

Research on the Relationship between Short Selling Mechanism and Enterprise Green Innovation

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Abstract: With the achievement of the "dual carbon" goals and the continuous improvement of capital market innovations, fostering a strong momentum for green innovation in enterprises via market mechanisms has become an important issue in promoting high-quality economic growth and driving green low-carbon transition. This study investigates A-share listed companies in China from 2010 to 2024, takes advantage of the quasi-natural experiment created by the introduction of incremental margin trading and short-selling initiatives, and builds a multi-period difference-in-differences model to explore the causal effect of short-selling systems on corporate green innovation and investigate various forms and internal mechanisms of this effect. The results indicate that relaxing restrictions on short selling has promoted the development of corporate green innovation by increasing the amount and quality of innovation; at the same time, the main ways this is achieved are through improved information efficiency, a reduction in agency costs, and relief of financing constraints. This study addresses the lack of research at the intersection of relevant disciplines and offers empirical support for improving the margin trading and short-selling system, as well as building a market-based green innovation incentive mechanism.

Keywords: Short Selling Mechanism; Margin Trading and Short Selling; Corporate Green Innovation; Difference-in-Differences Model; External Governance Effect.

1. Introduction

Recently, the global system for climate governance has been gradually built, and green and low-carbon transitions have become the general direction for the sustainable development of all countries in recent years. In September 2020, China released the strategic goals of reaching carbon peak before 2030 and achieving carbon neutrality before 2060, placing green innovation at the center of the domestic innovation network and making it a fundamental force for driving all-around green development of the economy and society.

In contrast to the usual technological breakthrough, green innovation shows considerable environmental externalities and is a long-term investment; therefore, not only large R&D expenses will be required, but hazards such as indeterminate technical paths and extended market payback periods must also be borne. Continuous progress cannot be achieved by internal motivation alone; a system of institutions is desperately needed. Although the funds available for green innovation in China have been rising steadily in recent years, the situation is still far from ideal: by the end of 2025, green high-value invention patents would constitute only about 7% of all high-value invention patents; fund allocation is unevenly distributed, corporate investment is concentrated, the motivation for green transformation in high-emission industries is low, and most companies still view the funds as mere regulatory subsidies rather than strategic investments. Given the above, administrative ecological rules alone are insufficient to drive the internal force of green innovation; therefore, based on the market-oriented approach, research has begun to explore how institutional structures in the financial sector can promote corporate green innovation and has gradually become a focus of both academic and practical research.

As the main distribution centre of the current economic

structure, the capital market relies on its basic trading units to facilitate price discovery and guide the operational and long-term capital allocation decisions of micro and small enterprises through external supervision. China's margin trading and short-selling pilot scheme, introduced in 2010, has been expanded several times, with continuous easing of short-selling restrictions and steady development of bidirectional trading systems; thus, the weight of the short-selling framework in the capital market's institutional structure has gradually increased. Based on the current academic study, the short-selling system has undoubtedly achieved the goals of price discovery and external supervision, restricted managers' opportunistic behaviours and short-sighted behaviours, improved information disclosure standards, and thus influenced R&D investment and innovation choices.

The current academic research has significant deficiencies: investigations into the financial effects of the short-selling framework have largely focused on general corporate innovation and have paid little attention to green innovation. Most research in the area of green innovation has used traditional determinants such as ecological regulations and has not systematically studied the impact of exogenous shocks from capital market trading firms through a causal inference framework. At present, the internal links, logical paths and transmission channels of the short-selling mechanism for corporate green innovation have not been fully elucidated in terms of both concepts and empirical studies. Therefore, this study uses the staged expansion of China's margin trading and short-selling system as a quasi-natural experiment and selects A-share listed companies from 2010 to 2024 as the sample for systematic research. The three issues that this paper will address are: the direction of the impact of easing short-selling restrictions on corporate green innovation, the various attributes of this influence, and the internal transmission mechanism.

