Short-Selling Mechanism and Corporate Green Innovation: Evidence from the Mediating Roles of ESG Performance and Analyst Coverage

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Abstract: This study examines the impact of the short-selling mechanism on corporate green innovation using a sample of Chinese A-share listed firms from 2010 to 2024. A multi-period difference-in-differences (DID) model is employed based on 40,045 firm-year observations.The results show that the short-selling mechanism significantly promotes green innovation, with the coefficient on the short-selling indicator remaining positive and significant at the 1% level (approximately 0.070) after controlling for firm and year fixed effects. This finding is robust to a series of tests, including parallel trends, placebo tests, alternative variable specifications, and PSM-DID.Mechanism analysis indicates that the effect operates through improvements in ESG performance and increased analyst coverage, both of which serve as partial mediating channels.Heterogeneity analysis further reveals that the effect is more pronounced among state-owned enterprises, firms in non-polluting industries, and those located in the eastern region.Overall, the findings provide new evidence on how capital market institutions influence corporate green transformation and offer policy implications for improving the short-selling system and promoting sustainable development.

Keywords: Short-Selling Mechanism; Green Innovation; ESG Performance; Analyst Coverage

1. Introduction

Under the strategic guidance of China's "dual carbon" goals, promoting a comprehensive green transformation of economic and social development has become a central task for achieving high-quality growth. As key microeconomic agents, firms play a pivotal role in this process. Engaging in green innovation not only contributes to energy conservation and emission reduction, but also enhances firms' competitive advantages and reflects their commitment to national strategies and environmental responsibility. However, green innovation is typically characterized by high costs, long investment horizons, and considerable uncertainty, making firms' incentives to undertake such activities sensitive to both internal governance and external institutional pressures. Identifying effective mechanisms to stimulate corporate green innovation has therefore become a key concern in both academic research and policy practice.

Capital market institutions and reforms play a fundamental role in resource allocation. As an important institutional arrangement, the short-selling mechanism allows investors to express negative views on stocks, thereby incorporating adverse information into prices and exerting external disciplinary pressure on corporate managers. Since the launch of China's margin trading and short-selling program in 2010 and its subsequent expansion, whether and how the short-selling mechanism affects corporate behavior-particularly long-term strategic decisions such as green innovation-has attracted increasing scholarly attention.

Against this backdrop, this study takes A-share listed firms from 2010 to 2024 as the research sample and exploits the staggered expansion of the margin trading and short-selling program as a quasi-natural experiment. A multi-period difference-in-differences approach is employed to examine the impact of the short-selling mechanism on corporate green innovation. Unlike prior studies, this paper not only investigates the direct effect but also introduces ESG performance and analyst coverage as mediating variables, thereby uncovering two underlying channels-reputation enhancement and information transmission-through which short selling may promote green innovation. These

findings provide new insights into the role of capital market institutions in shaping firms' green transformation and offer important implications for improving China's market framework and advancing sustainable development.

2. Theoretical Analysis and Research Hypotheses

Short-sell mechanism is an essential institutional arrangement within a capital market. It also changes investor behavior as well as company choice logic. Based on the efficient market assumption and asymmetric information, the adoption of the short selling mechanism makes negative information reflected through trading activities and thus increases downward pressure on stock price and creates effective external check for the managerial actions(Zhu Hongbing, et al., 2019, p.7)[1]. And to relieve this outside pressure companies can try to fix their expectation through voluntary information release and brand maintenance. So here we see corporate green innovation, if it is some strategy, long term value creation and social duty kind of thing, as an answer – maybe to help them deal with all these sort of short selling types of pressures. From the one point of view, the green innovation will give a positive signal that the firm thinks of sustainable growth and assumes its responsibility towards nature actively to the outside people, so the image of the company can be improved and some part of the sentiment brought about by the short-selling systems could therefore be offset, (Han Pengyu & Wang Yanli, 2025)[2].Secondly, green innovation is very costly, it has a large investment scale, it takes a lot of time and it is very risky. Thus stable external resources needs. Short sell mechanism brings external supervision and information transparencies. So companies need a way to do those things too internally – better governance structures and more open info stuff – if they're going to push forward with something like that green stuff over there. From all that we've learned in the last sections I'd go on to make the following statement:

Hypothesis 1 :Short selling mechanism will lead to green innovation of companies.

