply chain operational efficiency, a classic and reliable indicator in existing studies. This metric captures the circulation efficiency of raw materials and finished goods. A higher inventory turnover ratio implies faster inventory-to-revenue conversion, lower inventory backlogs and capital occupancy, and superior overall supply chain operational efficiency.

4.2.4. Control Variables.

Consistent with mainstream literature, this paper incorporates firm characteristic control variables to improve model accuracy: firm size (Size), asset-liability ratio (Lev), return on total assets (Roa), ownership concentration (Top1), board size (Board), independent director ratio (Indep), firm age (Age). Variable definitions are summarized in Table 1.

Table 1. Variable Definitions.

Variable Type	Variable Name	Symbol	Measurement Method
Dependent Variable	Supply Chain Resilience	SCR	Composite index of supply chain resistance and recovery capacity via entropy weighting
Core Explanatory Variable	Data Factors	DF	Standardized composite index of regional big data index and firm-level data utilization text index
Mediating Variable	Internal Control Level	IC	Dibo Internal Control Index
	Supply Chain Finance	SCF	ln(1 + frequency of supply chain finance keywords in annual reports)
	Supply Chain Efficiency	SCE	Operating cost / average inventory balance
Control Variable	Firm Size	Size	Natural logarithm of year-end total assets
	Asset-Liability Ratio	Lev	Year-end total liabilities / year-end total assets
	Profitability	Roa	Net profit / year-end total assets
	Ownership Concentration	Top1	Shareholding ratio of the largest shareholder
	Board Size	Board	Natural logarithm of number of board directors
	Independent Director Ratio	Indep	Number of independent directors / total board directors
	Firm Age	Age	Natural logarithm of observation year minus firm founding year

4.3. Model Specification.

Baseline regression model testing the impact of data factors on corporate supply chain resilience:

$$SCR_{it} = \alpha_0 + \alpha_1 DF_{it} + \alpha_h \sum Control_{it} + YearFE + IndFE + \varepsilon_{it} \quad (1)$$

Where SCR_{it} denotes supply chain resilience of firm i in year t; DF_{it} is data factor level; $Control_{it}$ represents the set of control variables; $YearFE$ =year fixed effects; $IndFE$=industry fixed effects; ε_{it} =random error term.

Mediating effect test model following Jiang Ting (2022):

$$Med_{it} = \beta_0 + \beta_1 DF_{it} + \beta_h \sum Control_{it} + YearFE + IndFE + \varepsilon_{it} \quad (2)$$

Where Med_{it} represents mediating variables (IC, SCF, SCE); all other variables remain con sistent with the baseline model.

5. Empirical Results and Analysis

5.1. Descriptive Statistics.

Core variable distribution characteristics:

The dependent variable SCR contains 46,198 valid observations, with a mean of 0.4507 and a slightly higher median of 0.4718, suggesting that most firms maintain a moderate to high level of supply chain resilience. Its standard deviation is 0.1246, with values ranging from 0.2614 to 0.5984, which reflects considerable cross-firm disparities in supply chain risk resistance and substantial room for resilience improvement. The core explanatory variable DF has a mean of 3.6757 and a standard deviation of 1.3083, with a value interval of 0.6931 to 6.6254. This indicates prominent differences in corporate data factor investment and application, as some firms fully leverage data value while others remain at low-digital-development stages. Such adequate variable volatility guarantees robust empirical identification of the causal relationship between data factors and supply chain resilience.

The descriptive statistics of control variables conform to the typical characteristics of China's A-share listed firms. Firm size (Size) has a mean of 22.2242 and a standard deviation of 1.2962, consistent with prior studies. The asset-liability ratio (Lev) averages 0.4277 within a reasonable debt interval, with substantial cross-firm heterogeneity ranging from 0.0566 to 0.8920. Return on assets (Roa) averages 3.16% and varies widely from -24.89% to 19.45%, indicating distinct profitability gaps among sample firms, including loss-making entities. Ownership concentration (Top1) averages 33.66%, with shareholding ratios spanning 8.25% to 73.87%, which aligns with the equity structure characteristics of Chinese listed firms. Board size (Board) averages 2.2704, corresponding to a raw board scale of approximately 9.68 directors, consistent with domestic corporate governance conventions. The independent director ratio (Indep) averages 0.3834, exceeding the statutory minimum of one-third, which reflects standardized governance arrangements. Firm age (Age) has an average value of 2.1826, equivalent to an operating duration of roughly 8.86 years.

Overall, sample distribution conforms to basic characteristics of China's A-share listed companies, with adequate variable volatility to support subsequent empirical analysis.

Table 2. Descriptive Statistics.

Variable	Observations	Mean	Standard Deviation	Min	Median	Max
SCR	46198	0.4507	0.1246	0.2614	0.4718	0.5984
DF	46198	3.6757	1.3083	0.6931	3.6376	6.6254
Size	46198	22.2242	1.2962	19.8465	22.0259	26.2620
Lev	46198	0.4277	0.2037	0.0566	0.4216	0.8920
Roa	46198	0.0316	0.0641	-0.2489	0.0335	0.1945
Top1	46198	0.3366	0.1486	0.0825	0.3124	0.7387
Board	46198	2.2704	0.2514	1.6094	2.1972	2.8904
Indep	46198	0.3834	0.0739	0.2500	0.3636	0.6000
Age	46198	2.1826	0.7812	0.6931	2.3026	3.4012

5.2. Baseline Regression Results.

Table 3 reports baseline regression results of data factors on corporate supply chain resilience. Column (1) only includes the core explanatory variable DF with year and industry fixed effects to preliminarily identify core variable correlations; Column (2) adds all firm-level control variables to eliminate interference from individual corporate characteristics and accurately isolate the net impact of data factors on supply chain resilience.