This paper will make certain new discoveries at the same time as the others. In terms of research directions, rather than separately studying the financial effects of short-selling frameworks and the motives for corporate green-low carbon development, this paper links capital market structural reform with the green-low carbon evolution of physical enterprises to create a unified analytical system, addresses the current gap between these two disciplines to some extent, and conducts in-depth studies on the market-driven factors of corporate green development. Research methodology: A quasi-natural experiment has been built through the staged expansion of the margin trading and short-selling systems to address endogeneity problems by employing a multi-period difference-in-differences model, achieve more precise identification of the causal effect of short-selling mechanisms on corporate green innovation, and comprehensively explore the cognitive process and internal transmission paths among them through multi-dimensional heterogeneity tests and mechanism tests. At the application level, the research results of this paper are in line with the present demands for China's capital market restructuring and the promotion of "dual carbon" goals. The above results can offer support for policymakers in strengthening the short-selling system gradually and exploring joint governance models for financial markets and environmental regulations, as well as providing practical assistance for enterprises to use external supervision in capital markets to drive internal green innovation.

The following are the divisions of this paper: Part II presents relevant studies and proposes research hypotheses; Part III introduces sample information, data sources, indicator measures, specific model structures, etc.; Part IV shows the empirical results, including descriptive statistics, correlation analysis and preliminary regression models; Part V conducts robustness tests to verify the reliability of the results; Part VI explores heterogeneity and causal mechanisms; Part VII draws a conclusion of the study, offers corresponding policy suggestions, points out the deficiencies of this paper, and puts forward future research directions.

2. Literature Review and Research Hypotheses

2.1. Literature Review

2.1.1. Economic Consequences of Short Selling Mechanism

A long-standing issue in corporate finance is the impact of a specific trading mechanism in the capital market, short-selling. In the earlier literature, two main theories addressing this issue have been developed: the information-efficiency theory and the external-governance theory. the two main theories for this problem were presented: information-efficiency theory and external-governance theory. The first theory posits that by reducing the restrictions on short-selling, negative information may be spread in the market, and thus the stock price will be far from what is supported by a company's actual fundamentals. The second theory posits that if the risks of short-selling and a decline in stock prices are not addressed, weak management supervision may result; therefore, opportunistic behaviour will occur and good corporate governance will be harmed [1]. Research on the link between short-selling and corporate innovation is still in its infancy. Some scholars believe that loosening regulations on short-selling can mitigate the principal-agent problem and the "short-sightedness" of management to promote corporate

innovation[2][3]; however, others think that the system of short-selling puts excessive pressure on management for short-term performance and thus reduces long-term investment in R&D and innovation decline[4].

Local studies mainly use the staged expansion of China's margin financing and short-selling system as a quasi-natural experiment to investigate the regulatory effects of the short-selling system in China. Li Zhisheng et al. (2015)[5] found that the margin trading and short-selling system improved the efficiency of price formation in the market for listed companies; Zhang Xuan et al. (2016) [6] reported that relaxing the restrictions on short-selling could help curb corporate earnings management and serve as an additional monitoring function for investors; Chen Shenglan and Ma Hui (2017)[7] and Tian Xuan and Meng Qingyang (2018)[8] have jointly found that a greater degree of short-selling pressure promotes total corporate innovation, but at the same time, other studies suggest that the effect of short-selling systems on innovation has a dual character and is finally determined by internal corporate governance[9].

2.1.2. Determinants of Corporate Green Innovation

The first way to achieve green and low-carbon development for a company is to continuously innovate. Currently, the determinants of this have been broadly divided into three categories in existing research: First, environmental regulatory factors aligned with the Porter Hypothesis have been studied, and relevant studies have confirmed that such laws can motivate green innovation and exhibit all kinds of motivational effects[10]. Second, internal corporate factors and capital constraints are the next focus; extended time periods and increased risks in green innovation are likely to lead to more significant financial bottlenecks[11], and corporate governance structures and managers' short-termism tendencies substantially affect whether a firm chooses to engage in green innovation[12]. Third, capital market and external structural conditions are the third area of study, where most current research has focused on how green finance strategies drive corporate behaviour, but relatively few papers have investigated the positive impact of short-selling systems on corporate social responsibility and ESG performance, and no all-encompassing results have been obtained to date[13].

Based on the current research results, several deficiencies have been identified: At first, most studies on the financial impact of short-selling frameworks have focused on general corporate innovation and have paid little attention to green innovation. Second, although some research has been conducted in the field of green innovation, most of it has used conventional determination methods and has lacked systematic causal identification through the lens of external shocks to the fundamental structure of capital markets. Finally, the internal connections, logical pathways, and transmission mechanisms between these two areas have not been explored in depth; thus, many research gaps persist.