A business's ESG performance is totally encompassing how it does with the environment, people and running things and we use this to see if they're good at being sustainable. Previous investigations show that satisfying social duties will make a company have better image to some extent and avoid the blow from the market(Chen peijie and luohuai 2026) [3]. Under short selling, the company has more external oversight. To protect their name and keep contact with investors, companies might want to improve how well they do when it comes to things like being green so they can send good messages. Zhu Hongbing et al. (2021) believe that the implementation of short selling system results into change of investor moods and trigger off arbitrage activities and firms could lessen harm done via selling on a short term basis by working out having a positive appearance. Good ESG is both more resilient toward troubles, as well as it gives green innovations access to help through stakeholder support and getting green loans. Thus the short selling mechanism might have a indirect effect towards green innovation activity since firms need to have improved esg performances. Based on this:

Hypothesis 2a :states that short selling can spur corporate green innovation via betterment in the firm's overall ESG scores.

As for how info intermeddias fit into the capiital market, is part of reducing inf asymmetry. As a professional information intermediary, when the analyst monitors the company, the disclosed information of the company will be more or less affected by external financial environment (Massa et al., 2012)[4]. In case we have no such thing called "short selling", those who write about what they know would lose motivation to make known bad things to others on an actual open ground where we call "markets for trading", thus not providing enough observation by others regarding companies(NieMing,2022)[5]. However, the introduction of the short-selling mechanism leads to greater analyst attention toward firms eligible for short selling compared to those that are not. Such attention can alleviate information asymmetry between firms and external investors, thereby easing financing constraints for corporate green innovation projects. Meanwhile, the market pressure effect generated by analyst coverage can enhance firms' willingness and level of voluntary information disclosure (Qian et al., 2026)[6]. As an important component of corporate environmental information disclosure, green innovation is more likely to attract analyst attention and receive positive evaluations. Therefore, the short-selling mechanism may indirectly promote corporate green innovation by increasing analyst coverage.

Based on this, this paper proposes the following hypothesis:

Hypothesis 2b: The short selling mechanism promotes corporate green innovation through increasing analyst attention.

3.Model Creation and Variable Design

3.1 Sample Selection and Data Sources

This paper chooses A - share listed companies between 2010-2024 as the research objects. To maintain its data valid and credible, some exclusions have to follow up: financial institution(s), companies that fall under abnormal conditions (ST & *ST firms) as well as incomplete or strange values of key variables. In the end we got 40,045 firm years of observation. Main source of Research data comes from these Authoritative Sources:- The China Research Data Service Platform(CNRDS)-Company Green Patents Application & Granted Data comes from China Research Data Service Platform(CNRDS) database is classified and defined strictly according to the International Patent Classification Green list standards set by WIPO, which guarantees the accuracy of the data. Huazheng ESG Composite Rating information comes from Huazheng Index Co., Ltd., showing how good companies are with nature, society, and rules; money numbers and who owns what in companies that sell things publicly come from Guotai-An Database (CSMAR); and paying attention by people who know about stocks comes from the Wind Database and CSMAR Analyst Forecast little part. So that no interference can take place owing to extreme values with respect to their results we made use of winsorization at 1 percentage point of the range within all kinds of controlling continuous variables within our study.

3.2 Dependent Variable: Corporate Green Innovation (GI)

Green patents reflect firms' green innovational accomplishment directly; they become major measures to determine how far a firm has moved green innovations (Qi shaozhou et al., 2018)[7]. Given that green patent grants are subject to examination lags after application, and application data more directly capture firms' innovation decisions and investment intentions, this study uses the total number of green patent applications in a given year as the primary proxy. As some firms may have zero applications, leading to a mass of zero values, the total number of green patent applications is transformed by taking the natural logarithm after adding one, denoted as GI, to mitigate right-skewness. For robustness checks, the logarithm of one plus the total number of granted green patents is used as an alternative measure to verify the reliability of the results.

