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The Impact of Supply Chain Concentration on Firm Value - Based on the Mediating Effect of Green Technology Innovation

Wenfang Liu. Ying Zhang*
Faculty of Economics and Management, Guangxi University of Science and Technology, LiuZhou, China
Email: 1126604573@qq.com

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Abstract

This paper constructs a fixed-effects panel model based on data from listed companies in heavy pollution industries in Shanghai and Shenzhen A-shares from 2013 to 2023, and empirically analyzes the impact of supply chain concen-tration on enterprise value and the intermediary role of green technology in-novation. The results show that, on the one hand, supply chain concentration significantly suppresses enterprise value, possibly due to the increased inter-nalization costs of environmental risks caused by excessive control over up-stream and downstream activities. On the other hand, green technology innova-tion plays a partial intermediary role between supply chain concen-tration and enterprise value, reducing costs through technological spillover and collab-ora-tive R&D, alleviating the negative impact of concentration on enterprise value. Heterogeneity analysis reveals that non-state-owned enterprises are more sig-nificantly affected by supply chain concentration, while equity-independent firms face greater negative impacts, and non-equity-independent firms experi-ence smaller and insignifi-cant effects. When optimizing supply chain concen-tration, companies should balance concentration with investment in green in-novation to enhance long-term competitive-ness and sustainability

Keywords

Supply chain concentration; Green technology innovation; Firm value; Mediation effect

1. Introductory

Driven by the dual forces of global industrial chain restructuring and the 'dual carbon' goals, supply chain security and green transformation have become core issues for China's high-quality development. However, current research mainly focuses on the direct impact of supply chain concentration on firm value or the isolated economic effects of green technology innovation, lacking an analysis of the transmission mechanisms between these factors. This paper utilizes data from heavily polluting companies listed on the A-share market (2013-2023) to explore the relationships among supply chain concentration, green innovation, and firm value. A fixed-effect

regression model and a mediation effect framework were applied, with instrumental variables derived from firm characteristics. The study addresses three main questions: (1) the impact of supply chain concentration on firm value; (2) whether green technology innovation acts as a 'lubricant' in supply chain integration, enhancing company valuation; (3) whether ownership attributes affect the enterprise value of heavily polluting firms.

The marginal contribution of this paper is twofold. First, most of the previous studies have focused on the overall manufacturing industry, and there are limited empirical studies on heavily polluting firms. This paper fills this gap by providing reliable evidence on the relationship between supply chain concentration and firm value at the micro level. Secondly, taking green technology innovation as the mediating variable, this paper explores the transmission mechanism between supply chain concentration and enterprise value, which provides a new perspective on how enterprise innovation affects enterprise value. This enriches the theoretical understanding of green supply chains.

2. Literature Review and Research Hypotheses

2.1. Relationship between supply chain concentration and firm value

Supply chain concentration measures the degree of concentration of firms in the procurement and sales chains, and the academic community divides on its impact on firm value, mainly weighing short-term efficiency gains with long-term innovation inhibitions.Some scholars believe that supplier concentration is positively correlated with firm performance, and Ying Liu (2020) points out that it contributes to cooperation and economies of scale. However, Chen Maonan (2020) found that high supplier concentration inhibits firm value, while Li Yanhui (2024) argues that it has an inverted U-shaped effect on firm value, and excessive concentration may have a negative impact. Zhang Tiesheng (2024) said that high supplier concentration exacerbates financial distress. Regarding customer concentration, Su Yumin (2024) believes that it significantly increases the value of cross-border e-commerce companies.

Overall, the impact of supply chain concentration on firm value is complex.Patatoukas (2012) points out that moderate concentration can enhance efficiency, but excessive concentration may pose systemic risks. Li Yaxin (2023) pointed out that overall supply chain concentration and downstream customer concentration are beneficial to retail firm performance, but upstream supplier concentration may have a negative impact. Chen Yue-Lin (2024) showed that both high and low levels of supply chain concentration have a dampening effect on the performance of wholesale and retail firms.Thus,this paper proposes hypothesis H1: supply chain concentration has a negative effect on firm value.

2.2. Relationship between supply chain concentration and green technology innovation

Green technology innovation is the key to enhancing the competitiveness of enterprises. High supply chain concentration contributes to innovation, as close and stable supplier cooperation and information flow facilitate technological innovation. Yin (2023) found that firms with higher voice in the supply chain have stronger R&D capabilities. However, Zhang Tiesheng (2023) points out that there is a U-shaped relationship between supply chain concentration and green technology innovation, indicating that this relationship is not only positive, but also moderated by multiple factors.This indicates that supply chain concentration can have a positive effect on green technology innovation under specific conditions.

