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The Impact of Derivative Use on Corporate Supply Chain Resilience: Evidence from China

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Abstract

Enhancing supply chain resilience is crucial for China's high-quality economic development. This study selected A-share listed companies from 2010 to 2023 as samples and investigated the impact of derivative usage on supply chain resilience. Research findings indicate that the utilisation of derivatives significantly enhances corporate supply chain resilience. This conclusion remains robust after employing multiple endogeneity treatment methods. Mechanism analysis indicates that derivative usage enhances supply chain resilience by alleviating corporate financing constraints and reducing business risks. Heterogeneity analysis reveals that the enhancing effect of derivatives is more pronounced among firms with higher internal control levels, lower market positions, and higher industry competitiveness. Finally, further analyses reveal that supply chain resilience significantly enhances corporate performance by improving asset utilisation efficiency and production efficiency, providing empirical evidence for firms to translate supply chain resilience advantages into operational outcomes.

Keywords

Supply Chain Resilience, Derivative, Risk Management

1. Introduction

The world today is undergoing a once-in-a-century transformation, with a new wave of technological revolution and industrial change surging forward. The international political and economic landscape is undergoing profound adjustments. However, challenges such as the reversal of economic globalisation, intensifying geopolitical conflicts, and the resurgence of trade protectionism have cast a shadow over global economic stability. Against this complex international backdrop, the stability and security of supply chain systems face unprecedented tests. In recent years, the frequent occurrence of "black swan" and "grey rhino" events has highlighted supply chain risks, inflicting severe impacts on global economic development. These risks exhibit distinct characteristics: they are diverse in nature, transmit rapidly, have profound effects, and are marked by high uncertainty. From the perspective of risk composition, these threats are no longer confined to traditional natural disasters but also encompass man-made factors such as trade frictions and political conflicts, alongside emerging risks including cyberattacks, data breaches, and pandemic outbreaks. Compounded by internal corporate issues like inventory planning errors and cash flow disruptions, these factors collectively exert a profound impact on the normal functioning of supply chains. In terms of impact, supply chain disruptions not only inflict short-term operational damage on enterprises but may also precipitate drastic adjustments to industrial structures, potentially affecting a nation's economic security and strategic competitiveness. Moreover, the increasingly complex and volatile global economic landscape significantly heightens uncertainties facing supply chains, posing substantial challenges for corporate decision-making and government policy formulation.

Against this global backdrop, the profound restructuring of the world economy intertwines with domestic industrial upgrading and transformation, with the complexity and uncertainty of the macroeconomic environment exerting persistent pressure on Chinese enterprises' supply chains. As a pivotal hub in global manufacturing, Chinese enterprises are deeply embedded within international industrial chains. They face both imported risks from volatile commodity prices upstream and uncertainties in cross-border transaction costs stemming from heightened exchange rate flexibility. Compounded by fluctuations in financing costs following deepened domestic interest rate liberalisation, the risk exposure in supply chain operations continues to expand. Commodity price volatility has been particularly pronounced. Geopolitical conflicts have driven up energy prices for crude oil and natural gas, while extreme weather events have disrupted supplies of staple raw materials such as grain and metals. The Shanghai Futures Exchange's 2023 Commodity Market Operations Report indicates that the annual volatility of core manufacturing raw materials like steel and copper in China exceeded 30% from 2021 to 2023. This directly squeezed profit margins for midstream manufacturers, necessitating frequent adjustments to downstream production plans and significantly increasing the difficulty of matching supply and demand within supply chains. Concurrently, the renminbi's exchange rate against major settlement currencies like the US dollar has exhibited heightened two-way volatility. The People's Bank of China's 2023 Renminbi Internationalisation Report indicates that monthly fluctuations exceeding 2% have occurred multiple times since 2022. This severely impacts export-oriented enterprises' foreign exchange earnings and import raw material procurement costs, further exacerbating supply chain cost instability.

Against this backdrop, enhancing the resilience of industrial and supply chains has become a core issue in national strategy. This progressive articulation of national intent and institutional arrangements underscores that enhancing supply chain resilience has become a vital strategic imperative for bolstering national competitiveness and resilience against risks. As the primary actors within supply chains, enterprises' capacity to strengthen their own supply chain resilience not only impacts their individual development but also profoundly influences the stability and security of the nation's overall industrial and supply chain ecosystem.

Enhancing supply chain resilience and security necessitates leveraging the role of financial markets. Derivatives, born out of risk management, serve as vital risk mitigation instruments within the financial sphere. They fulfill functions such as hedging, price discovery, and risk transfer, their fundamental purpose being to assist market participants in mitigating price risks and achieving effective risk management. Enterprises may utilise futures contracts to lock in raw material procurement prices in advance, thereby avoiding significant cost fluctuations. Options can be employed to flexibly address market price uncertainties, effectively controlling operational risks. Swap instruments can be leveraged to manage exchange rate and interest rate risks. Forward contracts can be used to lock in product sales prices for downstream enterprises, stabilising demand expectations and reducing the impact of market volatility on production planning. Existing research indicates that derivatives can stabilise corporate cash flows and reduce both operational and overall business risks (Bartram et al., 2011). They play a vital role in buffering external shocks, enhancing supply chain coordination efficiency, and improving emergency response capabilities, thereby providing robust support for stable supply chain operations. Building upon this foundation, to gain deeper insights into the impact of derivative usage on supply chain resilience and its underlying mechanisms, this study employs A-share listed companies from 2010 to 2023 as its research sample. Utilising the entropy-weighted method to construct a composite supply chain resilience index as the measurement metric, it investigates the influence of derivative usage on supply chain resilience. The findings reveal that the use of derivatives significantly enhances corporate supply chain resilience. This conclusion remains robust after employing multiple endogeneity treatment methods, including instrumental variables, propensity score matching, and Heckman two-stage regression. Mechanism analysis indicates that derivative usage enhances supply chain resilience by alleviating corporate financing constraints and reducing business risks. Furthermore, this study examines whether the impact of derivative usage on supply chain resilience varies across firms with differing internal and external characteristics. Heterogeneity analysis reveals that the enhancing effect of derivatives is more pronounced in firms with higher internal control levels, lower market positions, and higher industry competitiveness. Finally, further analyses reveal that supply chain resilience significantly enhances corporate performance by improving asset utilisation efficiency and production efficiency, providing empirical evidence for firms to translate supply chain resilience advantages into operational outcomes.

The potential marginal contributions of this paper include: firstly, extending research on the economic consequences of derivative instruments from the micro-level of individual enterprises to the systemic dimension of supply chain resilience. It innovatively establishes a theoretical link between derivative usage and supply chain resilience, addressing existing literature's neglect of macro-level supply chain attributes and broadening the boundaries of research on the economic consequences of derivatives. Second, it reveals the mediating transmission pathways through which derivatives influence supply chain resilience from the dual perspectives of corporate risk and financing constraints. Empirical testing confirms this mediating effect, clearly demonstrating the underlying logic and providing new insights and empirical evidence for understanding the role of derivatives in supply chain risk management. Thirdly, by conducting heterogeneity analysis based on firm-level characteristics, it not only reveals differentiated impact effects but also further substantiates the validity of the mediating mechanism. This renders the research framework more comprehensive and rigorous, enhancing the reliability and generalisability of the conclusions.