3.3 Key Explanatory Variable: Short-Selling Mechanism (did)

Considering that the Chinese margin trading enterprise uses staged development from 2010 forward, they meet "the quasi-natural experimental condition" that we require when creating a multi-period DID. In this study, it is the short selling mechanism that it defines through creation of interacting variables where first there is a creation of List with a variable of Dummy that is 1 if a company in question is listed in the list of margin trading eligible companies within our data collection period and otherwise, it will be equal to zero. The second step involves defining a different variable called Post using another form of dummy variable; here, it takes the value as '1' if firm is present in the margin trading qualifying list from the present year and onward, which translates to no '0' values being assigned during these specific cases, and the final part consists of the representation created for short selling mechanism known simply as did by making the List times Post product equation. If this is set at 1 then it means the firm is able to be short - sold now and a 0 would indicate the company is not being short - sold now.

3.4 Mediating Variables

Corpore ESG performance(ESG), measured through Huazheng ESG overall evaluation. The rating model rates companies across three aspects: environment, society and governance and gives scores between 1-9, higher number means more egs performance and it reflect the ability of company in sustainable growth and social responsibility as well.

Analyst coverage (Analyst): As key information intermediaries in capital markets, analysts' attention helps mitigate information asymmetry between firms and investors (Massa et al., 2012). In this study, the number of securities analysts issuing earnings forecasts for a given listed firm in the current year is used as the baseline

measure. To address the presence of zero values, one is added to this count and the natural logarithm is taken, denoted as Analyst.

3.5 Control Variables

Drawing on prior studies on the determinants of corporate innovation (Wang et al., 2021[8]; Hao et al., 2018 [9]), this study includes firm size (Size), leverage (Lev), return on assets (ROA), board size (Board), the proportion of independent directors (Indep), CEO duality (Dual), the shareholding ratio of the largest shareholder (Top1), firm age (Age), institutional ownership (Inst), and operating cash flow (CashFlow) as control variables to mitigate potential omitted variable bias. Detailed definitions and measurements of these variables are presented in Table 1.

Table 1. Definitions for Relevant Variables.

Variable Type	Variable Name	Symbol	Measurement Method
Dependent Variable	Corporate Green Innovation	GI	Log of (Green patent apps this yr + 1)
Explanatory variables	Short-sold companies	List	1: If it is on the margin trading list within our study time, then 1; 0 if not.
	Year of Short Selling	Post	1 if it's listed as in the stock exchange margin trading in the current year and also for the next years, or 0.
	Short Selling Mechanism	did	Interaction of List with Post
Intermediary variable	Company ESG performance	ESG	CSI ESG composite rating is given as the score from 1-9
	Analyst Interest	Analyst	The natural logarithm of the number of security analysts that cover a given public company added to one.
Control Variables	Company Size	Size	ln of Annual total Assets
	Debt-to-Equity Ratio	Lev	Total Liabilities at year end/Total assets at year-end.
	Return on Total Assets	ROA	Net Income / Average Total Assets
	Board Size	Board	ln (number of board members)
	The share of independent directors.	Indep	Number of independent directors divide on the amount of directors.
	Dual Role	Dual	If the Chairman and CEO are one and the same person, then that has a value of 1, otherwises have a value of 0.
	Percentage of shares of the largest shareholders	Top 1	Biggest shareholder's amount/total number of share
	Company Age	Age	ln(current year-year of incorporation+1)
	Institutional investor ownership ratio	Inst	Total institutional holder's shares/Total amount of issued shares

3.6 Model Construction

In order to obtain the causal relationship between Short Selling mechanism and Corporate Green Innovation with regard to policy characteristics of phased expansion of Margin Trading; This study will adopt the multi - period DID as its reference point for regression analysis.

$$GI_{i,t}=\beta_0+\beta_1 did_{i,t}+\sum\gamma_k Controls_{k,i,t}+\mu_i+\lambda_t+\varepsilon_{i,t} \quad (1)$$

In the model, $GI_{i,t}$ denotes the level of green innovation of firm i in year t. The key explanatory variable, $did_{i,t}$,captures the short-selling mechanism. $Controls_{k,i,t}$ represents the set of control variables described above. Firm fixed effects μ_i are included to account for time-invariant firm-specific heterogeneity, while year fixed effects λ_t control for common shocks across time, such as macroeconomic fluctuations and policy changes. $\varepsilon_{i,t}$ is the error term. The coefficient of primary interest is β_1 ; a significantly positive estimate indicates that the short-selling mechanism promotes corporate green innovation.