However, excessive supply chain concentration may have a dampening effect on green technology innovation. Studies such as Zhong Wen (2024) and Xiao Xuexing (2024) also found that the higher the upstream and downstream concentration of the supply chain, the higher the firm's innovation capability and R&D investment are both negatively correlated.Thus, this paper proposes hypothesis H2: supply chain concentration negatively affects green technology innovation.

2.3. Relationship between supply chain concentration, green technology innovation and firm value

Supply chain concentration and green technology innovation can interact with each other to a certain extent, affecting the innovation ability and long-term value of enterprises. Supply chain concentration helps enterprises to obtain more resource support and technical cooperation in green technology innovation by improving the efficiency of resource integration. For example, Xu Jinye (2019) found that enterprise's technological innovation investment can significantly regulate the relationship between customer concentration and debt financing cost, when the enterprise's technological innovation investment is higher, the impact of customer concentration on the enterprise's debt financing cost will be weakened, which will be conducive to the improvement of enterprise value. At the same time, Feng Zhanbin (2021) found that customer concentration can play a "synergistic effect", the degree by increasing bank borrowing and increase R & D investment, improve the degree of corporate strategic differences.

Some other empirical studies have also explored the specific relationship between the three.Jin Jiangyan (2023) shows that supplier and consumer concentration affect enterprise value creation, and technological innovation and R&D investment are the key factors. Zhang Yuan (2023) found that supplier concentration has a significant sssspositive impact on the innovation performance of retail enterprises, and the value creation mechanism plays a moderating role. Dong Qichen (2025) pointed out that supply chain uncertainty inhibits innovation and affects the long-term value of enterprises.Thus, this article proposes hypothesis H3: Green technological innovation plays a mitigating mediating role in the negative impact of supply chain concentration on corporate value.

3. Research design

3.1. Sample selection

Taking the 2012 edition of the industry classification of China Securities Regulatory Commission (CSRC) as the standard, the samples selected in this paper are the enterprise data of heavy pollutant enterprises industry listed in Shanghai and Shenzhen A-shares from 2013-2023, and the main sources of the data are the Oriental Wealth Net and the CSMAR database (CSMAR), and the sample data are processed as follows: (1) exclude the companies that have ever been ST and *ST, and (2) exclude the samples with missing financial data; (3) Shrinking all continuous variables up and down by 1%. Finally, 9,737 valid annual observations were obtained and used to construct the fixed-effects regression model.

3.2. Definition of variables

- Explained variables: There are several ways to measure the value of a business. For example, Liu Songyue (2018) uses firm market value (Mv) as the explanatory variable, and Gan Zhixia (2023) uses firm business performance (Roa) as the explanatory variable. In this paper, the Mv value is used as the measure of enterprise value, and the Roa value is used as the measure of robustness test.
- Explanatory variables:Referring to Jin Jiangyan (2024), supply chain concentration is measured by the average (Sup) of the procurement ratio of the top five suppliers and the sales ratio of the top five customers.
- Mediating variables: This paper measures green technology innovation through the number of green patent applications by listed companies, using the natural logarithm (Gti) of green patent data after adding 1, with reference to the Hsu Han-You method.
- Control variables: Referring to the relevant literature and considering the factors that have a significant impact on the value of the enterprise, the following control variables are selected: independent director ratio (Ind), asset-liability ratio (Lev), equity ratio (Epr), intangible asset ratio (Int), current asset ratio (Liq), selling expense ratio (Sar), and management expense ratio (Mer).

Table 1. Definition of variables

Variable type	Variable name	Variable symbol	Variable Definition
explanatory variable	enterprise value	Mv	Book-to-market ratio
explanatory variable	Supply chain concentration	Sup	(Proportion of purchases from top 5 suppliers + proportion of sales to top 5 customers)/2
intermediary variable	Green Technology Innovation	Gti	Green patent data are all natural logarithmic with 1 added.
control variable	Percentage of independent directors	Ind	Percentage of independent directors = number of independent directors/total number of board members
	gearing ratio	lev	Gearing ratio = total liabilities/total assets
	equity ratio	Epr	Equity ratio = total liabilities/shareholders' equity