2. Literature Review and Research Hypotheses

2.1. Literature Review

2.1.1. The Conceptual Framework of Supply Chain Resilience

Supply chain resilience refers to the capacity of a supply chain to effectively withstand impacts, rapidly return to normal operational status, and even achieve optimised adjustments during recovery to attain superior performance levels following exposure to external market risks, sudden disturbances, or shocks (Christopher & Peck, 2004; Soni et al., 2014). Amidst escalating global economic uncertainty, some scholars have elevated supply chain resilience to the level of national economic security and industrial strategy, conceptualising it as the comprehensive capacity of economic systems to flexibly respond, rapidly address, and promptly restore normal operations when confronting novel crises (Behzadi et al., 2020). Larin et al. (2021), adopting a holistic supply chain development strategy perspective, emphasise that the core objective of resilience building is to ensure all segments of the supply chain maintain high levels of stability and fault tolerance when confronted with adverse external shocks, thereby mitigating the negative impacts of disruption risks. Furthermore, research indicates that supply chain resilience is not solely about post-event recovery; it places greater emphasis on the capacity for timely response, dynamic adjustment, and continuous optimisation within highly uncertain risk environments (Um & Han, 2020).

2.1.2. Research on Factors Influencing Supply Chain Resilience

Factors influencing supply chain resilience vary depending on the stage of the supply chain and the industry sector, yet they also share certain commonalities. Supply chain resilience is primarily influenced by both internal and external factors.

Internal factors form the foundation for a supply chain's resistance to external risks and its capacity to build resilience, exhibiting greater complexity than external factors. Soni et al. (2014) employed an explanatory theoretical model to analyse the determinants of supply chain resilience, identifying the organisation's overall capability in resource allocation and collaborative response as a key influencing factor. In the digital economy era, the degree of information sharing has increasingly become a vital reference indicator among internal factors. Comprehensive information sharing facilitates division of labour and collaboration among enterprises, reduces negative value activities, and enhances supply chain management efficiency (Schallmo et al., 2019; Olorunniwo & Li, 2010). Regarding specific responses to external factors, enterprises typically adopt a series of reactive strategies centred on market and competitive environments. These include enhancing product reusability and implementing flexible responsive pricing to adapt to market shifts (Ji, 2009); strengthening customer relationship management and rapidly responding to changing customer demands to improve supply chain flexibility; and dynamically tracking and adapting to competitors' strategic adjustments to enhance their own survival capabilities in market competition (Beske & Seuring, 2014). Concurrently, the demands of external stakeholders such as investors and communities exert a direct influence on supply chain resilience. Their expectations and oversight pressures compel enterprises to adopt more robust and responsible operational practices, thereby safeguarding long-term collaborative relationships and corporate reputation (Freise & Seuring, 2015).

2.1.3. Research on Strategies for Enhancing Supply Chain Resilience

Strategies for enhancing supply chain resilience emphasise capacity building across three dimensions: preparedness to address potential sudden risks, rapid response capabilities during chain disruptions, and recovery and reconstruction capacity (Ponomarov & Holcomb, 2009). Previous literature has particularly focused on studying pre-emptive risk mitigation measures, such as appropriate supplier selection, supplier diversity, and supply chain flexibility (Hosseini et al., 2019; Gao et al., 2021; Gu et al., 2021). Numerous scholars have analysed the challenges confronting supply chain development from diverse perspectives (Pettit et al., 2019), offering their respective insights and recommendations. Some studies suggest that supply chain resilience can be achieved through multi-level strategies involving collaborative activities between organisations and their stakeholders (Pettit et al., 2011).

2.1.4. Research on the Economic Consequences of Derivative Instrument Usage

Firstly, regarding the impact of derivative usage on corporate risk, existing literature has extensively explored two dimensions: operational risk and informational risk. At the operational risk level, relevant studies have yet to reach a unified conclusion: some scholars, based on multinational samples, have demonstrated that the use of derivatives can significantly reduce corporate operational risk (Guay, 1999; Bartram et al., 2011; Belghitar et al., 2013; Huang et al., 2017); other studies, however, have found that derivatives do not effectively mitigate operational risk and may even amplify risk levels (Hentschel & Kothari, 2001; Lien & Zhang, 2008). Regarding information risk, existing research conclusions are relatively consistent: due to the inherent complexity of derivatives' economic substance and accounting treatment, they are prone to being utilised as earnings management tools, thereby elevating firms' information risk (Barton, 2001).

Secondly, regarding the impact of corporate risk on debt financing, existing literature similarly focuses on operational risk and information risk, yielding a relatively consistent conclusion: Increases in both operational and informational risks significantly widen bond credit spreads (Merton, 1974) and bank lending rates (Graham et al., 2008; Rahaman & Zaman, 2013), while simultaneously curtailing the scale of commercial credit access (D'Mello & Toscano, 2020).

Although research on derivatives and corporate debt financing has been relatively abundant internationally, domestic studies on this topic remain comparatively limited, with conclusions exhibiting marked divergence. Some studies indicate that the use of derivatives can enhance corporate debt financing capacity and reduce financing costs (Campello et al., 2011; Chen & King, 2014). Conversely, other research finds that derivatives have no significant impact on debt financing costs, and may even lead to increased financing costs (Yi et al., 2008; Coutinho et al., 2012).

2.2. Research Hypotheses

Against a backdrop of rising global economic uncertainty and heightened volatility in commodity prices, market risks such as exchange rates and interest rates pose increasingly prominent challenges to supply chains, emerging as core factors undermining their resilience (Jüttner & Maklan, 2011; Hosseini et al., 2019). Although Chinese enterprises have enhanced supply chain resilience through digitalisation and multi-source procurement, they still face challenges such as inadequate risk management and unstable cash flow when confronting financial market shocks. Financial decisions made by core node enterprises possess chain-wide transmission effects. As a fundamental risk management tool, the judicious use of derivatives can strengthen an enterprise's own risk-bearing capacity and generate positive spillovers through the supply chain network, directly enhancing supply chain resilience (Smith & Stulz, 1985; Guay, 1999). Derivative utilisation inherently constitutes a market-based resource allocation arrangement, centred on optimising corporate risk-bearing capacity, capital flows, and resource distribution through judicious financial instrument deployment. Grounded in resource-based theory and supply chain risk management frameworks, derivative deployment leverages risk-hedging effects to precisely mitigate diverse uncertainties across the entire supply chain, thereby concurrently enhancing both resilience and recovery capacity. Specifically, the direct risk-hedging effect of derivatives centres on combining financial instruments such as futures, options, forwards, and swaps to lock in key risk exposures across supply chain segments. This reduces the direct disruption of external shocks to supply chain operations, offering a clear, targeted enhancement to both resilience and recovery capacity.