To examine the mediating effects, this study follows the three-step approach proposed by Wen et al. (2014)[10] and extends the baseline specification accordingly.

First, the significance of the core explanatory variable is assessed using the baseline regression

model described above.

Second, the effect of the short-selling mechanism on the mediating variables is examined:

$$M_{i,t}=\alpha_0+\alpha_1 did_{i,t}+\sum\alpha_k Controls_{k,i,t}+\mu_i+\lambda_t+\varepsilon_{i,t} \quad (2)$$

Third, both the core explanatory variable and the mediating variable are incorporated simultaneously to assess the significance of the mediator and the change in the coefficient of the core explanatory variable. Specifically, $M_{i,t}$ denotes the mediating variables, including ESG performance (ESG) and analyst coverage (Analyst).

$$GI_{i,t}=\delta_0+\delta_1 did_{i,t}+\delta_2 M_{i,t}+\sum\delta_k Controls_{k,i,t}+\mu_i+\lambda_t+\varepsilon_{i,t} \quad (3)$$

A mediating effect is supported if the coefficient on the core explanatory variable is significant in the baseline model, the corresponding coefficient in the mediator regression is significant, and the coefficient on the mediating variable remains significant when both variables are included. Furthermore, if the coefficient on the core explanatory variable remains significant in this specification, the mediation is partial; otherwise, it is considered full mediation.

4. Empirical Results

4.1 Descriptive Statistics

Table 2 reports the descriptive statistics of the main variables. For the dependent variable, corporate green innovation (GI) has a mean of 0.837 and a standard deviation of 1.137, with values ranging from 0 to 4.605. This dispersion suggests substantial heterogeneity in green innovation activities across firms: while some firms have not engaged in green innovation, others exhibit relatively strong innovative performance.

The key explanatory variable, the short-selling mechanism (did), has an average value of 0.434, indicating that 43.4% of the firm-year observations are subject to short selling, which reflects the relatively broad coverage of the margin trading and short-selling program in China's capital market.

With respect to the mediating variables, ESG performance (ESG) has a mean of 4.226 and a standard deviation of 1.057, with values spanning from 1 to 9. This suggests that, on average, firms exhibit a moderate level of ESG performance, with considerable room for improvement. Analyst coverage (Analyst) has a mean of 1.392 and a standard deviation of 1.189, and the minimum value of zero indicates that some firms receive no analyst attention.

The control variables are generally consistent with those reported in prior studies and do not exhibit abnormal patterns, providing a reliable basis for subsequent regression analysis.

Table 2. Descriptive Statistics

VarName	Obs	Mean	SD	Min	Median	Max
GI	40045	0.837	1.137	0.000	0.000	4.605
did	40045	0.434	0.496	0.000	0.000	1.000
ESG	40045	4.226	1.057	1,000	4.000	9.000
Analyst	40045	1.392	1.189	0.000	1.386	3.784
Size	40045	22.200	1.289	20.000	21.983	26.360
Lev	40,045	0.396	0.198	0.050	0.387	0.851
ROA	40,045	0.040	0.056	-0.188	0.040	0.192
Board	40045	2.110	0.197	1.609	2.197	2.639
Indep	40045	0.377	0.053	0.333	0.364	0.571
Dual	40045	0.322	0.467	0.000	0.000	1.000
Top 1	40045	0.341	0.149	0.083	0.319	0.747
Age	40045	2.948	0.334	1.946	2.996	3.611
Inst	40045	0.424	0.255	0.003	0.435	0.913
CashFlow	40045	0.049	0.066	-0.145	0.048	0.234

4.2 Baseline Regression Analysis

Table 3 presents the baseline regression results examining the effect of the short-selling mechanism on corporate green innovation. Column (1) reports the specification without control variables, where the coefficient on did is 0.162 and statistically significant at the 1% level, providing preliminary evidence that the introduction of short selling is associated with an increase in green innovation.