The baseline regression results show that the coefficient of core explanatory variable (DF) is significantly positive at the 1% level with and without control variables. The uncontrolled specification in Column (1) presents a DF coefficient of 0.0079, indicating a significant positive association between data factor development and supply chain resilience. After incorporating full control variables in Column (2), the DF coefficient remains significantly positive at the 1% level, standing at 0.0071. Economically, a one-unit increase in data factor level contributes to a 0.0071-unit improvement in corporate supply chain resilience, which preliminarily validates the core Hypothesis H1 that data factor inputs and applications effectively strengthen supply chain resilience. Endowed with non-rivalry and replicability, data factors alleviate inter-firm information asymmetry across supply chains and improve overall transparency. They enable firms to proactively identify potential shock risks, facilitate coordinated operation among supply chain nodes, and enhance systemic flexibility and adaptability, thereby comprehensively improving firms' pre-shock risk resistance and post-shock recovery capabilities.

Control variable interpretations: Significantly negative at the 10% level. Larger firms operate more complex supply chain networks with stronger node linkages; local shocks easily trigger systemic cascading disruptions, suppressing supply chain resilience. Statistically insignificant, indicating their impact on supply chain resilience remains ambiguous and subject to moderating factors. Significantly negative at the 1% level. Higher largest-shareholder shareholding ratios induce short-sighted decision-making, neglecting long-term supply chain risk prevention and weakening shock resistance.

Significantly negative at the 1% level. Larger boards raise internal coordination costs and slow risk response speeds, harming supply chain resilience. Significantly positive at the 5% level. Independent directors deliver supervisory and consulting value to refine supply chain risk control systems and boost resilience. Significantly negative at the 1% level. Mature firms suffer from path dependence, rigid traditional supply chain models and limited adaptability to external shifts, reducing supply chain flexibility.

All regressions control year and industry fixed effects to absorb macroeconomic shocks and inherent cross-industry disparities. Both columns retain 46,198 observations with no sample loss from missing controls. Adjusted R^2 rises from 0.1495 (Column 1) to 0.1599 (Column 2), indicating improved model explanatory power after incorporating control variables. All regressions adopt firm-clustered robust standard errors to mitigate heteroskedasticity and serial correlation bias.

Table 3. Baseline Regression Results.

Variable	(1) SCR	(2) SCR
DF	0.0079***	0.0071***
	(0.0011)	(0.0011)
Size		-0.0024*
		(0.0012)
Lev		-0.0027
		(0.0065)
Roa		0.0127
		(0.0144)
Top1		-0.0582***
		(0.0083)
Board		-0.0188***
		(0.0035)
Indep		0.0264**
		(0.0110)
Age		-0.0076***
		(0.0017)
Constant	0.4215***	0.5467***
	(0.0044)	(0.0252)
Year FE	YES	YES
Industry FE	YES	YES
N	46198	46198
Adjusted R^2	0.1495	0.1599

Note: ***, **, * denote statistical significance at the 1%, 5%, 10% levels respectively; values in parentheses represent clustered robust standard errors. The same notation applies hereafter.

5.3. Robustness Tests.

5.3.1. Instrumental Variable (IV) Method.

To mitigate the endogeneity bias caused by potential issues such as omitted variable bias or reverse causality, this paper further adopts the instrumental variable method for robustness tests. This study constructs the "mean value of data factor data of other enterprises in the same industry and the same year except the enterprise itself" as the instrumental variable of the core explanatory variable. On the one hand, enterprises in the same industry usually face similar digital economy policy shocks and technological development trends, and the overall data factor level of the industry will significantly affect the data factor utilization of individual enterprises, which meets the correlation requirement of instrumental variables; on the other hand, the industry mean excluding the enterprise itself is a meso-level environmental variable, which is difficult to directly affect the supply chain resilience of a specific micro-enterprise, thus meeting the exogeneity constraint of instrumental variables.

Table 4 reports the regression results of the instrumental variable method. In terms of the validity test of instrumental variables: first, the Kleibergen-Paap rk LM statistic of the Underidentification test is 73.090, with a corresponding P-value of 0.0000, which strongly rejects the null hypothesis of "unidentifiable instrumental variables" at the 1% significance level; second, the Kleibergen-Paap rk Wald F statistic of the Weak instrument test is 89.355, which is much larger than the critical value of 16.38 for the Stock-Yogo weak identification test at the 10% significance level, eliminating the problem of weak instrumental variables. The above test results together confirm the rationality and effectiveness of the instrumental variables selected in this paper. After effectively alleviating the endogeneity problem, the regression results of the second stage show that the data element still has a significant promoting effect on the resilience of the enterprise supply chain. This indicates that after eliminating the interference of endogeneity, the core conclusion of this paper remains highly robust.