In enhancing supply chain resilience, the core lies in the capacity to withstand external shocks and maintain seamless connectivity across all supply chain segments. The principal external risks confronting corporate supply chains include fluctuations in upstream raw material prices, midstream exchange rate and interest rate variations, and uncertainties in downstream product demand. These risks may directly disrupt procurement, production, and delivery processes. Derivative instruments mitigate these specific risks at their source, thereby reducing disruptions to supply chain operations and establishing a firewall for stable functioning. Specifically, enterprises may utilise commodity futures contracts to lock in upstream raw material procurement prices, thereby circumventing issues such as sharply increased procurement costs and excessive capital tied up due to sudden price surges, while ensuring stable raw material supply (Allayannis & Ofek, 2001; Bartram et al., 2011). Exchange rate swaps can hedge against currency fluctuation risks in cross-border supply chains, preventing import/export cost volatility and profit erosion caused by exchange rate movements, thereby maintaining seamless cross-border supply chain integration. Product price options can hedge against downstream product price declines, locking in sales revenue and avoiding production cuts or supply chain contraction triggered by sudden demand shifts or price volatility. Risk hedging effectively mitigates the impact of various external risks on critical supply chain segments, helping enterprises maintain continuity in procurement, production, and delivery. This significantly enhances supply chain resilience, preventing disruption caused by sudden risk shocks.

In enhancing supply chain resilience, the risk-hedging effect of derivatives can accelerate recovery by mitigating the disruptive impact of risk shocks and reducing post-disruption restoration costs. When supply chains encounter sudden disruptions—such as those caused by pandemics, geopolitical conflicts, or core supplier defaults—specifically, pre-emptively locking in raw material prices through forward contracts with alternative suppliers enables swift switching to substitute providers during core supplier failures. This avoids additional costs from surging raw material prices and reduces the difficulty of restoring operations post-disruption. Hedging the default risk of key partners through credit derivatives enables companies to obtain corresponding risk compensation when partners default. This offsets losses from supply chain disruptions and provides financial support for supply chain reconstruction and production line restart (Namdar et al., 2017; Gao et al., 2021). Concurrently, the direct risk-hedging effect of derivatives helps maintain fundamental stability in core operations during disruptions, preventing operational paralysis from risk shocks and thereby shortening recovery timelines. In summary, derivative utilisation effectively enhances enterprises' rapid response and recovery capabilities post-disruption, accelerating supply chain restoration to normal operations and further refining the overall pathway for strengthening supply chain resilience.

Based on the above analysis, this paper proposes the following hypothesis:

H1: The use of corporate derivatives significantly enhances supply chain resilience.

3. Research Design

3.1. Sample Selection and Data Sources

The new Accounting Standards for Business Enterprises implemented in 2007 established explicit regulations for the on-balance-sheet accounting and disclosure of derivatives for the first time, providing robust institutional support for conducting large-sample empirical research on derivatives based on listed companies' financial statements. However, the outbreak of the global financial crisis in 2008-2009 caused corporate derivative usage behaviour to deviate significantly from normal operating conditions, making it difficult to reflect usage effects under regular circumstances. Consequently, this study selects A-share listed companies from 2010 to 2023 as the initial research sample, focusing on exploring the impact mechanism and effects of derivative usage on corporate supply chain resilience. To ensure sample validity and data reliability, financial listed companies, firms subject to ST treatment during the sample period, and samples with missing data were further excluded, yielding a final cohort of 36,678 valid observations. Additional data sources include the Guotai An database.

Currently, there are irregularities and lack of detail in the disclosure of derivative instruments by listed companies. This paper manually collects data on the use of derivative instruments from the annual reports of sample companies. The specific method is: searching the annual report for keywords such as "derivative", "hedge", "forward", "futures", "option", "swap", "exchange", etc., and judging based on the context whether the company uses derivative instruments, the types of derivative instruments, the types of risks hedged, the fair value of derivative instruments, the quality of information disclosure, and whether hedge accounting is applied.

3.2. Variable Definition and Model Construction

To examine the impact of derivatives on supply chain resilience, the model is set up as follows:

$$Y_{it} = \beta_0 + \beta_1 DT_{it} + \sum \gamma Controls_{it} + \sum Year + \sum Industry + \varepsilon_{it} \quad (1)$$

The dependent variable Y denotes supply chain resilience; DT represents the core explanatory variable for derivative usage; β_1 is the key coefficient of focus in this study. If Hypothesis H1 holds, the β_1 coefficient should be significantly positive; if Hypothesis H2 holds, the β_1 coefficient should be significantly negative. Controls denote a series of control variables; Year and Industry denote year and industry fixed effects; ε denotes the random error term. Furthermore, robust standard errors clustered at the firm level are employed in all regression equations. Specific variable definitions and measurements are detailed in **Table 1**.

Table 1. Variable definitions and measurements.

Variable Properties	Variable Name	Variable Symbol	Variable Definition
Dependent variable	Supply Chain Resilience	SCRes	Composite Index of Supply Chain Resilience
Explanatory variable	Derivatives Usage	DT	A dummy variable that equals 1 if the firm uses derivatives, and 0 otherwise.
	Firm Size	Size	Ln (Market Value)
	Leverage Ratio	Lev	Liabilities at year-end/Total Assets
Control variables	Board Size	Board	Ln (Board Size + 1)
	Operating Cash Flow	Cash	Net Operating Cash Flow/Average Total Assets
	Ownership Concentration	Top1	Shareholding Ratio of the Largest Shareholder
	Return on Total Assets	Roa	Net Profit/Total Assets
	Firm Growth	Growth	Revenue Growth Rate
	Firm Age	Age	Ln (Age + 1)
	Fixed Assets Ratio	Fixed	Net Fixed Assets/Total Assets
	Book-to-Market Ratio	BM	Book Value/Market Value
	Year	Year	Year dummy variables
	Industry	Industry	Industry dummy variables

First-Level Indicator	Secondary Indicator	Tertiary Indicator	Variable Definition	Direction
Supply Chain Resilience	Resistance	Fund occupation	$\ln \frac{Accounts\ Receivable}{Core\ bussiness\ revenue}$	−
		Relationship Stability	Proportion of stable top-five customers in consecutive years	+
	Resilience	Supply-demand deviation	Enterprise output/Enterprise demand	−
		Corporate Performance Deviation	$Perform_{it} = \beta_0 + \beta_1 Size_{it} + \beta_2 Lev_{it} + \beta_3 Growth_{it} + \beta_4 Age_{it} + \beta_5 Board_{it} + \sum Firm + \sum Year + \varepsilon_{it}$	+

4. Empirical Research

4.1. Descriptive Statistics

The descriptive statistics are presented in Table 2. Panel A indicates that the mean supply chain resilience of enterprises stands at 0.536, with 20.3% of companies utilising derivative instruments. This proportion is significantly lower than that observed in developed economies such as Europe and the United States, and also falls below levels recorded in developing nations including South Africa and Malaysia. Regarding the control variables, on average, the debt-to-equity ratio stands at 40.7%, the return on total assets averages 0.0405, the book-to-market ratio is 0.354, the revenue growth rate averages 0.168%, and the net operating cash flow as a percentage of average total assets averages 5.34%.

Table 2. Descriptive statistics.