Column (2) further incorporates the full set of control variables and includes both firm and year fixed effects. The coefficient on did remains

positive and statistically significant at the 1% level, with an estimated value of 0.070. This suggests that the positive effect of the short-selling mechanism on green innovation is robust to controlling for firm-specific characteristics and time trends. In economic terms, firms experience an approximate 7.0% increase in green innovation after being included in the margin trading and short-selling program.

Regarding the control variables, firm size (Size) exhibits a positive and statistically significant coefficient of 0.350 at the 1% level, consistent with the expectation that larger firms, endowed with greater financial and technological resources, are more capable of engaging in green innovation. Institutional ownership (Inst) is also positively associated with green innovation, with a coefficient of 0.176 significant at the 5% level, suggesting that institutional investors may play a facilitating role through monitoring and resource provision.

Other control variables, such as leverage (Lev) and return on assets (ROA), are not statistically significant, although their estimated signs are broadly consistent with existing literature and do not affect the main findings.

Table 3. Baseline Regression Result

	(1)	(2)
VARIABLES	GI	GI
did	0.162***	0.070***
	(8.189)	(3.711)
Size		0.350***
		(15.932)
Lev		-0.086
		(-1.336)
ROA		-0.022
		(-0.204)
Board		-0.022
		(-0.328)
Indep		0.223
		(1.161)
Dual		0.027
		(1.577)
Top 1		-0.095
		(-0.738)
Age		-0.043
		(-0.341)
Inst		0.176**
		(2.396)
CashFlow		-0.058
		(-0.791)
Constant	0.767***	-6.879***
	(89.184)	(-11.113)
Observed value	40,045	40,045
R^2	0.719	0.730
Firm fixed effects	YES	YES
Year fixed effects	YES	YES

Note that t-values are presented in parentheses. Asterisk indicates significance at the 10% level, double asterisks at 5%, triple asterisks at 1%.

4.3 Robustness Checks

To assess the reliability of the baseline findings, a series of robustness tests are conducted.

(1) Parallel Trends Test

The parallel trends assumption is a key prerequisite for the validity of the difference-in-differences framework, requiring that the treatment and control groups follow similar trends prior to the policy intervention. The results of the parallel trends test are illustrated in Figure 1.

As shown in Figure 1, before the implementation of the short-selling mechanism (i.e., to the left of the policy cutoff), the estimated coefficients for the lead terms are statistically insignificant and lie within the 95% confidence intervals, indicating no systematic differences in green innovation between the treatment and control groups prior to the policy shock.

Following the introduction of the short-selling mechanism (i.e., to the right of the policy cutoff), the coefficients on the lag terms become significantly positive and display an increasing pattern over time. This suggests that the positive effect of the short-selling mechanism on corporate green innovation persists over time, lending further support to the robustness of the baseline results.

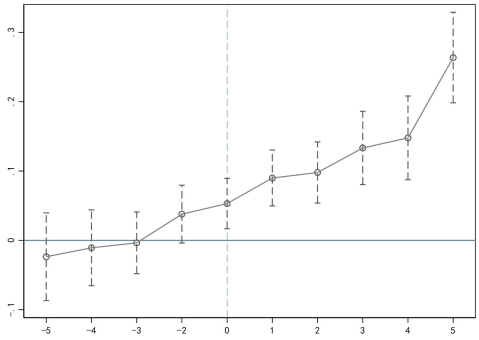

Figure 1. Parallel Trends Test

(2) Placebo Test

To rule out the possibility that the baseline results are driven by random shocks or omitted variables, a placebo test is conducted. Specifically, treatment firms and policy implementation timing are randomly reassigned to construct a fictitious policy indicator (pseudo

did). This procedure is repeated 500 times based on the baseline specification, and the distribution of the estimated coefficients is then examined.