Current assets ratio	Liq	Current asset ratio = current assets/total assets
Intangible assets ratio	Int	Intangible assets ratio = intangible assets/total assets
sales expense ratio	Sar	Sales Expense Ratio= Sales Expense Ratio ÷ Sales Revenue
management cost ratio	Mer	Administrative expense ratio = Administrative expenses ÷ Sales revenue
Nature of property rights	Soe	State-owned enterprises take 0, otherwise take 1
year (e.g. school year, fiscal year)	Year	Annual dummy variable to fix the effect of macro factors
corporations	Symbol	Enterprise dummy variables to fix the impact of enterprise factors

3.3. Modelling

In this paper, the main effect regression model of the relationship between the explanatory variable (Sup) and the explained variable (Mv) is constructed as shown in Eq. (1), which is used to test H1; in order to test H2 and H3, the mediation effect regression model is further constructed as shown in Eq. (2) and Eq. (3).

$$\mathrm{Mv}_{i,t} = a_0 + a_1 Sup_{i,t} + a_2 Control_{i,t} + \sum Year_{i,t} + \varepsilon_{i,t} \quad (1)$$

$$\mathrm{Gti}_{i,t} = a_0 + a_1 Sup_{i,t} + a_2 Control_{i,t} + \sum Year_{i,t} + \varepsilon_{i,t} \quad (2)$$

$$\mathrm{Mv}_{i,t} = a_0 + a_1 Sup_{i,t} + a_2 Gti_{i,t} a_3 Control_{i,t} + \sum Year_{i,t} + \varepsilon_{i,t} \quad (3)$$

Model (1) takes enterprise value as the dependent variable, supply chain concentration as the independent variable, control variables include time and company, and w is the random error term.

4. Empirical analysis

4.1. Descriptive statistical analyses

According to descriptive statistics, there are large differences in supply chain concentration, green technology innovation and enterprise value. The mean value of the enterprise was 22.92 with a standard deviation of 1.146, fluctuating between 20.93 and 26.36, showing some difference but overall concentration. The mean value of supply chain concentration was 0.348, the standard deviation was 0.173, and the fluctuation range ranged from 0.0625 to 0.844. The supply chain concentration fluctuates greatly, indicating that the supply chain management style is significantly different among enterprises. The mean value of green technology innovation was 0.78, the standard deviation was 1.057, and the fluctuation range was from 0 to 4.263, indicating that there was a significant difference in investment, with most companies investing less and a few investing more. In terms of control variables, although there are certain fluctuations in each variable, the indicators of most enterprises are relatively concentrated.

Table 2. Descriptive statistical analysis

variable name	Variable	Symbol	Average	Standard	Min	Max
enterprise value	Mv	9,737	22.92	1.146	20.93	26.36
Supply chain concentration	Sup	9,737	0.348	0.173	0.0625	0.844
Green Technology Innovation	Gti	9,737	0.78	1.057	0.000	4.263
Percentage of independent directors	Ind	9,737	0.198	0.0355	0.125	0.3
gearing ratio	Lev	9,737	0.398	0.201	0.0536	0.897
equity ratio	Epr	9,737	0.962	1.107	0.0518	7.344
Current assets ratio	Liq	9,737	0.492	0.187	0.0838	0.878
Intangible assets ratio	Int	9,737	0.0515	0.0477	0.00074	0.312
sales expense ratio	Sar	9,734	0.0871	0.132	0.000	0.583
management cost ratio	Mer	9,734	0.0739	0.0562	0.00679	0.355

4.2. Benchmark regression

The benchmark regression analysis aims to explore the relationship between company value and key variables. The results in Column 1 indicate that supply chain concentration has a significant negative impact on company value, confirming Hypothesis H1. After introducing more control variables in Column 2, the results still show a significant negative correlation between supply chain concentration and company value. Furthermore, the proportion of independent directors is significantly negatively correlated with company value, suggesting that a higher proportion of independent directors may lead to governance issues, thereby reducing company value.The gearing ratio is positively correlated with the value of the company, indicating that a higher debt ratio contributes to the value of the company. In column 3, the negative impact of supply chain concentration is still significant after considering the firm and year fixed effects, which validates hypothesis H1. The significance of the proportion of independent directors decreased from 1% to 5%, and the coefficient weakened, indicating that the impact on the company's value was weakened after controlling for the fixed effect.In the model, the ratio of intangible assets and the ratio of selling expenses becomes negatively significant, indicating that a high proportion of intangible assets and expenses may be detrimental to the value of the company. After the introduction of fixed effects,R^2 increased from 0.298 to 0.308, and the significance of most independent variables did not change significantly, indicating that the introduction of fixed effects did not significantly change the relationship between variables.

