Supply Chain Concentration and Green Innovation Activities of Enterprises——An Empirical Study Based on Panel Data of Chinese Listed Companies

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Abstract. Today, China is in an important period from high-speed development to high-quality development. Green development and innovation are important ways for many enterprises to upgrade, transform, enhance their competitiveness and achieve high-quality development. Based on this realistic background, this paper takes the panel data of A-share listed companies in Shanghai and Shenzhen stock exchanges from 2008 to 2019 as the research object, and empirically explores the impact and mechanism of green innovation, an important product feature of enterprise supply chain concentration. The results of this paper show that the higher the concentration of the upstream supply chain of listed companies, the lower their green innovation performance, and the negative effect has always existed and decreased. The further discussion found that the highly concentrated upstream supply chain reduces the input of enterprises' innovation activities and innovation strategy decisions, and thus inhibits green innovation. This paper incorporates green innovation performance and supply chain concentration into the same research system, and theoretically extends the scope of supply chain management research, which has reference and important practical significance for enterprises to carry out green innovation activities and improve their supply chain management and green innovation capabilities.

Keywords: supply chain concentration; green innovation; innovation decision-making.

1. Introduction

In the era of "mass entrepreneurship and innovation", seeking development through innovation has become the only way for enterprises to grow and develop. On the surface, innovation is a kind of technological behavior, but in-depth analysis, it is economic behavior. How to properly allocate resources to maintain the company's competitive advantage is the opportunity and challenges faced by many business operators. The implementation of an innovation-driven development strategy further strengthens technological innovation as the driving force for the survival and development of enterprises. General Secretary Xi Jinping once said: "Innovation drives development. We have the main force and the group army. Sometimes we also need to rely on the "one move" of small, medium and micro enterprises, and we must support the innovation and development of small, medium and micro enterprises." The development of small, medium and micro enterprises depends not only on It is only the government's support, but also on the impact of equity incentives, financing activities, supply chain structure, innovation investment, and other aspects.

With the development of society and the further clarification of the market division of labor, the production mode of many companies has changed, and the use of the supply chain for production has become the choice of many companies. Due to its advantages of high plasticity and low risk-taking, supply chain management can quickly perceive market changes and respond to market demands. Green technology innovation is an important factor to promote the win-win development of the environment and economy. However, since green technology innovation inherently has dual external attributes of environment and technology, how to encourage enterprises to carry out green technology innovation is a key issue.

However, supply chain concentration also affects green innovation performance to a certain extent. However, further research is needed on how and how it affects. For the first time, this paper analyzes the influence of supply chain concentration on the green innovation performance of enterprises and analyzes the mechanism existing in the transmission process. This research will provide clues for improving green innovation performance. Through a detailed analysis of the panel data of A-share listed companies in Shanghai and Shenzhen stock exchanges from 2008 to 2019, the results of this paper show that the higher the concentration of the upstream supply chain of listed companies, the lower their green innovation performance, and the negative The effect is always present and diminishing. The further discussion found that the highly concentrated upstream supply chain reduces the input of enterprises' innovation activities and innovation strategy decisions, and thus inhibits green innovation.

Compared with the existing research, the marginal contribution of this paper may be: First, based on the micro-level, this paper starts with the characteristics of the upstream supply chain of the enterprise to test its important influence on the dimension of the green development of the enterprise, and enriches the relevant information related to the enterprise supply chain. Empirical research; Second, this paper correspondingly enriches the research on the influencing factors of enterprise green innovation, that is, it provides empirical evidence from the perspective of the overall supply chain of the enterprise. Third, this paper further analyzes the potential channels through which supplier concentration affects the development of micro-enterprises own green innovation, fills the research gaps in related literature, and has important reference significance for related literature.

The follow-up structure of this paper is arranged as follows: the second part is the review and discussion of relevant literature and the proposal of theoretical hypotheses; the third part introduces the data sources and research design of this paper; the fourth part is the basic empirical results, including basic conclusions, robustness testing, and the mechanism analysis; the fifth part gives the research conclusion and policy implication of this paper.

2. Literature Review and Theoretical Hypotheses

Supply chain concentration is an important feature of an enterprise's supply chain structure, including supplier concentration and customer concentration, which reflect the concentration of upstream suppliers and downstream customers respectively. [1] Because the literature on customer concentration is quite mature and complete in this field, in this study, the author focuses on supplier concentration. Hereinafter, supplier concentration is also referred to as supply chain concentration.