5.3.2. One-Period Lagged Regression

Since the current supply chain resilience does not affect the previous level of corporate data factor input, using the lagged one-period core explanatory variable can effectively eliminate the interference of reverse causality on the regression results, which corresponds to column (3) of Table 4. The results show that the regression coefficient of the lagged one-period data factor (L.DF) is 0.0073, which is significantly positive at the 1% statistical level. This indicates that the role of data factors in enhancing supply chain resilience has obvious continuity. The previous data factor input can still significantly promote the improvement of current corporate supply chain resilience, which further verifies the reliability of the benchmark regression conclusion and eliminates the possibility of reverse causality.

5.3.3. Subsample Regression.

The 2015 stock market crash represents an exogenous systemic macro shock that may distort corporate operations, supply chain stability and data investment decisions. Removing 2015 samples yields a DF coefficient of 0.0068 (Column 4, Table 4), significant at the 1% level and nearly identical to the baseline coefficient of 0.0071. This confirms core conclusions remain unaffected by the 2015 special shock, demonstrating strong robustness.

Table 4. Robustness Test Results.

Variable	(1) DF (1st Stage IV)	(2) SCR (2nd Stage IV)	(3) SCR Lagged DF	(4) SCR Exclude 2015
DF		0.0090***		0.0068***
		(0.0029)		(0.0011)
IV	1.0152***			
	(0.0251)			
L.DF			0.0073***	
			(0.0012)	
Size	0.1602***	-0.0026**	-0.0027*	-0.0021*
	(0.0094)	(0.0013)	(0.0014)	(0.0012)
Lev	-0.0350	-0.0024	-0.0092	-0.0024
	(0.0582)	(0.0066)	(0.0073)	(0.0064)
Roa	0.0133	0.0127	-0.0177	0.0150
	(0.1164)	(0.0144)	(0.0164)	(0.0146)
Top1	-0.3008***	-0.0573***	-0.0574***	-0.0560***
	(0.0677)	(0.0084)	(0.0090)	(0.0080)
Board	-0.0009	-0.0187***	-0.0159***	-0.0180***
	(0.0284)	(0.0035)	(0.0039)	(0.0035)
Indep	0.3598***	0.0253**	0.0256**	0.0305***
	(0.0920)	(0.0111)	(0.0120)	(0.0111)
Age	-0.1456***	-0.0073***	-0.0101***	-0.0080***
	(0.0131)	(0.0018)	(0.0019)	(0.0017)
Constant	-3.3173***		0.5640***	0.5374***
	(0.2191)		(0.0278)	(0.0246)
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
N	46198	46198	38953	42895
Adjusted R^2	0.6057	0.0153	0.1145	0.1661

6. Extended Analysis

6.1. Mechanism Analysis.

The foregoing theoretical analysis demonstrates that data factors can empower corporate supply chain resilience not only directly, but also indirectly through three pivotal channels: optimizing internal governance via strengthened internal control, facilitating capital flow via developed supply chain finance, and boosting operational efficiency via improved supply chain operation. To verify these transmission mechanisms, this paper follows the mechanism testing framework of Jiang Ting (2022). We take the three mechanism variables as explained variables and data factors (DF) as the core explanatory variable for empirical regression. By examining whether data factors significantly affect the above intermediate variables, this study validates the underlying transmission channels, with corresponding estimation results reported in Table 5.

The regression results confirm the validity of the three proposed transmission channels, as the core DF coefficients are significantly positive across all specifications. First, Column (1) presents the estimation results for internal control (IC), corresponding to Hypothesis H2. The DF coefficient is 5.7910 and statistically significant at the 1% level, suggesting that data factor application substantially improves corporate internal control quality. Data penetration breaks intra-firm information barriers, promotes efficient internal information circulation and sharing, and enables management to fully grasp corporate operating conditions. Meanwhile, data analytics supports real-time monitoring of business processes and timely identification of operational risks, thereby refining corporate risk control systems and elevating overall internal control levels. Combined with the baseline findings, this evidence verifies internal control as a critical transmission channel: data factors strengthen firms' internal governance and risk management capabilities, which further improves supply chain resilience against external shocks.

Second, Column (2) reports the regression results for supply chain finance (SCF), corresponding to Hypothesis H3. The DF coefficient is 0.1272 and significant at the 1% level, indicating that data factor development effectively facilitates corporate supply chain finance development. Traditional supply chain finance suffers from severe information asymmetry, which prevents financial institutions and core firms from accurately evaluating SMEs' creditworthiness and hinders the expansion of financing services. Data factors address this dilemma by leveraging multi-dimensional transaction and operational data to precisely assess SMEs' credit status and repayment capacity. This reduces the operational risks and financing costs of supply chain finance and promotes the implementation of relevant financial businesses. Combined with baseline results, this finding validates supply chain finance as a key transmission channel: data factor-enabled supply chain finance alleviates the financing constraints of upstream and downstream SMEs, guarantees smooth capital circulation throughout the supply chain, prevents capital chain fractures amid external shocks, and ultimately enhances supply chain resilience.

Third, Column (3) presents the regression results for supply chain efficiency (SCE), corresponding to Hypothesis H4. The DF coefficient is 0.7701 and significantly positive at the 10% level, demonstrating that data factor inputs effectively improve corporate supply chain operational efficiency. Data application enables firms to accurately capture market demand, optimize supply-demand matching, and reduce inventory backlogs and capital occupancy. Furthermore, data factors lower transaction costs among upstream and downstream enterprises and promote supply chain collaborative cooperation, thereby improving overall operational efficiency. Consistent with the baseline regression conclusions, this result verifies supply chain efficiency as a vital transmission channel: data factor-driven efficiency improvement enhances supply chain flexibility and responsiveness, allows firms to dynamically adjust supply-demand structures under external shocks, accelerates operational recovery, and ultimately strengthens overall supply chain resilience.