The results are presented in Figure 2. As shown in Figure 2, the coefficients on the pseudo did are largely centered around zero and follow an approximately normal distribution. Moreover, the majority of the estimates are statistically insignificant at the 10% level, with p-values exceeding 0.1. These estimates differ markedly from the baseline coefficient on did (0.070).

Taken together, the findings suggest that the baseline results are unlikely to be driven by random variation, thereby supporting the validity of the estimated effect of the short-selling mechanism on corporate green innovation.

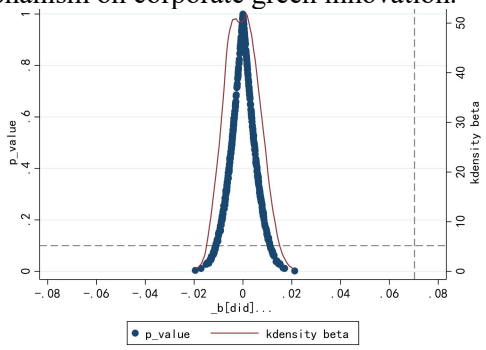

Figure 2. Placebo Test

(3) Dependent variable substitution

We use the amount of green patent grants given out by organizations as a common way to track corporate green innovations, so we're replacing the thing we have to predict with how many log(1 + green patent grant)'s they make for each company to look at something new. And results: Table 4 is provided.In Column (1), not include the control variable,DID is 0.157 that is statistically highly significant at 1%. Column (2) includes the control variables, still significantly positive at 1% level, DID is 0.079. This means that no matter what standard we apply - whether it be looking at green patent applications themselves or simply green patents awarded, -there is a very clear promotional function for short selling to have toward corporate green innovations, and our basic results were extremely robust.

Table 4. Different Dependent Variables of the Regression Results

	(1)	(2)
VARIABLES	GI	GI
did	0.157***	0.079***
	(8.659)	(4.603)
Size		0.303***
		(15.069)
Lev		-0.086
		(-1.437)
ROA		-0.273***
		(-2.793)
Board		-0.064
		(-1.051)
Indep		0.177
		(0.979)
Dual		-0.007
		(-0.490)
Top1		0.012
		(0.106)
Age		-0.062
		(-0.521)
Inst		0.075
		(1.162)
CashFlow		0.063
		(0.965)
Constant	0.624***	-5.799***
	(79.184)	(-10.384)
Observed value	40,045	40,045
R^2	0.718	0.728
Firm fixed effects	YES	YES
Year fixed effects	YES	YES

And (p), and (* p < 0.01, **, ***, p < 0.05) indicate whether they are significantly correlated.

Table 5. PSM Regression Results

	(1)	(2)
VARIABLES	GI	GI
did	0.111***	0.054**
	(4.215)	(2.082)
Size		0.344***
		(14.942)
Lev		-0.100
		(-1.390)
ROA		-0.273**
		(-2.211)
Board		0.001
		(0.016)
Indep		0.157
		(0.712)
Dual		0.021
		(1.147)
Top1		-0.118
		(-0.853)
Age		-0.031
		(-0.237)
Inst		0.027
		(0.377)
CashFlow		-0.088
		(-1.069)

Constant	0.560***	-6.746***
	(83.813)	(-10.118)
Observed value	21,326	21,326
R^2	0.672	0.682
Firm fixed effects	YES	YES
Year fixed effects	YES	YES

Note that t- values in parentheses are shown, and *, **, *** represent the corresponding significance at 10%, 5%, and 1%, respectively.

(4) PSM-DID

Propensity score matching (PSM) helps to reduce endogenous issues that happen due to samples' selection biases, but it doesn't completely eliminate the problem. The study is going to be good so I am going to have every single control variable in my model as covariate in a logit with exact 1:1 nearest neighbor matching. The PSM adjusted data was then entered into model regression. After PSM match, number of observations became 21, 326, here we give the regression result of matched data in table 5.