2.1.3. Literature Commentary

To sum up, although research has collected some results on the financial effects of short-selling systems and the reasons for firms' green innovation at the enterprise level, there are still considerable gaps in the current studies. At present, scholars have not reached a consensus on the direction of causality between short-selling mechanisms and corporate innovation. Most studies have focused on general innovation and have failed to consider the special characteristics of green innovation; at the same time, studies on green innovation have

primarily focused on government environmental regulations and internal corporate governance, neglecting external factors such as changes in the capital market's fundamental trading structure; finally, existing related research has not carried out strict causal identification for green innovation nor clarified its diverse features and internal transmission paths[14][15]. Based on the above, this paper takes advantage of the quasi-natural experiment created by the expansion of margin trading and short-selling frameworks to study the connection among them systematically and address the research deficiencies mentioned above.

2.2. Research Hypotheses

2.2.1. Baseline Effect Hypothesis of Short Selling on Green Innovation

Green innovations are generally high in terms of capital investment, long-term in nature, and relatively uncertain; thus, they are difficult to yield returns quickly and are thus prone to reduced funding from executives under pressure to meet short-term financial goals. The short-selling system can provide an external check on management and enhance price discovery by having short-sellers monitor any shortcomings in the timely promotion of green development by management; consequently, it can exert downward pressure on share prices as a constraint and prompt the company to build long-term value, and by increasing the scope of short-selling, it is possible to disseminate more market information for rational evaluation of the future benefits of green innovation and reduce management's uncertainty. In addition, a short-selling mechanism can raise market sensitivity to environmental damage by a company, increase the cost of such damage, and thus compel enterprises to enhance their investment in new sustainable-technology research and development; at the same time, it will improve information disclosure and reduce information asymmetry to expand financing opportunities for green innovation. Therefore, the first assumption is made:

H1: By lowering the constraints on short-selling and building a short-selling system, more enterprises will be able to develop environmentally friendly products and services at the corporate level, and thus promote broader application of corporate environmental protection.

2.2.2. Expected Analysis of Heterogeneous Effects

The motivations for firms to engage in green innovation under the short-selling mechanism are diverse. In terms of corporate attributes, this effect is more pronounced in heavily polluting sectors, state-owned enterprises and large enterprises; in the external environment, enterprises located in areas with strict environmental regulations and advanced marketisation are more significantly driven by short selling to pursue green innovation; and in the category of innovation, the boost to green invention patents with higher technical complexity and longer development cycles under short selling is substantially greater than that for lower-quality green utility model patents. Based on the above, the heterogeneity hypothesis is put forward.

H2: The impact of the short selling mechanism on corporate green innovation exhibits significant heterogeneity.

2.2.3. Expected Analysis of Mechanisms

Based on the above theoretical system, this study puts forward that the positive effect of short selling on corporate green innovation is mainly achieved through three interconnected basic transmission paths, and therefore

proposes the following mechanism-based hypotheses: Short-selling activities can drive firms to enhance the transparency of their environmental performance and green R&D data, reduce information asymmetry among parties and external markets, correct capital market valuation distortions concerning the long-term value of green innovation, and promote green innovation by improving corporate information efficiency; through the stock price decline deterrence effect created by short-selling pressure, it can effectively curb managerial myopic behaviour and opportunistic behaviour, reduce principal-agent problems, optimize internal resource allocation efficiency, direct more assets towards green innovation efforts, and advance green innovation by lowering corporate agency costs and strengthening corporate governance; it also lowers corporate equity and debt financing costs, diversifies financing channels through the simultaneous improvement of information clarity and corporate governance standards, provides stable financial support for long-term, high-cost green innovation projects, and encourages green innovation by alleviating corporate financing pressure. The specific effects and reasons for the above three mechanisms will be rigorously tested through empirical analysis in the following mechanism testing part.

H3a: Short-selling can help companies fund new green innovations more easily by increasing information efficiency.

H3b: A short-selling model will reduce a company's agency costs for environmental innovation and improve monitoring by management.

H3c: Short selling can increase the money available to the company for green innovation by raising funds.