Table 3. Benchmark regression results

	(1)	(2)	(3)
	Mv	Mv	Mv
Sup	-0.718***	-0.733***	-0.122*
	(-10.74)	(-12.64)	(-2.12)
Ind		-3.515***	-0.327**
		(-12.67)	(-1.41)
Lev		1.758***	1.196***

		(19.09)	(17.14)
Epr		-0.074***	-0.052***
		(-4.73)	(-5.29)
Liq		-1.815***	-0.708***
		(-30.51)	(-12.14)
Int		0.112***	-0.267**
		(0.52)	(-1.32)
Sar		0.459***	-0.862***
		(5.65)	(-7.95)
Mer		-4.522***	-3.417***
		(-24.19)	(-24.47)
_cons	23.166***	24.421***	23.202***
	(892.37)	(304.49)	(336.36)
N	9737	9734	9734
r2_a	0.012	0.298	0.308
Symbol fe	No	No	Yes
Year fe	No	No	Yes

4.3. Intermediation effects

The results of the first column show that there is a significant negative correlation between green technology innovation and supplier concentration (coefficient -0.148, t-value -1.69), indicating that high supplier concentration limits the choice space of enterprises in green technology innovation, and verifies hypothesis H2. Other control variables also significantly affect the level of green technology investment to a certain extent. The results of the second column show that supply chain concentration has a significant negative impact on green technology innovation (coefficient -0.148). At the same time, there was a significant positive correlation between green technology innovation and enterprise value (coefficient 0.157, t value 22.56), indicating that enterprises can enhance market value through green technology innovation, which verifies the relationship between environmental sustainability and economic value brought by green innovation.However, supply chain concentration has a negative impact on firm value, with a coefficient of -0.146 and a t-value of -2.6. It is worth noting that the input of green technological innovation acts as a mediating variable, which may mitigate the negative impact of supply chain concentration to a certain extent, thus supporting Hypothesis H3. Specifically, when firms significantly enhance green technological innovation, they can better improve the efficiency of production. reduce the negative impact of supply chain concentration on firms' market value. In addition, green technology innovation can further improve the financial status and market performance of enterprises by influencing other related variables, thus positively affecting enterprise value.

Table 4. Moderation of mediating effects of supply chain concentration, green technology innovation and firm value

	(1)	(2)
	Gti	Mv
Sup	-0.148***	-0.146**
	(-1.69)	(-2.6)
Ind	-0.268	-0.285**
	(-0.76)	(-1.27)
Lev	0.390***	1.134***
	(3.68)	(16.73)
Epr	-0.056***	-0.043***
	(-3.79)	(-4.51)
Liq	0.079	-0.720***
	(0.89)	(-12.72)
Int	1.011***	-0.426*
	(3.30)	(-2.17)
Sar	-0.076	-0.850***
	(-0.46)	(-8.07)
Mer	-2.350***	-3.047***
	(-11.08)	(-22.31)
Gti		0.157***
		(22.56)
_cons	0.873***	23.065***
	(8.33)	(342.89)
N	9734	9734
r2_a	0.135	0.064
symbol fe	Yes	Yes
Year fe	Yes	Yes

4.4. Heterogeneity test

The analysis reveals significant performance differences between non-state-owned enterprises (non-SOEs) and state-owned enterprises (SOEs) across various variables. Supply chain concentration negatively impacts both, with non-SOEs experiencing a stronger effect (-0.187) compared to SOEs (-0.115). This suggests that higher supply chain concentration harms non-SOEs more, likely due to their reliance on flexible partnerships. In contrast, SOEs benefit from greater government support within their supply chains, which mitigates the negative impact of supply chain concentration on them.

The analysis reveals notable differences between equity-independent and non-equity-independent firms. In equity-independent firms, supply chain concentration has a stronger negative effect on firm value, suggesting these firms are more flexible in adjusting supply chain strategies. In contrast, non-equity-independent firms, which are influenced by more shareholders or top management, show a smaller and non-significant impact from supply chain concentration. This indicates

they may have less flexibility in supply chain management due to increased external interference in their decision-making processes.