Panel A Descriptive Statistics of Main Variables						
Variable	N	Mean	SD	p50	Min	Max
SCRes	36678	0.536	0.210	0.633	0.0395	0.753
DT	36678	0.203	0.403	0	0	1
Size	36678	22.97	1.097	22.78	21.15	26.52
Top1	36678	0.344	0.149	0.323	0.0857	0.750
Lev	36678	0.407	0.204	0.398	0.0503	0.944
Fixed	36678	0.204	0.154	0.171	0.00190	0.680
BM	36678	0.354	0.163	0.332	0.0126	0.796
Roa	36678	0.0405	0.0623	0.0405	−0.294	0.216
Growth	36678	0.168	0.382	0.110	−0.590	2.625
Cash	36678	0.0534	0.0788	0.0499	−0.195	0.307
Age	36678	2.907	0.347	2.944	1.792	3.555
Board	36678	2.236	0.174	2.303	1.792	2.708

Panel B Annual Derivative Instrument Usage			
Variable	N	Derivatives-Using Firms	Proportion of Derivatives Usage
2010	1736	216	12.4%
2011	1967	265	13.5%
2012	2096	278	13.3%
2013	2144	303	14.1%
2014	2260	376	16.6%
2015	2455	416	16.9%
2016	2657	431	16.2%
2017	3417	554	16.2%
2018	3494	660	18.9%
2019	3688	756	20.5%
2020	4010	850	21.2%
2021	4547	1114	24.5%
2022	4814	1242	25.8%
2023	4849	1285	26.5%

Panel C Analysis of Variability in Key Variables								
	DT = 0 (1)		DT = 1 (2)		Diff [(1) - (2)]		Diff [(1) - (2)]	
Variable	Mean	Median	Mean	Median	Mean	T-value	Median	Z-value
SCRes	0.532	0.570	0.550	0.723	−0.018***	−6.735	−0.153***	−13.272

Note: *** indicates that compared with firms that do not use derivatives, users of derivatives have a higher median supply chain resilience index. The Z-statistic from the median rank-sum test is −13.272, which is significant at the 1% level.

As shown in Panel B, the number of companies employing derivatives has increased annually, rising from 216 in 2010 to 1285 in 2023. The proportion of companies utilising derivatives has also exhibited an overall upward trend, climbing from 12.4% to 26.5%. Panel C demonstrates that derivative users exhibit higher mean and median supply chain resilience compared to non-users. The mean difference test yields a T-value of −6.735, significant at the 1% level, while the median rank sum test produces a Z-value of −13.272, also significant at the 1% level. In summary, the results in Panel C indicate that companies using derivatives exhibit higher supply chain resilience, thereby partially supporting Hypothesis H1.

Prior to regression analysis, this study conducted correlation coefficient analysis on key variables, as presented in Table 3: Derivative usage (DT) exhibits a positive correlation with supply chain resilience, significant at the 1% level, which also partially supports the study's hypothesis. The mean variance inflation factor (VIF) of 1.3 indicates no severe multicollinearity among the primary independent variables.

Table 3. Correlation analysis.

	SCRes	DT	Size	Top1	Lev	Fixed	BM	Roa	Growth	Cash	Age	Board
SCRes	1											
DT	0.035***	1										
Size	−0.043***	0.226***	1									
Top1	−0.125***	0.024***	0.178***	1								
Lev	−0.044***	0.141***	0.385***	0.043***	1							
Fixed	−0.012**	0.057***	0.064***	0.097***	0.103***	1						
BM	−0.054***	−0.005	−0.245***	0.088***	−0.503***	0.039***	1					
Roa	−0.041***	0.015***	0.126***	0.138***	−0.360***	−0.052***	0.103***	1				
Growth	−0.006	0.014***	0.109***	0.004	0.031***	−0.041***	−0.098***	0.239***	1			
Cash	0.035***	0.052***	0.173***	0.091***	−0.145***	0.197***	0.000001	0.418***	0.068***	1		
Age	0.045***	0.051***	0.134***	−0.099***	0.186***	0.031***	−0.073***	−0.112***	−0.093***	0.028***	1	
Board	−0.096***	0.016***	0.215***	0.015***	0.148***	0.152***	0.005	0.017***	0.001	0.031***	0.025***	1

Note: ***, ** and * denote significance at the 1%, 5% and 10% levels respectively for regression coefficients; values in parentheses indicate t-statistics (same applies below).

4.2. Baseline Regression

Table 4 reports the estimation results of the benchmark regression model. The regression coefficient for the dummy variable (DT) representing the use of derivatives as the core explanatory variable is 0.0109, and is positively significant at the 5% statistical level. This result indicates that, after controlling for a series of firm characteristics such as firm size, equity structure, financial leverage, profitability, as well as year and industry fixed effects, the appropriate use of derivatives can significantly enhance the supply chain resilience of Chinese listed companies, strongly supporting the research hypothesis H1 of this paper. This finding provides new empirical evidence from the micro perspective of corporate financial decision-making regarding pathways to enhance supply chain resilience. It also confirms the positive role of derivatives as risk management tools in stabilising corporate operations and strengthening supply chain resilience.

Table 4. Derivatives and supply chain resilience.

	SCRes
DT	0.0109**
	(2.08)
Size	−0.0014
	(−0.52)
Top1	−0.1106***
	(−6.84)
Lev	−0.0682***
	(−4.54)
Fixed	0.0200
	(1.15)
BM	−0.1372***
	(−8.77)
Roa	−0.1805***
	(−6.22)
Growth	0.0119***
	(3.81)
Cash	0.0887***
	(4.63)
Age	−0.0169**
	(−2.26)
Board	−0.0532***
	(−4.21)
year	YES
industry	YES
_cons	0.8434***
	(13.19)
N	36678
r^2	0.1352
F	23.88

4.3. Robustness Test

4.3.1. Instrumental Variables Method

To address endogeneity problems caused by bidirectional causality and omitted variables, this paper uses the instrumental variable method for robustness testing. In the same year, region, and industry, firms face similar market risks and institutional environments. The derivative usage behavior of peers affects the firm's derivative usage decisions through industry norms, learning by imitation, and demonstration effects, satisfying the relevance assumption of the instrumental variable. This paper further controls for provincial and year fixed effects, effectively isolating the common impacts of regional macro policies, economic cycles, and time trends on both corporate derivative usage and supply chain resilience.

Therefore, this paper selects the mean derivative usage of other listed firms in the same year, region, and industry (IV) as the instrumental variable.

Table 5. Instrument variables method.

Variables	(1)	(2)
	first	second
	DT	SCRes
DT		0.0448***
		(5.5210)
IV	0.9512***	
	(65.8861)	
size	0.0740***	−0.0051***
	(34.0579)	(−3.8331)
Top1	−0.0608***	−0.1167***
	(−4.5358)	(−16.2297)
Lev	0.2551***	−0.1126***
	(18.9828)	(−15.0423)
Fixed	0.0215	0.0304***
	(1.5964)	(4.2175)
BM	0.2091***	−0.1664***
	(14.2169)	(−20.5889)
Roa	0.0978**	−0.1710***
	(2.5052)	(−8.1903)
Growth	−0.0095*	0.0136***
	(−1.8083)	(4.8254)
Cash	0.0506*	0.0671***
	(1.8007)	(4.4715)
Age	−0.0145**	−0.0206***
	(−2.2655)	(−6.0012)
Board	−0.0568***	−0.0504***
	(−4.8855)	(−8.0705)
year	YES	YES
Industry	YES	YES
Prov × year	YES	YES
Constant	−1.8184***	0.9416***
	(−8.4605)	(8.1457)
Observations	36,678	36,678
R-squared		0.162
Kleibergen-Paap rk Wald F statistic	.	4341

The regression results from the instrumental variables method are presented in

Table 5. In the regression of the instrument variable on the independent variable in Column (1), IV exhibits a statistically significant positive relationship with derivative instrument usage (DT) at the 1% level, satisfying the instrument variable correlation criterion. The Kleibergen-Paap rk Wald F-statistic is 4341, substantially exceeding the 10% critical value of 16.38 for the Stock-Yogo weak instrument variable test, thus ruling out weak instrument variables. The results in column (2) indicate that after mitigating endogeneity issues, the correlation coefficient between derivative instrument usage and supply chain resilience is significantly positive at the 1% level. This confirms that derivative instruments enhance corporate supply chain resilience, demonstrating the robustness of the study's findings.