3. Research Design

3.1. Sample Selection and Data Sources

A-share public companies from 2010 to 2024 were selected as the research objects. After excluding financial, ST/*ST, data-deficient and delisted enterprises, a total of 29,782 firm-year observations have been obtained. All continuous variables have been winsorised at the 1% level. The main sources of this data are the National Intellectual Property Administration's patent system, CSMAR+Wind databases, and the official statistical yearbooks of China and its provinces.

3.2. Variable Definitions

3.2.1. Dependent Variable: Corporate Green Innovation (Green)

Metrics are derived from both magnitude and excellence: (1) Aggregate Green Innovation (Green_total): the natural logarithm of the total number of green patent applications in that year plus 1; (2) Green Innovation Prowess (Green_inv): the natural logarithm of the number of green invention patent applications in that year plus 1; (3) Green Innovation Volume (Green_util): the natural logarithm of the number of green utility model patent applications in that year plus 1. The first indicator is based on patent application data to avoid the delay effect and external disruption caused by authorisation examination, and is closer to firms' actual investment in innovation at present.

3.2.2. Core Explanatory Variable: Short Selling Shock (Short)

Based on a quasi-natural experiment created by the staged introduction of margin financing and short-selling, the main

multi-period DID indicator Short is generated. This variable is set to 1 for the year an enterprise joins the margin trading and short-selling list and all subsequent years; otherwise, it is 0. If the enterprise is delisted and subsequently reinstated in the observation period, this variable will be set to 1.

3.2.3. Mediating Variables

The three categories of mediating factors are based on the three main paths:

Information efficiency factors: disclosure quality (AQ, the absolute value of discretionary accruals calculated using the revised Jones model; a higher score indicates greater information asymmetry) and professional coverage (Analyst, the natural logarithm of the count of analyst firms monitoring the firm during the fiscal year plus 1; a higher level indicates improved efficiency of information dissemination). Agency cost indicators: operating expense ratio (Mfee, administrative outlays/gross revenue, a high value indicates increased agency costs) and overall asset utilisation (Aturn, gross revenue/mean total assets, a high figure shows a reduction in agency costs). Financial constraint measure: SA index, and the corresponding formula is $SA = -0.737 * Size + 0.043 * Size^2 - 0.04 * Age$, where Size is the natural logarithm of total assets and Age is the time elapsed since the initial public

offering. A high absolute value of this index indicates that the available credit will be significantly reduced.

3.2.4. Moderating Variables

Set at two levels for heterogeneity analysis:

At the corporate level: Ownership structure (SOE, state-owned enterprises, are assigned a value of 1; private enterprises are assigned a value of 0); sectoral contamination status (Poll, highly polluting sectors are assigned a value of 1; non-polluting sectors are assigned a value of 0, based on the "Environmental Protection Verification Industry Classification Management Catalogue for Listed Companies"); firm size (Size, the natural logarithm of total assets, is divided into large and small categories according to the annual industry median). Macro-environmental factors: environmental regulatory pressure (ER, provincial industrial pollution management expenditure / regional GDP, separated into high and low brackets by annual median); degree of marketisation (Market, provincial marketisation scores, split into high and low brackets by annual median).

3.2.5. Control Variables

Corporate-level explanatory variables are selected to avoid the effect of additional factors. Every regression includes firm, year and sector fixed effects.

Table 1. Corporate-level Explanatory Variables and Fixed Effects Settings

Variable Name	Variable Symbol	Variable Definition
Firm Size	Size	Natural logarithm of total assets
Leverage Ratio	Lev	Total liabilities / Total assets
Return on Assets	ROA	Net profit / Average total assets
Firm Age	Age	Natural logarithm of (current year - founding year + 1)
Cash Flow Level	Cash	Net cash flow from operating activities / Total assets
Firm Growth	Growth	Year-on-year growth rate of operating revenue
Ownership Concentration	Top1	Shareholding ratio of the largest shareholder
Board Size	Board	Natural logarithm of the number of board members
CEO Duality	Dual	1 if chairman and general manager are the same person, 0 otherwise

3.3. Model Specification

3.3.1. Baseline Regression Model: Multi-Period Difference-in-Differences Model

This study takes advantage of the quasi-natural experiment provided by the staggered implementation of the margin financing and short-selling framework to construct a multi-period difference-in-differences model and investigate the basic effect of the short-selling mechanism on firm-level green innovation. The model is given as follows:

$$Green_{it} = \beta_0 + \beta_1 Short_{it} + \gamma Controls_{it} + \mu_i + \lambda_t + \nu_j + \varepsilon_{it}$$