Most of the traditional research on enterprise innovation is based on the theory of endogenous growth, which believes that innovation is the result of the investment of the enterprise's elements, and the improvement of innovation performance is due to the increase of the enterprise's innovation investment and the progress of science and technology. However, the research on enterprise innovation based on the theory of endogenous growth ignores the influence of external factors such as the macroeconomic environment, government, and other organizations on the innovation performance of enterprises. More importantly, according to the analysis logic of the endogenous growth theory, the innovation advantage should belong to the enterprises with stronger strength, but in reality, the phenomenon of weaker enterprises catching up with stronger enterprises in innovation often occurs. However, the enterprise innovation research of the growth theory cannot explain this phenomenon very well. On this basis, the resource-based theory can explain all this well. The resource-dependent theory believes that an organization is an open system, and its survival and development require resources, and it is impossible for any organization to hold all the necessary resources for its survival and development. resources to realize survival and development under self-supply. A large number of scarce and precious resources related to the survival of organizations are contained in the external environment of the organization, so all organizations depend on the external environment to some extent, and no organization can be completely independent. To survive, an organization has to introduce, absorb, and transform various resources from the external environment, including human resources, financial resources, social legitimacy, customers, and technical and material inputs, forming a network of inter-organizational resource interdependence [2]. With the deepening of research, scholars try to explore more external factors of enterprises such as economic policies based on the theory of resource dependence [3], Industry factors[4], other organizations'[5]impact on firm innovation performance. Any enterprise is in an open social environment, and enterprises must obtain the necessary resources for survival and development through an exchange [6]. Resource dependence theory believes that no organization is completely self-sufficient, and all organizations exchange with the environment and thus survive and develop [7]. When enterprise exchanges long-term resources with other enterprises, the two parties have resource dependence. The resource dependence of both parties can make the interests of both parties more closely bound together, thereby improving the alliance performance of both parties [8]. Therefore, integrating such interdependent resources has become an important motivation for forming long-term strategic partners. Just as the empirical research of Holm et al. found that the dependence on resources on both sides of the alliance makes both sides a production community with common interests [9]. In addition, Gulat's research on the formation of bilateral alliances also found that the higher the degree of interdependence between the two organizations, the more likely it is to integrate the resources and capabilities of both parties through strategic alliances under the same other factors [10].

To the above research results, the higher the concentration of the supply chain, the closer the connection between the two parties, the higher the resource dependence, and the higher the degree of interdependence, the more likely it is to obtain more information, thereby improving the innovation performance of enterprises. However, different scholars believe that the higher the concentration of the supply chain, the worse the innovation performance of enterprises. Li Rui [11] believes that the concentration of suppliers is significantly negatively correlated with the innovation investment of circulation enterprises; Huang Qianyuan; Song Yuanfang [12] think that the supplier concentration has an inhibitory effect on the R&D investment intensity of enterprises. With the increase of supplier concentration, the R&D investment intensity of enterprises decreases. As a result, the innovation performance of enterprises is reduced; Xu Chaoyang, Xu Guang, Li Ziyan, and Zhao Xiaoyang [13] through the research, it is concluded that there is a significant negative correlation between supplier concentration and enterprise R&D investment. If the concentration of the supply chain is high, there are only a few or even one supplier upstream of the enterprise, which not only causes excessive dependence but also weakens the bargaining power. To avoid risks, the enterprise needs to conduct a large number of special relations with suppliers. Sexual investment to maintain the stability of transactions has seriously crowded out the funds required for R&D, resulting in a decrease in the number of green patents of enterprises, and the green innovation capability of enterprises largely depends on the number of authorized patents and green innovation R&D investment. Based on the above analysis, this paper puts forward the hypothesis of the article:

H1: Under the same conditions, the higher the supplier concentration, the worse the green innovation performance of the enterprise.

3. Sample selection and empirical design

3.1. Data sources

To test the theoretical hypothesis proposed above, and taking into account the availability of various indicators of the company and the representativeness of the sample, this paper uses the panel of all A-share listed companies in the Shanghai and Shenzhen stock markets from 2008 to 2019 as the original sample, and the original sample data of listed companies All are from the Cathay Pacific CSMAR database and merged. The further screening process of the samples is as follows: First, because the financial statements of the financial industry are different from those of other companies, this paper screened according to the CSMAR industry code, and excluded the samples from the financial industry; secondly, the samples of ST companies during the research period were excluded; thirdly, the assets were excluded. Samples with a debt ratio greater than 1; fourth, to eliminate the influence of extreme values on the empirical analysis, this paper performs winsorize processing on all continuous variables by up and down 1%. Finally, after removing companies with missing relevant variables, the sample contains 3,595 companies with a total of 21,059 observations.

3.2. Concentration of supply chain

Referring to the standard practice of relevant literature, this paper starts with the characteristics of enterprise suppliers. Among them, according to the construction method of the Herfindahl Index, the sum of the squares of the ratios of the top five suppliers' purchases disclosed by the listed companies to the total purchases is used as the measure of the concentration of suppliers. The larger the value, the higher the concentration of the supply chain of the enterprise.