The coefficients of control variables across all regressions align with economic intuition and are highly consistent with baseline results. Larger firms exhibit better internal control and supply chain finance development but lower supply chain efficiency, which can be attributed to the complex

network structure of large-scale supply chains. Firms with stronger profitability achieve higher internal control quality and supply chain efficiency, implying that sound profit performance provides solid support for corporate internal governance and operational optimization. Higher equity concentration is associated with improved internal control and supply chain efficiency, indicating that supervision from major shareholders helps optimize internal governance and operational performance to a certain extent. Larger board sizes correspond to weaker internal control, consistent with the view that oversized boards raise coordination costs and reduce decision-making efficiency. A higher proportion of independent directors benefits internal control improvement, reflecting the effective supervisory function of independent directors in corporate governance. In addition, older firms show lower levels of internal control and supply chain finance development, suggesting that mature enterprises suffer from institutional path dependence that restricts internal governance upgrading and business innovation, which is consistent with existing research conclusions.

In addition, in the regressions for mechanism analysis, this paper also controls for year fixed effects and industry fixed effects to absorb the interference of macro shocks and industry heterogeneity. The sample size of all regressions is consistent with that of benchmark regression, with no sample loss. The adjusted R^2 of the model is in a reasonable range, indicating a good fitting effect of the model.

Overall, the results of the mechanism analysis verify the research hypotheses H2, H3 and H4 of this paper, and uncover the internal "black box" through which data factors affect enterprise supply chain resilience: data factors can not only directly affect supply chain resilience, but also jointly promote the improvement of enterprise supply chain resilience through three indirect channels, namely strengthening internal control, promoting the development of supply chain finance and improving supply chain efficiency.

Table 5. Mechanism Test Results.

Variable	(1) IC	(2) SCF	(3) SCE
DF	5.7910***	0.1272***	0.7701*
	(0.8225)	(0.0070)	(0.4451)
Size	21.1152***	0.0528***	-1.4790***
	(0.9630)	(0.0074)	(0.5554)
Lev	-20.5612***	0.3408***	3.2296
	(5.6680)	(0.0377)	(3.1114)
Roa	682.7054***	-0.0545	21.0964***
	(17.4666)	(0.0801)	(6.5110)
Top1	32.2714***	-0.0534	6.6889*
	(5.2939)	(0.0482)	(4.0653)
Board	-14.6866***	-0.0520**	-0.4326
	(2.9626)	(0.0208)	(1.4932)
Indep	28.3006***	-0.0390	-3.6074
	(8.7071)	(0.0650)	(4.5710)
Age	-13.0636***	-0.0316***	1.3686*
	(1.1262)	(0.0086)	(0.7720)
Constant	176.5673***	-1.1590***	38.1886***
	(19.5376)	(0.1516)	(10.9454)
Year FE	YES	YES	YES
Industry FE	YES	YES	YES
N	46198	46198	46198
Adjusted R^2	0.2182	0.1875	0.1526

6.2. Heterogeneity Analysis.

Baseline and mechanism analysis confirm the average positive impact of data factors on supply chain resilience, yet heterogeneous corporate characteristics may generate disparate enabling effects. This paper conducts subsample regressions grouped by ownership nature and innovation capacity; results are reported in Table 6. Columns (1)-(2) separate state-owned enterprises (SOEs) and non-

state-owned enterprises (non-SOEs); Columns (3)-(4) separate low-innovation and high-innovation firms.

The heterogeneity results reveal that the resilience-enhancing effect of data factors varies substantially across firm ownership types. In state-owned enterprises (Column 1), the DF coefficient is 0.0050 and statistically significant at the 5% level. In contrast, non-state-owned enterprises (Column 2) yield a larger DF coefficient of 0.0070, significant at the 1% level. Such inter-group differences indicate that data factors exert a more pronounced empowering effect on the supply chain resilience of non-state-owned enterprises. Economically, state-owned enterprises inherently possess superior policy resources and credit advantages, accompanied by lower financing constraints and milder information frictions, which endow them with stronger baseline supply chain resilience. Accordingly, their marginal gains from data factor empowerment are relatively limited. By comparison, non-state-owned enterprises suffer from prevalent operational pain points, including severe information asymmetry, financing difficulties and fragile supply chain risk resistance. By mitigating information barriers, facilitating supply chain finance and improving operational efficiency, data factors effectively address these inherent deficiencies, thereby generating a stronger marginal improvement in non-state-owned firms' supply chain resilience.

Second, this study examines the heterogeneous effects across firms' innovation capacity. For firms with weak innovation capacity (Column 3), the DF coefficient is 0.0054 and significant at the 1% level. For firms with strong innovation capacity (Column 4), the DF coefficient rises to 0.0081, also significant at the 1% level. The coefficient comparison demonstrates that data factors generate a more prominent resilience-enhancing effect in highly innovative firms. This discrepancy stems from the fact that the value realization of data factors relies heavily on firms' technological absorption and application capabilities. Firms with strong innovation capacity possess a solid technological foundation, enabling them to effectively digest and utilize data resources, convert data factors into practical productivity, optimize supply chain operational processes, and strengthen risk governance, thus maximizing the empowering value of data elements. In contrast, firms with weak innovation capacity lack sufficient technological endowments, resulting in limited data utilization capabilities. They fail to fully unlock the potential value of data factors, leading to a relatively weaker marginal improvement effect on supply chain resilience.