4.3.2. Preference Score Matching Method

Bartram et al. (2011) employed propensity score matching to address endogeneity issues in derivative usage. This paper adopts a similar approach by matching samples of derivative users with non-users, while controlling for industry and year effects. In this study, the propensity score matching method employs logit estimation for propensity scores, matching only individuals within the common score range. The specific matching approach is nearest neighbour one-to-one matching with replacement. The differences in supply chain resilience between derivative users and non-users before and after matching are shown in Table 6. This reveals that post-matching, derivative users exhibit higher supply chain resilience, with a T-value of 2.3.

Table 6. Differences in supply chain resilience levels before and after pairing.

Variable Sample	Treatment Group	Control Group	Difference	Standard Error	T-Value
Before matching	0.5502	0.5319	0.0183	0.0027	8.73
Estimated value	0.5502	0.5408	−0.0094	0.0040	2.30

The validity of propensity score matching hinges upon the fulfilment of the balance assumption and the common support assumption. Testing the balance assumption primarily involves two aspects: firstly, calculating the standard deviation of the treatment and control groups before and after matching. A smaller standard deviation post-matching indicates superior matching effectiveness. Table 7 demonstrates that the absolute values of standard deviations post-matching are substantially lower than pre-matching, indicating a significant reduction in standard deviation and thus good matching effectiveness (Rosenbaum & Rubin, 1983). Secondly, it examines whether the means of relevant variables in the treatment and control groups are equal after matching. If the matching is effective, there should be no significant differences between variables post-matching, and the mean T-test should yield non-significant results. Table 7 indicates that the T-value for fixed assets as a proportion of total assets is −3.6, significant at the 1%

level. Beyond this, the T-values for all other variables are small and fail to pass the significance test. Therefore, overall, the matching satisfies the balance assumption.

Table 7. Balance test.

Variable Name	Before MatchingU	Mean		SD (%)	SD Decreased (%)	T-test	
	After MatchingM	Treatment	Control			T	*P*
Size	U	23.46	22.844	53.3		44.41***	0.000
	M	23.45	23.421	3.1	94.3	1.74	0.082
Top1	U	0.3514	0.3428	5.8		4.45***	0.000
	M	0.3513	0.3552	−2.6	54.4	−1.57	0.117
Lev	U	0.4638	0.3922	36.3		27.34***	0.000
	M	0.4637	0.4606	1.6	95.7	0.99	0.324
Fixed	U	0.2212	0.1994	14.5		10.95***	0.000
	M	0.2212	0.2303	−6.0	58.7	−3.60***	0.000
BM	U	0.3521	0.3542	−1.3		−1.01	0.313
	M	0.3520	0.3538	−1.1	17.1	−0.67	0.502
Roa	U	0.0422	0.0400	3.7		2.75***	0.000
	M	0.0422	0.0415	1.2	68.7	0.72	0.472
Growth	U	0.1778	0.1650	3.4		2.58**	0.010
	M	0.1778	0.1796	−0.5	85.6	−0.29	0.768
Cash	U	0.0615	0.0513	13.0		9.96***	0.000
	M	0.0614	0.0625	−1.3	89.8	−0.80	0.422
Age	U	2.9422	2.8978	12.8		9.86***	0.000
	M	2.9422	2.9451	−0.8	93.5	−0.52	0. 607
Board	U	2.2409	2.2341	3.9		3.05***	0.000
	M	2.2411	2.2408	0.1	96.3	0.09	0.93

For the shared support hypothesis, as illustrated in **Figure 1**, the left panel depicts the density function prior to matching, while the right panel shows the density function post-matching. It is evident that before matching, the control group exhibited significantly higher density scores than the treatment group. Following matching, the control group's kernel density distribution shifted to the right, and the disparity between the control and treatment groups diminished. This indicates that propensity score matching partially corrected the differences between the treatment and control groups. Following matching, regression analysis was conducted, with results presented in **Table 8**. Consistent with the main regression findings of this paper, post-matching analysis confirms a significant positive correlation between derivative instrument usage and corporate supply chain resilience levels, thereby demonstrating the robustness of the research conclusions.

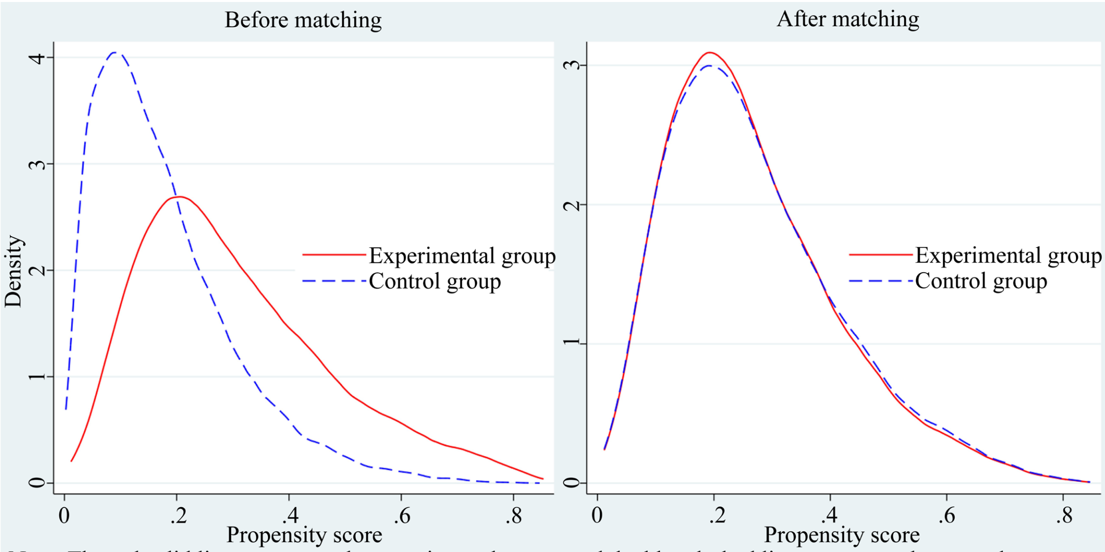

Figure 1. Density function plots before and after matching.

Table 8. Impact of derivative instrument utilisation on corporate supply chain resilience levels following pairing.