3.3. Enterprise green innovation

This paper uses the natural logarithm lnGPall of the sum of the number of green invention patents and green utility model patents granted by listed companies in the current year to measure the output of listed companies' innovative activities in the green environment. In the subsequent robustness analysis, green invention patents and green utility model patents are also discussed separately.

3.4. Empirical model setting

To verify the theoretical assumptions proposed above, this paper intends to construct a two-way fixed effect model to discuss the impact of listed companies' investment efficiency on green innovation. The specific empirical analysis model is shown in formula (1):

$$lnGPall_{it} = \beta_0 + \beta_1 \text{Concentration}_{it} + \beta_2 X_{it} + Year_{FE} + Industry_{FE} + \varepsilon_{it} \tag{1}$$

Among them, the subscripts i and t represent the company and the year, respectively. The explained variables are the natural logarithm of green invention patents and green utility model patents granted by the listed company I in year t, which comprehensively measures the green innovation output level of listed companies. The core explanatory variable is the level of supply chain concentration of listed company I in year t. Therefore, as the core parameter to be estimated in this paper, the theoretical assumption should be expected to be significantly negative. The set of control variables at the firm level in the model is specified as follows. To control for macroscopic external environmental shocks, this paper controls the year-fixed effect. Considering the interference of the potential invariant factors of the enterprise industry on the causal inference of this paper, Equation (1) also controls the fixed effect of the enterprise industry. is the random disturbance term of the model. Finally, to prevent the heteroscedasticity problem from affecting the reliability of the empirical results of this paper, all statistical inferences in this paper are discussed based on the heteroscedasticity robust standard errors.

3.5. Selection of control variables

In terms of control variables, in order to reduce the endogenous bias caused by omitted variables, and referring to the existing literature, the enterprise-level control variables in this paper include: enterprise size (Size, measured by the natural logarithm of the total assets of the listed company at the end of the current year), Asset-liability ratio (Leverage, measured by the ratio of total liabilities to total assets of the listed company at the end of the current year), age of the company (Age, measured by the company's listing year), business performance (ROA, measured by the listed company's return on assets for the year), fixed Asset scale (Fix, measured by the proportion of fixed assets of the listed company in the current year), cash ratio (Cash, measured by the cash ratio held by the listed company in the current year), corporate growth rate (Growth, measured by the proportion of independent directors of the listed company in the current year), the size of the board of directors (Boardsize, measured by the shareholding ratio of the board of directors of the listed company in the current year), equity concentration (Top1, measured by the shareholding ratio of the largest shareholder of the listed company in the current year), enterprise ownership (SOE, measured by whether the listed company is a state-owned enterprise), loss Status (Loss, if the listed company has a loss in the current year, take 1, otherwise it is 0). Table 1 shows the variable types, names, and detailed definitions. Table 2 is the descriptive statistics of each variable.

Table 1. Variable types, names and detailed definitions

variable type	Variable name and letter representation	Variable Definition Description
Explained variable	Green Innovation lnGPall	The natural logarithm of the number of green patents of listed companies in the current year
core explanatory variables	Concentration	Supply chain concentration of listed companies in the current year
Enterprise Control Variables	Enterprise size Size	The natural logarithm of the total assets of the listed company at the end of the current year
	Enterprise asset-liability ratio Leverage	The proportion of total liabilities to total assets of listed companies in the current year
	business age Age	Listed company listing period
	business performance ROA	Return on assets of listed companies in the current year
	Fixed asset size Fix	The ratio of fixed assets to total assets of listed companies in the current year
	cash ratio Cash	The ratio of cash held by listed companies in the current year
	business growth rate Growth	The operating income growth rate of listed companies in the current year
	Board size Boardsize	Shareholding ratio of the board of directors of listed companies
	Ownership concentration Top1	Shareholding ratio of the largest shareholder of the listed company in that year
	business ownership SOE	Whether the listed company is a state-owned enterprise
	loss status Loss	Dummy variable: Take 1 when the listed company has a loss in the current year

Table 2. Descriptive statistics of variables

	sample size	mean	standard deviation	minimum	median	maximum
lnGPall	21059	.321	0.727	0	0	6.308
Concentration	21059	.35	0.203	0	.305	1
Size	21059	22.075	1.259	19.35	21.896	26.395
Leverage	21059	.414	0.205	.027	.402	.936
Age	21059	9.302	7.319	0	7	27
ROA	21059	.435	0.456	-.581	.359	3.037
Fix	21059	.21	0.156	.002	.178	.769
Cash	21059	1.156	1.911	.036	.573	30.123
Growth	21059	15.527	32.175	-51.998	10.774	169.779
Boardsize	21059	11.935	18.922	0	.252	68.606
Top1	21059	.344	0.146	.082	.324	.758
SOE	21059	.316	0.465	0	0	1
Loss	21059	.038	0.191	0	0	1

Before conducting the empirical regression analysis, it is necessary to analyze the correlation between the main research variables. The correlation coefficient matrix of the core explanatory variables and the control variables is shown in Table 3. It can be seen from the correlation coefficient matrix in Table 3 that the correlation coefficient between each control variable is not large, and the maximum value is only about 0.5. Therefore, there is no systematic bias in the statistical inference caused by the high collinearity problem. In conclusion, the empirical model of this paper is set correctly.