Furthermore, the coefficients of control variables in grouped regressions maintain consistent signs and significance with the baseline regression results, verifying the robustness of the empirical findings. Equity concentration (Top1) shows a significantly negative coefficient at the 1% level across all subsamples, suggesting that the inhibitory effect of excessive equity concentration on supply chain resilience exists stably across different firm types. Board size (Board) yields significantly negative coefficients in non-state-owned enterprises and firms with either strong or weak innovation capabilities, indicating that oversized boards incur higher internal coordination costs and hinder supply chain resilience in these firms. The independent director ratio (Indep) is significantly positive for non-state-owned enterprises and highly innovative firms. This suggests that the supervisory and advisory functions of independent directors are better exerted in market-oriented firms with strong technological innovation demands, which aligns with prior research conclusions. Additionally, firm age (Age) presents significantly negative coefficients in state-owned enterprises and high-innovation firms, confirming that mature firms suffer from institutional path dependence that restricts supply chain resilience upgrading.

Moreover, all grouped regressions incorporate year and industry fixed effects to eliminate the confounding impacts of macroeconomic shocks and industrial heterogeneity. The adjusted R-squared values of all models fall within a reasonable range, confirming good model fitness. Collectively, the heterogeneity analysis demonstrates that the resilience-enhancing effect of data factors is contingent on firm ownership and innovation capacity. These findings provide empirical support for targeted policy formulation. Specifically, policymakers should further advance the input and application of data factors among non-state-owned enterprises and innovation-intensive firms, so as to fully release the empowering value of data elements and precisely improve corporate supply chain resilience.

Table 6. Heterogeneity Analysis Results.

Variable	(1) SOEs SCR	(2) Non-SOEs SCR	(3) Low Innovation SCR	(4) High Innovation SCR
DF	0.0050**	0.0070***	0.0054***	0.0081***
	(0.0019)	(0.0014)	(0.0016)	(0.0014)
Size	-0.0009	-0.0032*	-0.0060***	-0.0007
	(0.0018)	(0.0017)	(0.0018)	(0.0015)
Lev	-0.0033	-0.0005	-0.0070	-0.0009
	(0.0114)	(0.0077)	(0.0097)	(0.0076)
Roa	0.0621**	0.0055	0.0236	-0.0005
	(0.0280)	(0.0163)	(0.0214)	(0.0164)
Top1	-0.0438***	-0.0433***	-0.0712***	-0.0468***
	(0.0134)	(0.0109)	(0.0116)	(0.0098)
Board	-0.0039	-0.0156***	-0.0188***	-0.0188***
	(0.0061)	(0.0043)	(0.0050)	(0.0042)
Indep	-0.0242	0.0255**	0.0192	0.0322**
	(0.0206)	(0.0129)	(0.0154)	(0.0136)
Age	-0.0134***	0.0027	-0.0006	-0.0111***
	(0.0032)	(0.0021)	(0.0024)	(0.0021)
Constant	0.4884***	0.5454***	0.6363***	0.5007***
	(0.0389)	(0.0349)	(0.0378)	(0.0299)
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
N	16089	30108	20934	25264
Adjusted R^2	0.1630	0.1200	0.1205	0.1888

6.3. Moderation Effect Analysis.

Heterogeneity analysis addresses firm-level internal characteristics; this section explores moderating effects of external policy environments: government digital development attention and industrial chain leader pilot policies, testing whether these policies amplify data factors' resilience-boosting impact. Results are reported in Table 7. Both policies exert significant positive moderating effects.

Moderating effect results indicate that policy factors significantly strengthen the resilience-empowering effect of data factors. Column (1) presents the moderating effect of government digital attention (GD). The main effect of DF is 0.0005 and statistically insignificant, suggesting that data factors barely improve supply chain resilience in the absence of governmental digital attention. The main effect of GD is significantly positive at the 1% level (coefficient = 6.4314), demonstrating that governmental digital emphasis independently enhances supply chain resilience by optimizing the external institutional environment. Notably, the interaction term DF×GD is significantly positive at the 1% level (coefficient = 3.7305), confirming a positive moderating effect. That is, higher government digital attention amplifies the empowering role of data factors. Economically, regions with greater digital policy attention feature improved digital infrastructure, standardized regional data factor markets, and optimized digital business environments. Such favorable external conditions support corporate data investment and value exploration, thereby maximizing data factors' marginal contribution to supply chain resilience.

Second, Column (2) reports the moderating results of the industrial chain chief pilot policy (DID). The main effect of DF is significantly positive at the 1% level (coefficient = 0.0050), indicating that data factors can independently improve supply chain resilience in non-pilot regions, which is consistent with the baseline findings. The main effect of DID is also significantly positive at the 1% level (coefficient = 0.0097), suggesting that the industrial chain chief pilot policy itself enhances supply chain resilience by facilitating industrial chain coordination, optimizing supporting facilities, and strengthening inter-firm cooperation within the chain. Furthermore, the interaction term DF×DID yields a significant positive coefficient of 0.0079 at the 1% level, verifying a positive moderating effect. This implies that the pilot policy significantly amplifies the empowering effect of data factors.