	SCRes
DT	0.0108*
	(1.69)
Size	−0.0036
	(−0.70)
Top1	−0.1106***
	(−3.35)
Lev	−0.1136***
	(−3.39)
Fixed	0.0935***
	(2.69)
BM	−0.1715***
	(−4.66)
Roa	−0.1972**
	(−2.52)
Growth	0.0180*
	(1.80)
Cash	0.0923*
	(1.77)
Age	−0.0209
	(−1.23)
Board	−0.0246
	(−0.83)

Continued

_cons	0.8632*** (6.82)
N	11197
r^2	0.1464
F	7.2980

4.3.3. Heckman's Two-Stage Model

The use of derivatives constitutes an endogenous choice for enterprises (Choi et al., 2015). Factors such as firm size, debt-to-equity ratio, growth potential, profitability, and cash flow volatility all influence derivative utilisation. Consequently, it is necessary to mitigate the impact of sample self-selection issues. The results are presented in **Table 9**: Column (1) displays the first-stage regression results, indicating that larger firms with higher debt ratios exhibit a greater propensity to employ derivatives. Column (2) presents the regression results for derivative usage on corporate supply chain resilience after incorporating the inverse Mills ratio. where the inverse Mills ratio is significant at the 1% level, indicating the presence of self-selection bias. After accounting for this bias, the regression coefficient for the dummy variable DT (denoting derivative usage) remains significant at the 10% level. This confirms that companies employing derivatives exhibit significantly higher supply chain resilience than those that do not, thereby demonstrating the robustness of the research conclusions.

Table 9. Regression results for the heckman two-stage model.

	DT	SCRes
DT		0.0096* (1.8283)
mean_derivativeuse	5.4515*** (19.4906)	
Size	0.2837*** (32.0288)	−0.0138*** (−2.9600)
Top1	−0.1710*** (−2.9837)	−0.1039*** (−6.3631)
Lev	1.6357*** (25.8427)	−0.1458*** (−5.4613)
Fixed	0.1344** (2.1437)	0.0194 (1.1215)
BM	1.2532*** (19.4260)	−0.1980*** (−8.4394)
Roa	0.8694*** (4.8650)	−0.2319*** (−7.4407)

Continued

Growth	−0.0390*	0.0143***
	(−1.7046)	(4.5567)
Cash	0.2544**	0.0728***
	(2.0962)	(3.7152)
Age	−0.0441	−0.0133*
	(−1.6150)	(−1.7788)
Board	−0.2226***	−0.0393***
	(−4.5252)	(−2.9642)
imr		−0.0590***
		(−3.3590)
year	YES	YES
industry	YES	YES
_cons	−9.1456***	1.2304***
	(−38.5870)	(9.1464)
N	36530	36530
r^2	0.1328	0.1353
F		23.74

4.4. Mechanism Analysis

4.4.1. Mitigate Corporate Risk

Derivatives mitigate external uncertainties' adverse impact on business operations by precisely hedging market risks such as price volatility, exchange rate fluctuations and interest rate adjustments. This reduces cash flow volatility, thereby enhancing supply chain resilience and fortifying its foundational robustness. Enterprises may utilise futures and options to lock in raw material or product prices, thereby hedging against cost fluctuations (Bartram et al., 2011). Additionally, foreign exchange forwards and interest rate swaps can be employed to optimise capital liquidity. These operations effectively smooth cash flow volatility and mitigate operational risks.

A stable cash flow not only safeguards the maintenance of safety stock and the orderly adjustment of production plans in daily operations, but also enhances a company's capacity to absorb sudden shocks, preventing supply chain paralysis caused by funding chain disruptions. Shao et al. (2019) empirically demonstrate that derivative transactions can reduce overall operational risk through risk management effects, maintain continuity in production and operations, and thereby enhance a company's resilience to external risks. This enables enterprises to confidently secure supply channels and guarantee product delivery during unforeseen circumstances such as raw material price fluctuations or sudden shifts in market demand. Consequently, they avoid becoming weak links in the supply chain, ultimately achieving enhanced supply chain resilience. Therefore, this study employs net operating cash flow as a proportion of operating revenue to measure cash flow, using the three-year standard deviation of cash flow at t − 2, t − 1, and t to gauge corporate cash flow volatility. The regression results are presented in Table 10 (1). Findings indicate that derivatives exhibit a significant negative correlation with cash flow volatility at the 1% level, demonstrating that derivatives can mitigate corporate risk and thereby enhance supply chain resilience.

Table 10. Results of mechanism analysis.

	(1)	(2)
	risk	KZ
DT	−0.0151***	−0.0666***
	(−7.01)	(−2.69)
Size	−0.0054***	−0.0175
	(−3.68)	(−1.25)
Top1	−0.0056	−0.7008***
	(−0.60)	(−8.43)
Lev	−0.0833***	4.2837***
	(−7.00)	(49.05)
Fixed	−0.0687***	2.5324***
	(−6.87)	(30.20)
BM	−0.0706***	−4.0214***
	(−6.90)	(−38.03)
Roa	−0.3338***	−5.9034***
	(−11.50)	(−31.86)
Growth	0.0405***	−0.1410***
	(11.04)	(−6.06)
Cash	−0.1412***	−15.3914***
	(−8.25)	(−115.41)
Age	0.0102**	0.3277***
	(2.15)	(7.97)
Board	−0.0185**	−0.2107***
	(−2.53)	(−3.14)
year	YES	YES
industry	YES	YES
_cons	0.3256***	1.2184***
	(9.40)	(3.68)
N	32827	33510
r^2	0.2483	0.7861
F	39.44	2759

4.4.2. Easing Financing Constraints

Enterprises utilise derivative instruments such as futures, options, and swaps to hedge against price volatility, exchange rate risks, and interest rate risks, thereby mitigating uncertainties in their operating environment (Bartram et al., 2011). Through risk management, the predictability of future cash flows improves, reducing unexpected losses caused by market fluctuations and thus safeguarding the stability of internal funds (Shao et al., 2019). Stable cash flows signal low risk to financial institutions, potentially lowering loan risk premiums and facilitating access to low-cost financing (Chen & King, 2014). Enhanced internal capital adequacy reduces reliance on external financing, particularly during short-term liquidity shocks, thereby avoiding the accumulation of high-interest debt. Furthermore, hedging activities indirectly demonstrate an enterprise's risk management capabilities, bolstering investor confidence, lowering equity financing costs, and mitigating information asymmetry (Dadalt et al., 2002). Thus, derivatives provide a financial foundation for enhancing supply chain resilience by stabilising cash flows and reducing financing costs. The capital freed by easing financing constraints can be directed towards strengthening other critical supply chain segments. Firstly, it enables collaboration with multiple suppliers to avoid single-source dependency, stockpiling of critical materials to address sudden disruptions, and investment in digital supply chain management systems to improve demand forecasting and response speed (Namdar et al., 2017). Secondly, they bolster fulfilment capabilities, as ample funds ensure timely supplier payments, thereby maintaining supply chain partnerships and averting disruption risks stemming from payment defaults (Gao et al., 2021). Finally, they enhance shock resilience, enabling enterprises to swiftly mobilise funds for alternative solutions during crises and shorten recovery periods. This study employs the KZ index to measure corporate financing constraints, where a higher KZ indicates greater constraints. The regression results, as shown in **Table 10** (2), reveal that DT and KZ are significantly negatively correlated at the 1% level. This indicates that derivative instruments can alleviate corporate financing constraints, thereby enhancing corporate resilience.