Table 3. Correlation coefficient matrix of core explanatory variables and control variables

	Concentration	Size	Leverage	Age	ROA	Fix	Cash	Growth	Boardsize	Top1	SOE	Loss
Concentration	1.00***											
Size	-0.21***	1.00***										
Leverage	-0.12***	0.51***	1.00***									
Age	0.00	0.41***	0.36***	1.00***								
ROA	-0.03***	-0.03***	0.08***	-0.04***	1.00***							
Fix	0.06***	0.08***	0.09***	0.09***	0.06***	1.00***						
Cash	0.13***	-0.27***	-0.52***	-0.22***	-0.07***	-0.17***	1.00***					
Growth	0.01*	0.02***	-0.00	-0.12***	0.08***	-0.11***	-0.02***	1.00***				
Boardsize	0.01	-0.31***	-0.29***	-0.49***	0.03***	-0.15***	0.19***	0.13***	1.00***			
Top1	-0.03***	0.16***	0.05***	-0.06***	0.11***	0.08***	0.01	-0.04***	-0.06***	1.00***		
SOE	-0.03***	0.35***	0.28***	0.46***	0.09***	0.21***	-0.13***	-0.12***	-0.41***	0.22***	1.00***	
Loss	0.01**	-0.02***	0.11***	0.08***	-0.26***	-0.02***	-0.06***	-0.14***	-0.06***	-0.09***	-0.04***	1.00***

4. Empirical Results

4.1. Analysis of benchmark regression results

The benchmark stepwise regression results of the previous empirical model (1) are shown in Table 4. The explained variables are the natural logarithms of the total number of green patents of listed companies in that year. Among them, column (1) does not control any fixed effects and control variables, column (2) adds enterprise-level control variables, and column (3) further adds industry and year two-way fixed effects. It can be seen that, regardless of the control, the estimated coefficients of all model core explanatory variables Concentration are significantly negative at the 1% statistical level. Therefore, the higher the concentration of the supply chain of listed companies, the lower their own green innovation performance. In summary, the above theory is proved.

Table 4. Benchmark stepwise regression results

VARIABLES	(1) lnGPall	(2) lnGPall	(3) lnGPall
Concentration	-0.523***	-0.296***	-0.198***
	(0.022)	(0.020)	(0.021)
Size		0.157***	0.166***
		(0.007)	(0.007)
Leverage		0.117***	0.233***
		(0.029)	(0.030)
Age		-0.017***	-0.014***
		(0.001)	(0.001)
ROA		-0.033***	0.011
		(0.010)	(0.012)
Fix		-0.071**	-0.301***
		(0.032)	(0.036)
Cash		-0.004*	-0.000
		(0.002)	(0.002)
Growth		-0.001***	-0.001***
		(0.000)	(0.000)
Boardsize		0.000	0.000
		(0.000)	(0.000)
Top1		-0.199***	-0.140***
		(0.037)	(0.036)
SOE		-0.005	0.024*
		(0.012)	(0.012)
Loss		-0.020	-0.027
		(0.026)	(0.026)
Year FE	No	No	Yes
Industry FE	No	No	Yes
Observations	21,059	21,059	21,059
R-squared	0.021	0.087	0.138

Note: The estimation software is StataSE17.0. Observations are at the firm level. ***, **, and * indicate statistical significance at 1%, 5%, and 10%, respectively. Numerical heteroskedasticity robust standard errors in parentheses. "Yes" means that the fixed effect is controlled, and "No" means that the fixed effect is not controlled.

4.2. Nonlinear effects of supply chain concentration on total factor productivity

Is there a non-linear effect in the impact of the concentration of the enterprise supply chain on its green innovation activities? Based on this, this paper tests by introducing the quadratic term of supplier concentration. The estimated results of the nonlinear impact of supply chain concentration on total factor productivity are shown in Table 5: Among them, the explained variable is the natural logarithm of the total number of green patents of listed companies in that year. The model controlled for all control variables and two-way fixed effects mentioned earlier. It can be seen from Table 5 that the estimated coefficients of supply chain concentration Concentration and its quadratic term Con2 are -0.412 and 0.240, respectively, and both are significant at the 1% statistical level. This result shows that the impact of enterprise supplier concentration on green innovation has a small value. As shown in Figure 1, since the value range of supply chain concentration is [0, 1], it can be inferred that supply chain concentration has a significant impact on enterprises. Although the negative effect of green innovation has always existed, it is decreasing.