Table 5 shows results of the PSM regression. And so with the control variables included and also excluded from our regression result set is it clear that we continue to see large positive coefficient values associated with our key IV short selling mechanism thus we believe we do have sufficient support via the data for supporting Hypothesis H1 to be true. A balance was done with the PSM and Table 6 shows us there is a decrease on the standardized deviations of control variables post-matching as compared to pre-matching. Also after match, standardised differences in all control variables are below 10%, so we can say that this PSM matching meets balance requirements.

Table 6. Resultsof the PSMBalanceTest

Variable	Matching	Mean of Experimental Group	Mean of Control Group	Deviation	Reduction in Deviation	T-value	P-value
Size	Before matching	22.54	21.465	97.8		84.14	0.000
	After matching	21.547	21.606	-5.4	94.5	-5.66	0.000
Lev	Before matching	0.409	0.367	22		20.27	0.000
	After matching	0.366	0.369	-1.1	95.1	-0.8	0.423
ROA	Pre-matching	0.043	0.034	16		14.93	0.000
	After matching	0.036	0.036	-1.1	93.4	-0.77	0.444
Board	Pre-match	2.130	2.068	32.3		29.81	0.000
	After matching	2.079	2.079	0.2	99.3	0.16	0.869
Indep	Before matching	0.375	0.379	-7.7		-7.2	0.000
	After matching	0.377	0.378	-0.9	88.1	-0.68	0.494
Dual	Pre-matching	0.302	0.366	-13.5		-12.68	0.000
	After matching	0.363	0.361	0.5	96.5	0.34	0.732
Top 1	Before matching	0.343	0.336	4.6		4.2	0.000
	After matching	0.331	0.333	-1.4	69	-1.09	0.277
Age	Before matching	2.939	2.968	-8.8		-8.06	0.000
	After matching	2.942	2.952	-3	66	-2.24	0.025
Inst	Pre-match	0.468	0.330	55.9		51.84	0.000
	After matching	0.349	0.352	-1.1	98	-0.85	0.393
CashFlow	Pre-matching	0.0513	0.045	9.2		8.48	0.000
	After matching	0.044	0.046	-2.9	68	-2.16	0.031

4.4 Mechanism Analysis

(1) The Mediating Role of ESG Performance

Table 7. Mediating effect of corporate ESG.

	(1)	(2)	(3)
VARIABLES	GI	ESG	GI
did	0.070***	0.053**	0.069***
	(3.711)	(2.249)	(3.666)
ESG			0.017***
			(3.334)
Size	0.350***	0.339***	0.344***
	(15.932)	(15.652)	(15.571)
Lev	-0.086	-1.309***	-0.064
	(-1.336)	(-17.607)	(-0.985)
ROA	-0.022	0.683***	-0.034
	(-0.204)	(4.608)	(-0.312)
Board	-0.022	0.161**	-0.024
	(-0.328)	(2.061)	(-0.370)
Indep	0.223	1.442***	0.199
	(1.161)	(6.213)	(1.032)
Dual	0.027	-0.005	0.027
	(1.577)	(-0.245)	(1.586)
Top 1	-0.095	0.591***	-0.105
	(-0.738)	(4.539)	(-0.816)

Age	-0.043	0.082	-0.045
	(-0.341)	(0.570)	(-0.353)
Inst	0.176**	-0.166**	0.179**
	(2.396)	(-2.213)	(2.442)
CashFlow	-0.058	-0.239**	-0.054
	(-0.791)	(-2.510)	(-0.736)
Constant	-6.879***	-4.064***	-6.809***
	(-11.113)	(-6.409)	(-11.002)
Observed values	40,045	40,045	40,045
R^2	0.730	0.444	0.730
Firm fixed effects	YES	YES	YES
Fixed effects by year	YES	YES	YES

Note: T-values shown in parentheses; * indicates 10%; **indicates 5%; ***indicates 1%.

Table 7 reports the results of the mediation analysis with ESG performance as the mediating variable. In Column (1), the coefficient on did is 0.070 and statistically significant at the 1% level, satisfying the precondition for mediation analysis.

Column (2) examines the effect of the short-selling mechanism on ESG performance. The coefficient on did is 0.053 and significant at the 5% level, indicating that the introduction of short selling is associated with an improvement in firms' ESG performance.