4.5. Heterogeneity Analysis

4.5.1. Internal Control

Internal control, as the core of corporate risk management, influences the effectiveness of derivative risk management functions, thereby affecting its capacity to enhance supply chain resilience. The high leverage and complexity inherent in derivatives mean their positive effects are highly dependent on robust internal controls. Effective internal controls can constrain speculative use and ensure risk hedging objectives are met, whereas weak controls may exacerbate corporate risks and diminish their beneficial impact. Consequently, this paper employs the Dibo Internal Control Index as a proxy variable. Specifically, the Dibo Internal Control Index is increased by one, then log-transformed, and grouped according to annual industry averages. A level above the annual industry average represents higher internal control, while a level below the annual industry average represents lower internal control. The regression results are shown in Table 11, showing that there is significant heterogeneity in the positive impact of derivatives use on supply chain resilience: within the high internal control group, the regression coefficient for derivative usage is significantly positive, indicating effective risk hedging that substantially enhances supply chain resilience. Conversely, within the low internal control group, although the regression coefficient for derivative usage is positive, it fails to pass the significance test, suggesting that its positive impact is not effectively realised.

Table 11. Regression results of internal control level.

	Low Level of Internal Control	High Level of Internal Control
DT	0.0077	0.0117**
	(1.17)	(2.02)
Size	−0.0066*	0.0003
	(−1.88)	(0.09)
Top1	−0.0964***	−0.1102***
	(−4.76)	(−6.33)
Lev	−0.0494***	−0.0684***
	(−2.76)	(−4.02)
Fixed	−0.0201	0.0419**
	(−0.99)	(2.21)
BM	−0.0503**	−0.1699***
	(−2.56)	(−9.81)
Roa	−0.1311***	−0.1450***
	(−3.86)	(−3.77)
Growth	0.0085*	0.0189***
	(1.68)	(5.05)
Cash	0.0749**	0.0854***
	(2.43)	(3.89)
Age	−0.0530***	−0.0041
	(−5.57)	(−0.51)
Board	−0.0530***	−0.0526***
	(−3.45)	(−3.82)
Year	YES	YES
Industry	YES	YES
_cons	1.0481***	0.7647***
	(12.67)	(11.08)

Continued

N	12538	24140
r^2	0.1580	0.1354
F	11.2341	23.4331
P-value for Between-Group Difference Test	0.0000***	

4.5.2. Industry Competitiveness

The competitive environment within an industry profoundly shapes a firm's developmental trajectory. In intensely competitive sectors, enterprises confront greater uncertainties and face heightened difficulties in securing critical resources such as capital and customers, experiencing significant resource-squeeze pressures. Concurrently, heightened competitive intensity translates to elevated operational risks. Consequently, compared to firms operating in less competitive industries, those within fiercely contested sectors exhibit greater sensitivity in supply chain resilience to the utilisation of derivatives. In other words, the role of derivatives in enhancing corporate resilience is more pronounced in highly competitive industries.

This paper employs the Herfindahl-Hirschman Index (HHI) to measure industry competitiveness, defined as the sum of the squares of the ratios of each company's primary business revenue to the industry's total revenue. A lower HHI value indicates greater industry competition. Group the Herfindahl index by annual industry average. Industries above the annual industry average represent higher competition levels, while industries below the annual industry average represent lower competition levels. The regression results, as shown in **Table 12**, reveal that in highly competitive industries, the regression coefficient linking derivatives to supply chain resilience is larger than in less competitive industries. This indicates that when operating in a highly competitive sector, derivatives yield a greater marginal increase in supply chain resilience, thereby amplifying their strengthening effect.

Table 12. Regression results of industry competition level.

	Low Level of Industry Competition	High Level of Industry Competition
DT	0.0056	0.0166**
	(0.90)	(2.15)
Size	−0.0007	−0.0025
	(−0.22)	(−0.63)
Top1	−0.0986***	−0.1287***
	(−5.34)	(−5.07)
Lev	−0.0752***	−0.0484**
	(−4.32)	(−2.13)

Continued

Fixed	0.0161	0.0279
	(0.79)	(1.07)
BM	−0.1323***	−0.1328***
	(−7.33)	(−5.51)
Roa	−0.1806***	−0.1770***
	(−5.31)	(−3.86)
Growth	0.0113***	0.0133**
	(2.97)	(2.56)
Cash	0.0984***	0.0846***
	(4.20)	(2.80)
Age	−0.0236***	−0.0028
	(−2.75)	(−0.24)
Board	−0.0574***	−0.0458**
	(−4.01)	(−2.37)
year	YES	YES
industry	YES	YES
_cons	0.8546***	0.8064***
	(11.48)	(8.34)
N	24305	12373
r^2	0.1420	0.1346
F	17.03	10.30
P-value for between-group difference test	0.0000***	

4.5.3. Market Position

A firm's market position significantly influences its capacity to manage risk. Compared to enterprises with lower market standing, those occupying a higher position typically maintain closer relationships with banks and enjoy more accessible financing channels, enabling them to mitigate the financial pressures arising from external shocks more effectively. A superior market position signifies greater industry influence, competitiveness, and profitability. This not only enhances customer willingness to collaborate but also reduces the likelihood of cash flow constraints stemming from fluctuations in sales revenue (Sheikh, 2019), thereby sustaining more stable cash flows. Conversely, enterprises with low market standing frequently confront heightened operational risks, diminished credibility, and weaker competitiveness, rendering them less able to secure adequate financial backing from institutions. Consequently, compared to their high-standing counterparts, these firms may exhibit greater sensitivity to employing derivatives to bolster their resilience. In other words, the role of derivatives in enhancing corporate resilience is more pronounced among enterprises with lower market standing.

Table 13. Regression results for market position.

	Low Market Position	High Market Position
DT	0.0148**	0.0024
	(2.30)	(0.33)
Size	−0.0031	−0.0015
	(−0.89)	(−0.44)
Top1	−0.1200***	−0.0988***
	(−5.82)	(−4.88)
Lev	−0.0415**	−0.0979***
	(−2.10)	(−4.92)
Fixed	0.0159	0.0167
	(0.72)	(0.74)
BM	−0.0593***	−0.2082***
	(−2.81)	(−10.67)
Roa	−0.1381***	−0.2669***
	(−4.01)	(−5.47)
Growth	0.0065	0.0173***
	(1.51)	(3.97)
Cash	0.1106***	0.0871***
	(4.16)	(3.30)
Age	−0.0341***	−0.0002
	(−3.56)	(−0.02)
Board	−0.0714***	−0.0324**
	(−4.50)	(−2.00)
Year	YES	YES
Industry	YES	YES
_cons	0.9380***	0.7902***
	(11.46)	(9.58)
N	18826	17852
r^2	0.1409	0.1407
F	12.26	20.93
P-value for between-group difference test	0.0000***	

This article uses the Lerner index to measure the market position of enterprises, namely: (Operating Revenue—Operating Costs—Selling Expenses—Administrative Expenses)/Operating Revenue. The larger the Lerner index, the higher the company's market position. The Lerner index is grouped according to the annual industry average. Higher than the annual industry average represents a higher market position, while lower than the annual industry average represents a lower market position.

The empirical findings are shown in Table 13 to support this view: the positive association between derivative usage and corporate supply chain resilience proves statistically significant only within the low market position sample group. This indicates that when enterprises occupy a lower market position, the strengthening effect of derivatives on their supply chain resilience becomes more pronounced.