Table 5. Nonlinear impact of enterprise supply chain concentration on green innovation

VARIABLES	(1) lnGPall
Concentration	-0.412***
	(0.088)
Con2	0.240***
	(0.087)
Size	0.165***
	(0.007)
Leverage	0.232***
	(0.030)
Age	-0.014***
	(0.001)
ROA	0.008
	(0.012)
Fix	-0.295***
	(0.036)
Cash	-0.000
	(0.002)
Growth	-0.001***
	(0.000)
Boardsize	0.000
	(0.000)
Top1	-0.139***
	(0.036)
SOE	0.024**
	(0.012)
Loss	-0.028
	(0.026)
Year FE	Yes
Industry FE	Yes
Observations	21,059
R-squared	0.138

Note: The estimation software is StataSE17.0. Observations are at the firm level. ***, **, and * indicate statistical significance at 1%, 5%, and 10%, respectively. Numerical heteroskedasticity robust standard errors in parentheses. "Yes" means that the fixed effect is controlled, and "No" means that the fixed effect is not controlled.

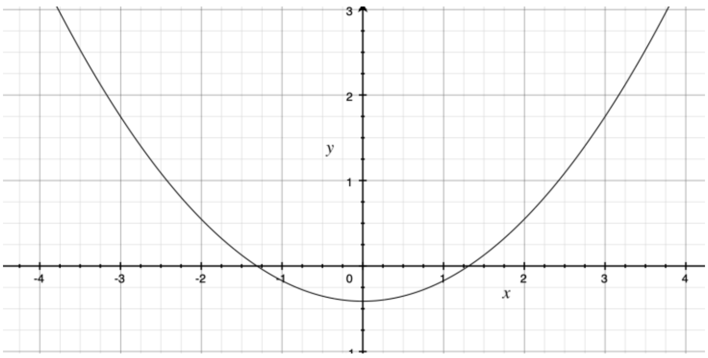

Figure 1. Nonlinear impact of enterprise supply chain on its green innovation

Source: Author's calculations.

4.3. Robustness test

First of all, green patents can be divided into green invention patents and green utility model patents. Generally speaking, the former is more innovative than the latter. This paper further divides the types of corporate green innovation patents into green invention patents and green utility model patents and re-examines the impact of supply chains on green patent categories.

Table 6 shows the robustness test of the estimated results of the replaced core explained variables. Among them, the explanatory variable lnGP in column (1) is the natural logarithm of the authorized amount of green invention patents in the year of the listing formula plus 1; the explanatory variable lnGPnew in column (2) is the natural logarithm of the authorized amount of green utility model patents in the listing formula year plus 1. All columns control for two-way fixed effects and the previous control variables. It can be seen from the estimated coefficients that they are all significantly negative at the 1% statistical level, so the previous conclusion is robust.

Table 6. Robustness Test 1: Invention Patents and Utility Model Patents

VARIABLES	lnGP	lnGPnew
Concentration	-0.083***	-0.140***
	(0.013)	(0.018)
Size	0.105***	0.127***
	(0.005)	(0.006)
Leverage	0.059***	0.228***
	(0.019)	(0.026)
Age	-0.006***	-0.012***
	(0.001)	(0.001)
ROA	0.011	0.003
	(0.007)	(0.010)
Fix	-0.181***	-0.225***
	(0.024)	(0.032)
Cash	0.001	-0.001
	(0.001)	(0.002)
Growth	-0.000***	-0.000***
	(0.000)	(0.000)
Boardsize	0.000	0.000
	(0.000)	(0.000)
Top1	-0.108***	-0.078**
	(0.025)	(0.031)
SOE	0.026***	0.007
	(0.008)	(0.011)
Loss	0.019	-0.037*
	(0.018)	(0.022)
Year FE	Yes	Yes
Industry FE	Yes	Yes
Observations	21,059	21,059
R-squared	0.097	0.119

Note: The estimation software is StataSE17.0. Observations are at the firm level. ***, **, and * indicate statistical significance at 1%, 5%, and 10%, respectively. Numerical heteroskedasticity robust standard errors in parentheses. "Yes" means that the fixed effect is controlled.

Further, consider the characteristics of the city where the company is located. China is a vast territory, and enterprises in different regions may have different spatial characteristics, which will affect the choice of the supply chain. To further reduce the influence of the fixed characteristics of the city on the results of this paper, this paper further controls the fixed effect of the city where the company is registered to reduce the potential endogeneity problem caused by this dimension factor.

Table 7 is a robustness test considering the fixed characteristics of the city. The explanatory variable in column (1) is the natural logarithm of all green patent authorizations in the year of the listing formula plus 1, and the explanatory variable in column (2) lnGP is the green patent in the year of the listing formula. The natural logarithm of the authorized amount of invention patents plus 1; the explanatory variable lnGPnew in column (3) is the natural logarithm of the authorized amount of green utility model patents in the year of the listing formula plus 1. All columns control for two-way fixed effects and the previous control variables, with a new control for city fixed effects. As can be seen, the conclusion still holds.