Table 5. Analysis of the results of the heterogeneity test

	non-state enterprise	state-owned business	Equity independence	Non-equity independent
	Mv	Mv	Mv	Mv
Sup	-0.187***	-0.115***	-0.247***	-0.047***
	(-2.26)	(-1.21)	(-3.75)	(-0.22)
Gti	0.078***	0.093***	0.086***	0.207***
	(8.54)	(9.45)	(12.51)	(-0.69)
Ind	-0.327	-1.376***	-0.581*	-1.486*
	(-1.02)	(-4.49)	(-2.45)	(-2.47)
Lev	1.065***	0.827***	0.954***	1.531***
	(10.74)	(7.02)	(12.78)	(6.78)
Epr	-0.062***	0.009	-0.022*	-0.016
	(-3.71)	(0.930)	(-2.13)	(-0.58)
Liq	-0.365***	-0.17	-0.402***	-0.069
	(-4.72)	(-1.37)	(-5.91)	(-0.31)
Int	-0.632*	0.785*	-0.224***	0.061
	(-2.16)	(2.17)	(-0.93)	-0.08
Sar	-0.654***	-0.257	-0.591***	-1.343***
	(-4.96)	(-1.09)	(-4.95)	(-4.43)
Mer	-2.340***	-2.151***	-2.437***	-3.065***
	(-11.58)	(-7.50)	(-13.97)	(-3.82)
_cons	22.842***	23.585***	23.156***	23.371***
	(242.28)	(234.24)	(307.70)	(117.27)
N	6226	3508	7373	2361
r2_a	0.863	0.934	0.701	0.453
symbol fe	Yes	Yes	Yes	Yes
Year fe	Yes	Yes	Yes	Yes

4.5 Stability tests

In order to ensure the robustness of the regressions, this paper conducts robustness tests by substituting core variables. On the measure of enterprise value, the regression is re-run by replacing the method of enterprise value (Mv) with enterprise operating performance (Roa). The regression results are basically consistent with the previous results, indicating that the results of this paper are basically reliable. As can be seen from the table,the R2 of the robustness test result is 0.164, indicating that the model has a good fit. There is a significant negative correlation between supply chain concentration and business performance, and its effect reaches the level of statistical significance in both models, which are -0.014*** and -0.019***, respectively, indicating that the increase in supply chain concentration may lead to a decline in business performance, which affects the overall value of the enterprise. Green technology innovation significantly and positively affects enterprise business

performance in the model, with a coefficient of 0.101, indicating that green technology innovation may bring competitive advantage and market recognition, and enhance the value of the enterprise, which verifies hypothesis H3.

Table 6. Analysis of stability test results

	(1)	(2)
	Roa	Roa
Sup	-0.014***	-0.019***
	(-2.55)	(-2.57)
Ind	-0.039**	-0.039
	(-1.74)	(-1.74)
Lev	-0.148***	-0.148***
	(-21.98)	(-21.99)
Epr	-0.004***	-0.004***
	(-3.81)	(-3.78)
Liq	0.064***	0.064***
	(11.38)	(11.38)
Int	0.019	0.018***
	(0.96)	(0.94)
Sar	-0.139***	-0.139***
	(-13.30)	(-13.30)
Mer	-0.411***	-0.409***
	(-30.43)	(-30.13)
Gti		-0.101***
		(-0.68)
_cons	0.118***	0.117***
	(17.65)	(17.51)
N	9734	9734
r2_a	0.165	0.164
symbol fe	Yes	Yes
Year fe	Yes	Yes

5. Conclusions

This paper constructs a theoretical framework containing supply chain concentration, green technology innovation and enterprise value, reveals the relationship between the three through theoretical and empirical analyses, and draws the following research conclusions:

(1) Supply chain concentration has a significant negative impact on firm value, which indicates that when a firm's supply chain is dependent on a small number of suppliers, it may increase operational risk, thus affecting its overall value. Meanwhile, supply chain concentration also negatively affects green technology innova-

tion. This suggests that excessive supply chain concentration may limit the investment and development of enterprises in green technology innovation, thus reducing their space and motivation for independent innovation.

(2) Green technology innovation plays a partial mediating effect between supply chain concentration and firm value, which means that supply chain concentration can mitigate the negative effect on firm value by influencing firms' investment and development in green technology innovation. Specifically, as supply chain concentration increases, enterprises may obtain more resource support, technology sharing and scale effects in green technology innovation, thus affecting overall enterprise value.

(3) Across firms of different natures, for SOEs, the negative impact of supply chain concentration on firm value is stronger for non-SOEs. The possible reason for this is that state-owned enterprises occupy a more dominant position in the supply chain, which leads to restrictions on access to resources and allocation of production factors for non-state-owned enterprises, thus reducing their operational flexibility and market competitiveness. Supply chain concentration has a greater negative impact on firm value in equity-independent firms, while in non-equity-independent firms, the impact is smaller and insignificant.

Therefore, when optimising the management of supply chain concentration, companies need to balance the relationship between concentration and innovation investment in order to improve long-term competitiveness and sustainable development potential.

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