4.6. Further Analysis

This paper further explores the impact of supply chain resilience on corporate performance, clarifying its effects on core dimensions of business outcomes. Production efficiency constitutes a vital manifestation of an enterprise's core competitiveness. This study adopts total factor productivity (TFP) as the primary metric for measuring production efficiency, as it comprehensively reflects the synergistic utilisation efficiency of various production factors within an enterprise. Specifically, TFP_OP (calculated using the OP method) and TFP_GMM (calculated using the GMM method) effectively mitigate endogeneity and sample selection bias, thereby accurately depicting an enterprise's true production efficiency level. Furthermore, return on equity (ROE) is selected as the core metric for assessing the efficient utilisation of corporate assets. It directly reflects a firm's capacity to generate returns using its own capital and serves as a vital quantitative representation of corporate performance.

The regression results indicate that the regression coefficient for DT*SCRes in column (1) is 0.4111, significant at the 1% statistical level. This demonstrates that the synergistic effect between derivative instrument utilisation and supply chain resilience can significantly enhance a firm's short-term production efficiency. This is primarily because highly resilient supply chains effectively stabilise production processes, reduce output fluctuations, and prevent production disruptions and idle capacity caused by external shocks such as raw material shortages or logistics bottlenecks. Consequently, they ensure the sustained and efficient deployment of production factors like labour and capital, thereby driving short-term total factor productivity growth. Table 14 shows that the regression coefficient for DT * SCRes is 0.4017, significant at the 1% statistical level, further validating the sustained positive impact of supply chain resilience on production efficiency. Compared to TFP_OP, TFP_GMM mitigates endogeneity issues through the dynamic panel regression model, better reflecting the long-term promotional effect of the synergistic interaction between derivative usage and supply chain resilience on production efficiency. Column (3) results indicate that the regression coefficient for DT * SCRes is 0.0113, significant at the 1% statistical level. This demonstrates that the synergistic effect of derivative usage and supply chain resilience significantly enhances firms' asset utilisation efficiency, thereby promoting improved corporate performance.

Table 14. Impact of supply chain resilience on corporate performance.

	(1)	(2)	(3)
	TFP_OP	TFP_GMM	ROE
DT * SCRes	0.4111***	0.4017***	0.0113***
	(13.70)	(13.52)	(3.78)
Size	0.4104***	0.3272***	0.0009
	(51.91)	(40.16)	(0.93)
Top1	0.1181**	0.1377***	−0.0190***
	(2.26)	(2.62)	(−3.24)
Lev	1.7085***	1.5620***	0.0925***
	(32.29)	(29.26)	(9.53)
Fixed	−0.9166***	−1.6001***	0.0310***
	(−14.95)	(−25.50)	(2.70)
BM	1.2295***	1.0023***	0.0826***
	(24.49)	(19.87)	(10.05)
Roa	1.6546***	1.7166***	2.3949***
	(15.79)	(16.04)	(28.40)
Growth	0.1443***	0.1488***	0.0227***
	(13.60)	(14.00)	(6.33)
Cash	0.0952	0.1350**	−0.1421***
	(1.48)	(2.06)	(−4.31)
Age	0.1331***	0.1150***	0.0043
	(5.35)	(4.54)	(0.99)
Board	−0.0654	−0.0814*	0.0096
	(−1.58)	(−1.95)	(0.97)
_cons	−3.9675***	−2.6995***	−0.1487***
	(−19.85)	(−13.23)	(−3.86)
N	36140	36140	35772
r^2	0.6282	0.5854	0.4281
F	650.1575	505.4381	546.7233

5. Conclusions and Recommendations

The use of derivatives significantly enhances corporate supply chain resilience, and this conclusion remains robust after employing multiple endogeneity treatment methods including instrumental variables, propensity score matching (PSM), and Heckman two-stage methods. Mechanism analysis indicates that derivative usage enhances supply chain resilience by alleviating corporate financing constraints and reducing business risks. Furthermore, this study examines whether the impact of derivative usage on supply chain resilience varies across firms with differing internal and external characteristics. Heterogeneity analysis reveals that the enhancing effect of derivatives is more pronounced among firms with higher internal control levels, lower market positions, and higher industry competitiveness. Finally, further analyses reveal that supply chain resilience significantly enhances corporate performance by improving asset utilisation efficiency and production efficiency, providing empirical evidence for firms to translate supply chain resilience advantages into operational outcomes.

Based on the empirical findings presented above, the following recommendations are proposed:

For business operators, it is imperative to abandon narrow perceptions of derivatives and recognise their core value in risk hedging. By aligning with the enterprise's operational scale, supply chain configuration, and specific risk exposures, forward contracts, futures, options, and other derivatives should be judiciously employed to effectively mitigate operational risks such as raw material price volatility and exchange rate fluctuations. This approach smooths cash flow fluctuations and safeguards the stable operation of core supply chain functions including procurement, production, and distribution. Concurrently, leverage derivatives to enhance operational credibility, mitigate information asymmetry with external investors, further reduce financing costs, and broaden funding channels. This provides robust financial backing for optimising supply chain configurations and establishing contingency reserves. Additionally, prioritise internal resource optimisation to minimise waste from raw material stockpiling and idle capacity. Rely on high-resilience supply chains to ensure seamless production continuity, elevate operational efficiency, and tangibly translate supply chain resilience into corporate performance advantages.

For derivatives market regulators, the first priority is to refine the regulatory framework governing derivatives markets, specifying detailed rules for derivatives trading and clarifying the compliance boundaries for corporate use of derivatives. This involves rigorously distinguishing between risk hedging and speculative arbitrage activities, cracking down on non-compliant speculative trading, and preventing additional operational risks arising from derivatives usage. Such measures will foster a regulated and orderly market environment enabling enterprises to appropriately utilise derivatives for risk hedging and enhancing supply chain resilience. Secondly, diversify the product offerings within the derivatives market. Addressing the core risk challenges faced by enterprises, guide market participants to develop more derivative products tailored to the practical operational needs of businesses. Broaden the scope of derivative coverage to assist enterprises in precisely hedging supply chain-related risks. Thirdly, strengthen oversight of information disclosure by refining rules governing enterprises' disclosure of derivative usage. Require enterprises to provide detailed disclosures on the purpose, type, and risk management measures associated with derivative instruments. This will enhance transparency in derivative usage, help alleviate information asymmetry, and ensure derivatives function effectively.

For government departments, the first step is to formulate targeted policy support based on research findings regarding heterogeneity, with a particular emphasis on bolstering enterprises characterised by low internal control standards, weak market positions, and high industry competitiveness. Through preferential measures such as tax relief and fiscal subsidies, the cost of employing derivative instruments for such enterprises should be reduced, thereby encouraging their use of derivatives to hedge risks and enhance supply chain resilience. Secondly, optimise the corporate financing environment by guiding financial institutions to increase credit support for enterprises, further lowering financing costs and broadening funding channels. Concurrently, enhance the social credit system to mitigate information asymmetry between enterprises and financial institutions, thereby providing robust financial backing for supply chain resilience development. Thirdly, strengthen guidance to promote the refinement of enterprises' internal control systems and risk management mechanisms. This will enhance internal governance efficiency and improve risk identification and response capabilities, thereby assisting enterprises in more effectively utilising derivatives for risk hedging and fully unlocking their potential to bolster supply chain resilience.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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