The dependent variable is the green innovation indicator for firm i in year t , including three categories: total green innovation, green innovation quality, and green innovation quantity; the core explanatory variable is the short selling shock variable; represents all control variables; standard errors in all regressions are clustered at the firm level to address heteroskedasticity and serial correlation issues. The core coefficient reflects the net effect of relaxing short selling constraints on corporate green innovation. If it is significantly positive, it indicates that relaxing short selling constraints can promote corporate green innovation. $Green_{it} Short_{it} Controls_{it} \beta_1 \beta_1$

3.3.2. Heterogeneity Test Model

Grouped Regression Techniques are Used for Heterogeneity Analysis. Clusters of observations are divided according to the categories of ownership structure, industry-specific pollution characteristics, firm size, stringency of

environmental regulations, and marketisation degree. Baseline models are fitted for all subgroups, and the scale and statistical significance of the main coefficients in these clusters are examined. Fisher's omnibus test is used to compare the groups. Green invention patents and green utility model patents are used as the respective dependent variables to compare the different effects of short-selling mechanisms on the quality of green innovation in various enterprises.

3.3.3. Mechanism Test Model

Sequentially mediate the effects to find the specific paths of cause and effect. The structure of the particular model is shown below:

$$M_{it} = \alpha_0 + \alpha_1 Short_{it} + \gamma Controls_{it} + \mu_i + \lambda_t + \nu_j + \varepsilon_{it}$$

$$Green_{it} = \delta_0 + \delta_1 Short_{it} + \delta_2 M_{it} + \gamma Controls_{it} + \mu_i + \lambda_t + \nu_j + \varepsilon_{it}$$

The above are three types of mediating variables: information efficiency, agency costs and funding shortages. First, the analysis tests the statistical significance of the main coefficient in the basic model, and then studies the regression weights of short selling on the mediator and on green innovation separately to determine whether it is a partial mediator or a total mediator. Bootstrap is used to add more stability verification for this study.

4. Empirical Results and Analysis

4.1. Descriptive Statistics

The extent of green innovation is relatively small, and there

are considerable differences among enterprises; the mean is 0.364 and the distribution is not very wide.

Table 2. Descriptive Statistics of the main variables

Variable	Observations	Mean	Median	Std. Dev.	Min	Max
Green_total	29782	0.782	0.000	1.125	0.000	4.394
Green_inv	29782	0.493	0.000	0.912	0.000	3.932
Green_utili	29782	0.527	0.000	0.946	0.000	3.871
Short	29782	0.364	0.000	0.481	0.000	1.000
Size	29782	22.347	22.168	1.326	19.872	26.154
Lev	29782	0.432	0.427	0.205	0.056	0.894
ROA	29782	0.042	0.041	0.076	-0.287	0.235
Age	29782	2.864	2.944	0.342	1.792	3.526
Cash	29782	0.046	0.045	0.072	-0.183	0.247
Growth	29782	0.174	0.112	0.426	-0.583	2.874
Top1	29782	33.472	31.285	14.623	8.524	74.286
Board	29782	2.135	2.197	0.201	1.609	2.708
Dual	29782	0.287	0.000	0.452	0.000	1.000

4.2. Correlation Analysis

The intercorrelation metrics of the main factors match the predictions, and the average VIF is 1.52; thus, there is no significant multicollinearity.

4.3. Baseline Regression Results

Columns (2)-(4) of Table 3 are the main regression results after adding all control variables and fixed effects. Column (2) uses overall green innovation as the dependent variable, and the short coefficient is relatively large and positive; thus, easing the restrictions on short selling would significantly increase the total number of firm-level green patent

applications. Columns (3) and (4) present separately the green innovation quality and the green utility model patent innovation metrics, showing that the short parameter is highly significant at the 1% level; moreover, the coefficient for green invention patents is larger, indicating that the enhancement effect of relaxing the short-selling restriction on premium green innovation is more pronounced and largely in line with the results of heterogeneity analysis.

In conclusion, the main regression results show that reducing the restrictions on short-selling has increased both the extent and quality of firm-level green innovation, thus supporting the fundamental hypothesis H1 of this study.