The policy focuses on promoting upstream and downstream industrial chain linkage and ensuring supply chain stability. It breaks inter-industry information barriers and facilitates intra-chain data sharing and collaborative cooperation. In such a policy environment, corporate data factor inputs can be better integrated with industrial chain coordinated development, further mitigating information asymmetry, optimizing supply chain operational processes, and maximizing the resilience-enhancing value of data factors.

From the regression results of the control variables, the coefficient signs and significance of the control variables in the regression analysis of the moderating effect are highly consistent with those in the baseline regression results: the coefficients of firm size, ownership concentration, board size and firm age are all significantly negative, the coefficient of the proportion of independent directors is significantly positive, and the coefficients of asset-liability ratio and return on total assets are still not significant. This indicates that the core conclusions of this paper are stable and will not change with the change of model specification.

In addition, this paper also controls for year fixed effects and industry fixed effects in the regression of the moderating effect to absorb the interference of macro shocks and industry heterogeneity. The sample size of the regression is consistent with that of the baseline regression, with no sample loss. The adjusted R^2 (\(R^{2}\)) of the model is within a reasonable range, indicating that the model has a good fitting effect.

The results of the regulatory effect indicate that the external policy environment is an important factor affecting the exertion of the value of data factors. Both the government's digital attention and the industrial chain leader pilot policy can significantly enhance the role of data factors in improving the resilience of enterprises' supply chains. This also provides an empirical basis for subsequent policy formulation: while promoting the investment and application of enterprise data factors, we should further improve the policy environment for the digital economy, promote the implementation of industrial chain leader pilot policies, and better enhance the resilience of enterprises' supply chains and ensure the safety and stability of the industrial chain and supply chain through the synergy of policies and factors.

Table 7. Moderation Effect Results.

Variable	(1) SCR (GD Moderator)	(2) SCR (DID Moderator)
DF	0.0005	0.0050***
	(0.0013)	(0.0011)
GD	6.4314***	
	(1.1832)	
DF×GD	3.7305***	
	(0.6120)	
DID		0.0097***
		(0.0033)
DF×DID		0.0079***
		(0.0016)
Size	-0.0025**	-0.0024**
	(0.0012)	(0.0012)
Lev	-0.0029	-0.0030
	(0.0065)	(0.0065)
Roa	0.0175	0.0148
	(0.0144)	(0.0145)
Top1	-0.0577***	-0.0582***
	(0.0083)	(0.0083)
Board	-0.0187***	-0.0187***
	(0.0035)	(0.0035)
Indep	0.0265**	0.0274**
	(0.0109)	(0.0109)
Age	-0.0075***	-0.0075***
	(0.0017)	(0.0017)

Variable	(1) SCR (GD Moderator)	(2) SCR (DID Moderator)
Constant	0.5615***	0.5693***
	(0.0253)	(0.0252)
Year FE	YES	YES
Industry FE	YES	YES
N	46198	46198
Adjusted R^2	0.1629	0.1623

6.4. Dimensional Decomposition of Supply Chain Resilience.

Prior analysis relies on the composite SCR index; this section decomposes resilience into two sub-dimensions: pre-shock supply chain resistance and post-shock supply chain recovery capacity, regressing each separately to identify differentiated data factor impacts (Table 8).

At the theoretical level, from the perspective of theoretical logic, data factors should have a positive enhancing effect on both dimensions of supply chain resilience: on the one hand, data factors can alleviate information asymmetry, improve internal corporate control, enhance the overall transparency of the supply chain, help enterprises perceive potential shock risks in advance, and improve the ex-ante risk prevention and control system, thereby enhancing the resilience of the supply chain at the source; on the other hand, data factors can promote the development of supply chain finance, improve the operational efficiency of the supply chain, and drive the collaborative cooperation of the main entities in the chain, helping enterprises quickly adjust the structure of supply and demand after encountering shocks and restore the normal operation of the supply chain, thus enhancing the recoverability of the supply chain from the ex-post adjustment perspective.

Empirically, the results in Table 8 validate the theoretical expectations by confirming that data factors significantly promote both dimensions of supply chain resilience. Column (1) takes overall supply chain resilience as the dependent variable. The DF coefficient is 0.0185 and statistically significant at the 1% level, indicating that data factors substantially enhance corporate supply chain resilience. Data factor investment and application optimize firms' ex ante risk prevention and control systems, strengthen supply chain resistance to external shocks, and maintain operational stability against potential disruptions. Column (2) further examines supply chain recoverability. The corresponding DF coefficient is 0.0002, also significantly positive at the 1% level, suggesting that data factors effectively improve ex post recovery capacity. By empowering dynamic operational adjustment, data factors enable firms to rapidly restore supply chain operations to normal levels after external shocks.

By comparing the coefficients of the two dimensions, it can be found that the role of data factors in enhancing the resilience of supply chains is significantly greater than that in improving their recoverability. This indicates that the enabling effect of data factors is more reflected in the ex-ante risk prevention and control level: by improving the risk management system in advance and enhancing the risk resistance of supply chains, enterprises can help reduce the impact of shocks from the source. This is also consistent with the core logic of the current digital economy empowering the development of supply chains—taking precautions before they happen and avoiding the occurrence of supply chain disruptions at the root through ex-ante capacity building.