Table 7. Robustness Test II: Considering the Fixed Characteristics of the City

	(1)	(2)	(3)
VARIABLES	lnGPall	lnGP	lnGPnew
Concentration	-0.163***	-0.059***	-0.116***
	(0.022)	(0.014)	(0.019)
Size	0.166***	0.107***	0.128***
	(0.007)	(0.005)	(0.006)
Leverage	0.181***	0.040**	0.185***
	(0.031)	(0.020)	(0.027)
Age	-0.013***	-0.005***	-0.011***
	(0.001)	(0.001)	(0.001)
ROA	-0.006	0.004	-0.011
	(0.012)	(0.008)	(0.011)
Fix	-0.160***	-0.098***	-0.125***
	(0.039)	(0.026)	(0.034)
Cash	-0.001	0.001	-0.001
	(0.002)	(0.001)	(0.002)
Growth	-0.001***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)
Boardsize	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)
Top1	-0.138***	-0.099***	-0.082***
	(0.037)	(0.026)	(0.032)
SOE	0.006	0.013	-0.001
	(0.013)	(0.009)	(0.011)
Loss	-0.032	0.018	-0.042*
	(0.026)	(0.018)	(0.022)
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
City FE	Yes	Yes	Yes
Observations	20,957	20,957	20,957
R-squared	0.187	0.136	0.162

Note: The estimation software is StataSE17.0. Observations are at the firm level. ***, **, and * indicate statistical significance at 1%, 5%, and 10%, respectively. Numerical heteroskedasticity robust standard errors in parentheses. "Yes" means that the fixed effect is controlled.

Third, in order to make the basic results obtained in this paper more credible, we first exclude the interference of firm entry and exit on the benchmark empirical results. The listed company data used in this paper has a long span of years, and there are inevitably companies entering and exiting. At the same time, this article excludes ST companies and the financial industry in that year, and many companies are newly listed every year. Therefore, in the sample, the entry and exit of enterprises may result in potential interference, so this paper needs to eliminate the influence of this potential factor.

Specifically, this paper conducts a balanced panel treatment of the sample period to exclude this effect. Table 8 shows the estimation results excluding the interference of the entry and exit of enterprises. The estimated coefficients of all columns of core explanatory variables are significantly negative, so the basic conclusions of the previous article still exist and are robust.

Table 8. Robustness Test III: Eliminate the Interference of Enterprises' Entry and Exit

VARIABLES	lnGPall	lnGP	lnGPnew
Concentration	-0.194***	-0.106***	-0.116***
	(0.039)	(0.025)	(0.033)
Size	0.217***	0.143***	0.177***
	(0.015)	(0.012)	(0.013)
Leverage	0.192***	0.030	0.197***
	(0.059)	(0.039)	(0.051)
Age	-0.018***	-0.009***	-0.015***
	(0.002)	(0.001)	(0.002)
ROA	-0.016	-0.009	-0.021
	(0.021)	(0.014)	(0.018)
Fix	-0.111	-0.048	-0.091
	(0.071)	(0.050)	(0.061)
Cash	0.003	-0.002	0.005
	(0.005)	(0.003)	(0.004)
Growth	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)
Boardsize	-0.001	0.000	-0.001***
	(0.001)	(0.000)	(0.000)
Top1	-0.279***	-0.224***	-0.180***
	(0.068)	(0.048)	(0.059)
SOE	0.004	0.012	0.003
	(0.023)	(0.016)	(0.020)
Loss	-0.066	0.017	-0.088**
	(0.047)	(0.036)	(0.039)
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Observations	7,136	7,136	7,136
R-squared	0.269	0.197	0.244

Note: The estimation software is StataSE17.0. Observations are at the firm level. ***, **, and * indicate statistical significance at 1%, 5%, and 10%, respectively. Numerical heteroskedasticity robust standard errors in parentheses. "Yes" means that the fixed effect is controlled.

4.4. Estimation of instrumental variables

Although the endogeneity problem caused by potentially unobservable variables is partially mitigated by the use of a panel two-way fixed-effects model, this problem has not been rigorously considered within a unified causal identification framework. To this end, this paper attempts to further use instrumental variables to address potential endogeneity issues. The instrumental variable selected in this paper is the mean value of the supply chain concentration of other companies in the city where the company belongs in the same year. The validity of this instrumental variable is reflected in: (1) the supply chain concentration of enterprises in the same city during the same period has a correlation, which meets the requirements of the correlation of the instrumental variables; (2) other enterprises in the same city do not directly affect the green innovation performance of the enterprise, Therefore, the instrumental variable can be expected to satisfy exclusivity.