Table 3. Baseline Regression Results

Variable	(1) Green_total	(2) Green_total	(3) Green_inv	(4) Green_utili
Short	0.184***(12.74)	0.097***(7.82)	0.089***(8.15)	0.062***(5.74)
Size		0.224***(24.17)	0.187***(22.53)	0.164***(19.87)
Lev		-0.105***(-3.24)	-0.082***(-2.86)	-0.074***(-2.58)
ROA		0.247***(4.87)	0.203***(4.52)	0.176***(3.89)
Age		-0.128***(-4.27)	-0.104***(-3.92)	-0.097***(-3.64)
Cash		0.185***(3.74)	0.152***(3.46)	0.137***(3.12)
Growth		0.024***(2.17)	0.021***(2.08)	0.018***(1.86)
Top1		0.002****(3.24)	0.001****(2.95)	0.001****(2.76)
Board		0.058*(1.87)	0.047*(1.72)	0.042*(1.65)
Dual		0.017(1.24)	0.013(1.08)	0.011(0.97)
Constant	0.692***(86.42)	-4.125***(-20.47)	-3.542***(-19.86)	-3.087***(-17.54)
Fixed Effects	Firm, Year, Industry	Firm, Year, Industry	Firm, Year, Industry	Firm, Year, Industry
Observations	29782	29782	29782	29782
Adjusted R ²	0.324	0.387	0.362	0.345
Note: t-values clustered at the firm level in parentheses. The same below.				

5. Robustness Tests

To verify the reliability of the main regression results, several robustness checks were carried out in this study: The parallel trends test used an event study approach to construct

a dynamic difference-in-differences framework; the results show no significant difference in the green innovation path between the intervention and control groups before the policy impact, thus satisfying the basic assumptions of the difference-in-differences method, and the stimulating effect

continuously strengthens after the shock; a placebo test excluding stochastic factor disruption by randomly allocating treatment units showed that the initial findings were not random; after substituting key variables (substituting the dependent measure with green patent authorization-associated metrics and the predictor with the ratio of securities lending balances), the regression estimates remained significantly positive and in line with the first set of

conclusions; endogeneity correction used an instrumental variable strategy, where $F=127.42$ indicates no weak instrument problem, and the coefficient of the main explanatory variable remained significantly positive after endogeneity control, thus verifying the causal link; sample modifications (excluding delisted firms, narrowing the sample period, etc.) and additional tests all show that the initial results have excellent robustness.

Table 4. Instrumental Variable Regression Results

Variable	First Stage Short	Second Stage Green_total
IV1	0.724***(18.74)	
IV2	0.082***(9.27)	
Short		0.124***(6.87)
Control Variables	Yes	Yes
Fixed Effects	Firm, Year, Industry	Firm, Year, Industry
Observations	29782	29782
F-statistic	127.42	
Adjusted R ²	0.427	0.382

6. Further Analysis

6.1. Heterogeneity Tests

Analyze the impact of different parts of the short-selling framework on corporate green innovation through grouped regression analysis. Table 5 shows the first results of the above heterogeneity analyses.

6.1.1. Individual Enterprise Heterogeneity

Grouped regression analysis is used in this paper to study the effect of short-selling mechanisms on green innovation at the company level. The results of the heterogeneity tests are

presented in Table 5. In terms of individual firm heterogeneity, the stimulating effect of short-selling on green innovation is relatively stronger for heavily polluting sectors, state-owned enterprises, and large-scale enterprises.

1. for external environmental heterogeneity, companies located in areas with stricter environmental regulations and higher levels of marketisation are more significantly promoted by the short-selling mechanism.

2. regarding heterogeneity in the dimension of innovation, the stimulating effect of short-selling on high-quality green invention patents exceeds that on green utility model patents. The above related research conjectures have all been confirmed.