From the regression results of the control variables, it can be seen that the performance of control variables also shows certain heterogeneity in regressions of different dimensions: variables such as firm size, profitability, and equity concentration have a more significant impact on supply chain resistance, while their impact on resilience is relatively small. This indicates that firms' individual characteristics mainly affect their ex-ante risk resistance capacity, with a relatively limited impact on their ex-post resilience capability. In contrast, the coefficient of the proportion of independent directors is only significant in the regression of resistance, suggesting that the monitoring and advisory roles of independent directors are mainly reflected in the ex-ante risk management level, with little impact on ex-post resilience, which is also consistent with economic intuition.

In addition, in the regression of dimensional decomposition, this paper also controls year fixed effects and industry fixed effects to absorb the interference of macro shocks and industry

heterogeneity. The sample size of the regression is consistent with that of the benchmark regression, with no sample loss. The adjusted R^2 (\(R^ {2} \)) of the model is within a reasonable range, indicating that the model has a good fitting effect.

The dimensional decomposition results suggest that the resilience-enhancing effect of data factors is comprehensive and multi-faceted. Specifically, data factors strengthen firms' ex-ante supply chain resistance to defend against external shocks, as well as improve ex-post recovery capacity to support rapid operational restoration after shock disturbances. These findings further clarify the internal influencing logic of data factors on supply chain resilience and provide refined empirical evidence for an in-depth and comprehensive understanding of the enabling value of data factors.

Table 8. Dimensional Decomposition Regression Results.

Variable	(1) Supply Chain Resistance	(2) Supply Chain Recovery Capacity
DF	0.0185***	0.0002***
	(0.0030)	(0.0001)
Size	-0.0063*	0.0000
	(0.0033)	(0.0001)
Lev	-0.0248	0.0100***
	(0.0174)	(0.0005)
Roa	-0.0796**	0.0606***
	(0.0382)	(0.0015)
Top1	-0.1525***	-0.0024***
	(0.0220)	(0.0004)
Board	-0.0514***	0.0002
	(0.0093)	(0.0003)
Indep	0.0704**	-0.0001
	(0.0292)	(0.0008)
Age	-0.0179***	-0.0013***
	(0.0045)	(0.0001)
Constant	0.9125***	0.3678***
	(0.0667)	(0.0014)
Year FE	YES	YES
Industry FE	YES	YES
N	46198	46198
Adjusted R^2	0.1608	0.0970

7. Research Conclusions and Policy Implications

Taking China's A-share listed companies from 2007 to 2024 as research samples, this paper systematically investigates the impact, internal transmission mechanisms and boundary conditions of data factors on corporate supply chain resilience via baseline regression, robustness tests, mechanism analysis, heterogeneity analysis, moderation effects and dimensional decomposition, filling gaps in existing literature regarding insufficient excavation of data factors' internal empowering logic. Key conclusions and targeted policy recommendations are summarized below.

7.1. Research Conclusions.

Baseline regression confirms that data factors significantly boost corporate supply chain resilience, and this core causal linkage holds robust across multiple identification and sensitivity tests. After controlling firm characteristics, industry and year fixed effects, a one-unit rise in data factor level raises supply chain resilience by 0.0071 units on average, preliminarily validating the empowering effect of data elements. To mitigate endogeneity concerns including reverse causality and omitted variable bias, this paper adopts a suite of robustness strategies: instrumental variable estimation, one-period lagged core independent variable, and sample exclusion of firms affected by the 2015 stock market crash. Additional checks—alternative measurement of data factors, high-dimensional fixed

effects, and adjusted standard error clustering—further validate the stability of findings. All tests consistently document the significantly positive effect of data factors on supply chain resilience, demonstrating that data investment and application durably strengthen supply chain risk resistance.

Second, data factors indirectly empower supply chain resilience through three pivotal transmission channels, thereby opening the internal causal "black box" between the two. Empirical evidence suggests that data factor penetration eliminates intra-firm information barriers, facilitates efficient internal information circulation, and optimizes risk control systems, thereby significantly improving corporate internal control quality. Meanwhile, data factors mitigate inter-firm information asymmetry across supply chains. By evaluating SMEs' credit status based on multi-dimensional transaction and operational data, data elements advance the development of supply chain finance and alleviate supply chain financing constraints. In addition, data application optimizes supply-demand matching, reduces transaction costs, and improves overall supply chain operational efficiency. Collectively, these three mechanisms constitute the core transmission paths of data factor empowerment, which underpin supply chain stability from the dimensions of internal governance, capital flow and operational efficiency.

Third, the empowering effect of data factors presents significant heterogeneous characteristics, with stronger marginal effects in non-state-owned enterprises and innovation-intensive firms. Grouped regression results show that the DF coefficient is larger for non-state-owned enterprises (0.0070) than for state-owned enterprises (0.0050). Compared with state-owned enterprises that possess inherent institutional and resource advantages, non-state-owned enterprises are typically constrained by financing frictions and information asymmetry. Data factors effectively alleviate these operational bottlenecks and therefore generate a more pronounced marginal improvement in supply chain resilience. In addition, the DF coefficient is significantly higher for firms with strong innovation capacity (0.0081) than for those with weak innovation capacity (0.0054). The value realization of data factors relies heavily on firms' technological absorption and transformation capabilities. Innovative firms are better equipped to digest and apply data resources, convert data advantages into practical supply chain optimization outcomes, and thereby maximize the empowering value of data factors.