The estimation results of the instrumental variable 2SLS are shown in Table 9: First, the IV estimation coefficient is significantly positive, and the Cragg-Donald Wald F value is 14.521, so there is no weak IV problem; secondly, from the 2SLS estimation results, we can see the core explanation The estimated coefficient of the variable still passes the 1% significance test and is significantly negative. Therefore, under the estimation of 2SLS, the core conclusion of this paper still exists.

Table 9. 2SLS estimation results

VARIABLES	(1) lnGPall
Concentration	-4.016***
	(1.381)
Size	-0.010
	(0.065)
Leverage	0.287***
	(0.053)
Age	-0.007**
	(0.003)
ROA	0.015
	(0.022)
Fix	-0.044
	(0.109)
Cash	0.048***
	(0.018)
Growth	0.000
	(0.000)
Boardsize	-0.001
	(0.001)
Top1	-0.102*
	(0.054)
SOE	-0.024
	(0.025)
Loss	0.011
	(0.042)
Cragg-Donald Wald F statistic	14.521
Year FE	Yes
Industry FE	Yes
Observations	20,193
R-squared	-0.792

Note: The estimation software is StataSE17.0. Observations are at the firm level. ***, **, and * indicate statistical significance at 1%, 5%, and 10%, respectively. Numerical heteroskedasticity robust standard errors in parentheses. "Yes" means that the fixed effect is controlled.

4.5. Mechanism analysis

Why can the concentration of the enterprise supply chain affect the green innovation activities of enterprises? As the theoretical analysis shows, the highly concentrated supply chain section represents the over-reliance of manufacturing firms on certain upstream firms. When an enterprise is heavily dependent on external resources, the enterprise will be unable to face the impact caused by changes in the external environment, which will affect innovation investment with greater uncertainty and change innovation decisions at the same time. To verify the mediation effect of the two, this paper sets the following mediation effect model:

$$Z_{it} = \gamma_0 + \gamma_1 Concentration_{it} + \gamma_2 X_{it} + YEAR\_FE + Industry\_FE + \varepsilon_{it}^1 \quad (2)$$

$$lnGPall_{it} = \delta_0 + \delta_1 Concentration_{it} + \rho Z_{it} + \delta_2 X_{it} + YEAR\_FE + Industry\_FE + \varepsilon_{it}^2 \quad (3)$$

Among them, is the mediating variable. If the model satisfies the significance in equation (2) at the same time, and the neutralization in equation (3) is significant, there is a mediating effect. The mediating variables selected in this paper are innovation investment and innovation strategic decision.

First, Table 10 examines the mediating effect of firm R&D investment. The two-column models control for all control variables as well as two-way fixed effects. First of all, it can be seen from column (1) that the estimated coefficient of Concentration is -0.692, which is significantly negative at the 1% statistical level, indicating that supplier concentration significantly reduces the R&D investment of enterprises. Further observation of the estimation results in column (2) shows that the estimated coefficient of RDexp is 0.12, which is significantly positive at the 1% level, which indicates that R&D investment is positively correlated with the green innovation investment of enterprises. Therefore, the concentration of enterprise suppliers reduces the R&D investment of the enterprise, which in turn reduces the green innovation performance of the enterprise.

Table 10. Mechanism Analysis 1: R&D Input

VARIABLES	(1) RDexp	(2) lnGPall
RDexp		0.120***
		(0.005)
Concentration	-0.692***	-0.200***
	(0.050)	(0.026)
Size	0.847***	0.087***
	(0.010)	(0.008)
Leverage	-0.564***	0.376***
	(0.060)	(0.036)
Age	-0.025***	-0.015***
	(0.002)	(0.001)
ROA	0.504***	-0.039***
	(0.033)	(0.015)
Fix	-0.720***	-0.223***
	(0.072)	(0.044)
Cash	-0.007*	0.004
	(0.004)	(0.002)
Growth	0.001*	-0.001***
	(0.000)	(0.000)
Boardsize	0.001***	0.000
	(0.000)	(0.000)
Top1	-0.358***	-0.121***
	(0.059)	(0.042)
SOE	-0.030	0.028*
	(0.025)	(0.015)
Loss	0.036	-0.026
	(0.046)	(0.030)
Year FE	Yes	Yes
Industry FE	Yes	Yes
Observations	17,662	17,653
R-squared	0.524	0.163

Note: The estimation software is StataSE17.0. Observations are at the firm level. ***, **, and * indicate statistical significance at 1%, 5%, and 10%, respectively. Numerical heteroskedasticity robust standard errors in parentheses. "Yes" means that the fixed effect is controlled.