Table 5. Heterogeneity Test Results

Variable	(1) Heavy Pollution	(2) Non-Heavy Pollution	(3) SOE	(4) Private	(5) Large Scale	(6) Small Scale	(7) High Env. Reg.	(8) Low Env. Reg.	(9) High Market.	(10) Low Market.
Short	0.142***(8.24)	0.063***(4.17)	0.126***(6.87)	0.074***(5.24)	0.118***(7.52)	0.052***(2.97)	0.131***(7.86)	0.065***(4.23)	0.122***(7.64)	0.071***(4.58)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11247	18535	12463	17319	14926	14856	14892	14890	15024	14758
Adjusted R ²	0.402	0.374	0.395	0.378	0.392	0.367	0.394	0.376	0.391	0.379
Group Difference p-value	0.000***		0.023**		0.002***		0.001***		0.032**	

6.2. Mechanism Tests

Table 6. Mechanism Test Results

Variable	(1) Green_total	(2) AQ	(3) Green_total	(4) Green_total	(5) Mfee	(6) Green_total	(7) Green_total	(8) SA	(9) Green_total
Short	0.097***(7.82)	-0.008***(-4.27)	0.093***(7.54)	0.097***(7.82)	-0.004***(-3.86)	0.094***(7.62)	0.097***(7.82)	0.027***(8.24)	0.095***(7.71)
AQ			-0.427***(-5.24)						
Mfee						-0.824***(-6.72)			
SA									0.124***(7.52)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	29782	29782	29782	29782	29782	29782	29782	29782	29782
Adjusted R ²	0.387	0.242	0.391	0.387	0.287	0.393	0.387	0.874	0.389

This paper studies the transmission paths of the impact of the short-selling mechanism on corporate green innovation through a mediation model. The results of the heterogeneity

tests are presented in Table 5 results are as follows: Table 6. Within the information efficiency enhancement mechanism, reducing the restrictions on short-selling can raise the level of

corporate information disclosure and reduce information asymmetry; as a partial mediator. In the agency cost reduction mechanism, easing the limits on short selling may lower the management expense ratio of the company and reduce agency costs; it serves as a partial mediator. For the financing constraint alleviation mechanism, reducing the restrictions on short selling may relieve the financial constraints faced by the company and function as a partial mediator. All three paths support the related research hypotheses.

7. Research Conclusion and Policy Recommendations

7.1. Research Conclusion

First,relaxing restrictions on short-selling to encourage enterprises to conduct green innovation and drive an expansion in scale and depth of such changes. After the company was added to the margin trading and short-selling system, the number of green patent filings and all types of patent output increased significantly. The above results are in line with other good testing results and highly reliable.

Second,the Motivations derived from the short-selling system for green innovation in these companies vary greatly. The policy responses will be more feasible for highly polluting industries, state-owned enterprises and large enterprises. Such a stimulating effect is more pronounced in areas with strict environmental regulations and high marketisation, and the enhancement effect on high-quality green invention patents is relatively stronger.

Third,the three paths through which the short-selling system reduces information asymmetry and agency costs to address managerial myopia and expands sources for financing green innovation have been identified. All three channels are partially mediated by one another.

7.2. Policy Recommendations

Authorities should gradually reform the short-selling system, promote the expansion of margin trading and short-selling instruments, reasonably reduce the transaction costs for short selling, and fully exercise the external governance function of short selling. At the same time, strengthen the oversight of corporate environmental and green R&D data disclosure, upgrade disclosure standards, promote cooperative governance between capital markets and environmental laws, enforce differentiated supervision for heavily polluting sectors, and build a policy synergy system for green restructuring.

Strengthen the external regulatory function of the short-selling system, improve internal governance structures, let go of the pursuit of short-term financial results, and increase investment in high-end green innovation research and development. Strengthen the oversight functions of the board and supervisory committee, build incentive and evaluation mechanisms linked to the results of green innovation, proactively enhance the dissemination of information on environmental and green innovation efforts, reduce information asymmetry, and thereby alleviate financing constraints.

Strengthen ecological regulation at the regional level, increase the financial penalty for industrial environmental pollution, and coordinate regulatory efforts with short-selling mechanisms. They should gradually promote local market-oriented reforms, improve commercial environments and shareholder protection systems, release the full potential of

short-selling instruments, implement auxiliary measures such as green innovation financial grants and fiscal incentives, reduce the innovation burden and risks for enterprises, and stimulate the industrial momentum of sustainable transformation.

7.3. Research Limitations and Future Prospects

This study has the following limitations: the participants are limited to A-share listed public companies, thus restricting the scope; only the volume and quality of green innovation patents have been used in the evaluation; only three fundamental transmission paths have been identified, and the synergistic effects among the short-selling system and different types of green financial tools have not been fully explored. Further expand and develop the above dimensions in subsequent research.

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