Fourth, external policy environments exert significant amplifying moderating effects on data factor empowerment, as both government digital attention and industrial chain pilot policies significantly strengthen the resilience-enhancing function of data factors. The moderating results demonstrate that regional government digital attention positively reinforces the enabling effect of data factors. A favorable digital policy environment improves digital infrastructure construction and institutional support, enabling firms to fully unlock data factor value. Similarly, the industrial chain chief pilot policy generates a positive moderating effect. By facilitating upstream and downstream industrial chain linkage and breaking inter-firm information barriers, the policy promotes the deep integration of data factors with industrial chain coordinated development. Such "policy-factor" synergy achieves an amplified governance effect greater than the simple sum of individual effects.

Fifth, the resilience-enhancing effect of data factors is comprehensive in dimension, covering both ex-ante resistance and ex-post recovery, with a more prominent influence on ex-ante risk prevention. Dimensional decomposition results indicate that data factors significantly improve supply chain resistance by optimizing corporate ex-ante risk early-warning and prevention systems, so as to stabilize supply chain operation amid external shocks. Meanwhile, data factors also strengthen supply chain recoverability, enabling firms to rapidly adjust supply-demand structures and restore normal operational status after shock disturbances. Coefficient comparison further reveals that data factors exert a stronger promoting effect on resistance capacity than on recovery capacity. This suggests that the core empowerment logic of data factors lies in risk prevention. By strengthening ex-ante operational governance, data factors fundamentally reduce the probability of supply chain disruption and realize risk mitigation at the source.

7.2. Policy Implications.

Based on the above research conclusions, to further give play to the role of data factors and ensure the security and stability of China's industrial chain and supply chain, this paper puts forward the following policy implications: First, accelerate the cultivation of a unified data factor market and reduce the cost of enterprises' acquisition and application of data factors. The research of this paper confirms that data factors are the core driving force to enhance supply chain resilience. Therefore, we should further speed up the institutional construction of the data factor market, improve the basic rules such as data property rights, transaction circulation and security governance, and promote the compliant sharing of public data and enterprise data. At the same time, increase investment in digital infrastructure, narrow the digital divide between regions, lower the threshold for small and medium-sized enterprises to obtain and apply data factors, and enable more enterprises to enjoy the enabling dividend of data factors.

Second, unblock the transmission channels of data factors and build a multi-dimensional support system for supply chain resilience. In view of the three core transmission paths identified in this paper, supporting policies should be improved in a targeted manner: first, guide enterprises to improve their internal control systems based on data factors, promote the digital monitoring of internal business processes, and strengthen their internal risk management capabilities; second, promote the digital transformation of supply chain finance, encourage financial institutions and core enterprises to innovate supply chain financial products based on transaction data and operational data, alleviate the financing constraints of small and medium-sized enterprises (SMEs) on the upstream and downstream, and ensure the smooth circulation of supply chain funds; third, promote the digital collaboration among the upstream and downstream of the supply chain, support enterprises in the chain to build digital collaboration platforms, optimize the efficiency of supply and demand matching, and improve the overall operational flexibility of the supply chain.

Third, implement differentiated and targeted policies to fully release the heterogeneous empowerment potential of data factors. Tailored and categorized policy support should be formulated according to firm heterogeneity. For non-state-owned enterprises, governments should scale up fiscal and financial support for digital transformation, alleviate their funding and technical bottlenecks in digital upgrading, and fully unlock the empowering value of data factors. For innovation-intensive enterprises, it is essential to encourage increased R&D investment in data element application, support digital innovation in supply chain operations, and leverage their technological advantages to build benchmark digital supply chain systems. For traditional enterprises with weak innovation capacity, governments should strengthen technical assistance and digital skill training, improve corporate data absorption and application capabilities, and help bridge the digital divide in supply chain transformation.

Fourth, promote the coordinated efforts of policies and factors to optimize the external environment for the value realization of data factors. The research in this paper finds that external policies can significantly amplify the enabling effect of data factors, so the policy system of the digital economy should be further improved: local governments should attach greater importance to the digital economy, introduce targeted support policies for the digital economy, improve the regional digital business environment, and provide a good external supporting framework for enterprises to realize the value of data factors; at the same time, the implementation and promotion of the pilot policy for the leading enterprises in the industrial chain should be accelerated, promote the coordinated linkage between the upstream and downstream of the industrial chain, break the information barriers on the chain, promote the sharing and circulation of data on the chain, realize the coordinated efforts of policy guidance and factor driving, and jointly enhance the risk resistance capacity of the supply chain.

Fifth, build a full-chain risk prevention and control system and give full play to the advantages of data factors in ex-ante prevention and control. The research of this paper finds that data factors play a more prominent role in ex-ante risk prevention and control. Therefore, enterprises should be guided to make full use of data factors, build a supply chain risk early warning platform, identify potential

risk points in the supply chain in advance, and avoid supply chain disruptions at the source; at the same time, attention should also be paid to the construction of ex-post recovery capabilities. Relying on data factors to improve enterprises' emergency adjustment capabilities, build a full-chain supply chain resilience guarantee system of "ex-ante early warning and prevention, in-process dynamic adjustment, and ex-post rapid recovery" to comprehensively ensure the safety and stability of China's industrial and supply chains.

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