Further, this article refers to the practice of Xu Fei (2019) to construct a continuous innovation strategy of enterprises for analysis. The model is as follows:

$$HRD\_ind_i = \begin{cases} 1\ \text{, if RD} > \text{Industry average} \\ 0\ \text{, if RD} \leq \text{Industry average} \end{cases} \tag{4}$$

Among them, formula (4) is that enterprise i is the indicator variable of the current innovation strategy of the enterprise compared with the industry average, and RD is the R&D R&D investment of the enterprise. To express the characteristics of the sustainability of the company's R&D strategy, this paper further calculates the characteristics of the company's innovation strategy in the continuous period: if the company's R&D investment is higher than the industry average for two or more consecutive periods, that is, 1 for two consecutive periods, then it is determined that the company has adopted a continuously high level. The innovation strategy is recorded as and takes 1, otherwise, it is 0.

Table 10 examines the mediating effect of corporate innovation strategies. The two-column models control for all control variables as well as two-way fixed effects. First of all, it can be seen from column (1) that the estimated coefficient of Concentration is -2.119, which is significantly negative at the statistical level of 1%, indicating that supplier concentration significantly reduces the probability of companies adopting sustained high innovation strategies. Further observing the estimation results in column (2), the estimated coefficient of HRD_ind is 0.027, which is significantly positive at the 1% level, which indicates that there is a significant relationship between the company's sustained high innovation strategy and green innovation. Therefore, the concentration of enterprise suppliers changes the innovation strategy choice of enterprises, which in turn reduces the green innovation performance of enterprises. To sum up, both mechanism's intermediary paths exist.

Table 11. Mechanism Analysis II: Strategic Decision-Making of Enterprise Innovation

VARIABLES	(1) HRD_ind	(2) lnGPall
HRD_ind		0.027***
		(0.002)
Concentration	-2.119***	-0.226***
	(0.152)	(0.026)
Size	2.113***	0.132***
	(0.029)	(0.010)
Leverage	-1.931***	0.360***
	(0.193)	(0.037)
Age	0.046***	-0.019***
	(0.005)	(0.001)
ROA	1.589***	-0.020
	(0.101)	(0.015)
Fix	-1.484***	-0.270***
	(0.215)	(0.045)
Cash	-0.090***	0.005**
	(0.016)	(0.002)
Growth	-0.002**	-0.001***
	(0.001)	(0.000)
Boardsize	-0.004**	0.000
	(0.002)	(0.000)
Top1	-1.866***	-0.114***
	(0.195)	(0.043)
SOE	-0.079	0.027*
	(0.081)	(0.015)
Loss	0.434***	-0.034
	(0.145)	(0.029)
Year FE	Yes	Yes
Industry FE	Yes	Yes
Observations	17,662	17,653
R-squared	0.384	0.153

Note: The estimation software is StataSE17.0. Observations are at the firm level. ***, **, and * indicate statistical significance at 1%, 5%, and 10%, respectively. Numerical heteroskedasticity robust standard errors in parentheses. "Yes" means that the fixed effect is controlled.

5. Summary

5.1. Conclusion

Based on the above research and demonstration, this paper can draw the following three conclusions:

Supply chain concentration has a negative effect on the green innovation performance of enterprises;

The negative effect has always existed but gradually weakened;

Innovation investment and innovation strategic decisions play an intermediary role in the impact of supply chain concentration on the green innovation performance of enterprises. The specific performance is as follows: R&D investment and innovation strategic decision-making are positively correlated with the green innovation investment of enterprises. The degree of decrease in innovation investment and change in the choice of the innovation strategy of enterprises, thereby reducing the green innovation performance of enterprises.

5.2. Political implications

Based on the above research conclusions, this paper proposes the following three management suggestions and practical implications that may improve the green innovation performance of enterprises:

Pay attention to the influence of supply chain resources on the green innovation of enterprises. The internal resources and capabilities of enterprises affect innovation performance, and supply chain resources and capabilities also affect the innovation performance of enterprises in the chain. While providing products or services, suppliers not only control the delivery period, but are also responsible for the quality of the products, and suppliers may have information that the enterprise cannot obtain at other levels, so it is necessary to pay attention to supply chain resources for enterprises. The impact of green innovation.

Reduce the concentration of suppliers. Because supplier concentration is too high, it will affect the innovation investment and innovation strategy choice of enterprises, and then affect the green innovation performance of enterprises. To minimize the negative impact of the high concentration of suppliers on the green innovation performance of enterprises, enterprises need to optimize the strategic relationship with suppliers and customers and reduce the resource dependence on suppliers as much as possible while maintaining the relative stability of trading partners. To avoid excessive concentration of suppliers, to improve the green innovation performance level of enterprises.

Enterprises should enhance their awareness of independent innovation and master core technologies. While paying attention to the impact of external resources, attention should also be paid to the effective use and promotion of the company's internal resources. At the same time, enterprises should independently strengthen investment in innovation, turn green innovation into their advantages through R&D activities, and increase their market share through product differentiation, so as to improve their bargaining power and take the initiative in market transaction negotiations.

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