In Column (3), both did and ESG are included. The coefficient on ESG is 0.017 and significant at the 1% level, while the coefficient on did remains positive and significant at the 1% level (0.069), albeit slightly smaller than in the baseline regression.

Taken together, these results provide evidence of a partial mediating effect of ESG performance. That is, the short-selling mechanism promotes corporate green innovation in part by improving firms' ESG performance.

A plausible explanation is that the external monitoring pressure induced by short selling incentivizes firms to place greater emphasis on environmental responsibility and long-term sustainability. By enhancing ESG performance, firms are able to convey more favorable signals to the market, which in turn facilitates access to resources and supports the implementation of green innovation activities.

(2) The Mediating Role of Analyst Coverage

Table 8 presents the mediation results for analyst coverage. Consistent with the baseline findings, the coefficient on did in Column (1) remains positive and statistically significant.

Column (2) shows that the coefficient on did is 0.145 and significant at the 1% level, suggesting that the introduction of the short-selling mechanism is associated with increased analyst coverage.

When both did and analyst coverage are included in Column (3), the coefficient on Analyst is 0.041 and significant at the 1% level. Meanwhile, the coefficient on did remains positive and statistically significant at the 1% level (0.064), although smaller in magnitude than in the baseline regression.

These results indicate that analyst coverage also serves as a partial mediating channel through which the short-selling mechanism promotes corporate green innovation.

One possible explanation is that greater analyst attention improves the firm's information environment by reducing information asymmetry between firms and investors. This enhanced transparency allows the value of green innovation projects to be more accurately recognized by the market, thereby providing more favorable external conditions for firms to undertake such activities.

Table 8. Mediating effect of analyst attention.

	(1)	(2)	(3)
VARIABLES	GI	Analyst	GI
did	0.070***	0.145***	0.064***
	(3.711)	(7.145)	(3.405)
Analyst			0.041***
			(5.531)
Size	0.350***	0.469***	0.330***
	(15.932)	(22.669)	(14.918)
Lev	-0.086	-0.317***	-0.073
	(-1.336)	(-4.496)	(-1.139)
ROA	-0.022	4.123***	-0.192*
	(-0.204)	(29.678)	(-1.745)
Board	-0.022	0.026	-0.023
	(-0.328)	(0.396)	(-0.345)
Indep	0.223	0.086	0.220
	(1.161)	(0.445)	(1.145)
Dual	0.027	0.037**	0.025
	(1.577)	(1.972)	(1.495)
Top 1	-0.095	-0.710***	-0.066
	(-0.738)	(-5.157)	(-0.513)
Age	-0.043	-0.293**	-0.031
	(-0.341)	(-2.339)	(-0.246)
Inst	0.176**	1.457***	0.116
	(2.396)	(16.258)	(1.558)
Cash Flow	-0.058	-0.188**	-0.050
	(-0.791)	(-2.294)	(-0.686)
Constant	-6.879***	-8.714***	-6.519***
	(-11.113)	(-14.676)	(-10.462)
Observed values	40,045	40,045	40,045

R2	0.730	0.735	0.731
Firm fixed effects	YES	YES	YES
Year fixed effects	YES	YES	YES

Note that the t - values are presented with their parentheses after them *, **,*** represent significant at the 10%, 5% and 1%.

5. Heterogeneity Analysis

5.1 Ownership Type Heterogeneity

Table 9 displays the regression findings separated by ownership type. As we have the data from the SOE group, here we can get that coefficient of D ID is 0.097 that is clearly positive at 1% and with regard to our non-SOE group the figure of DID has come down somewhat so as to yield 0.075, although still positive albeit at a lower 1% confidence, it still shows up there. It means the promotional power of short selling mechanism towards a firm's green innovation would be stronger in the case of state owned company. Furthermore, this study will be carried out to make sure there is difference between the two groups by applying the Chow Test and those results are 1%. Reasonable explanations can include: Generally speaking, all these state-owned company bear huge social responsibility, under the pressure of short selling regulations supervision from outside, thus their own internal efforts towards sustainable development with green ideas could also become a strong internal motivation factor for them. Also, S-state-owned companies have access to resources and policies and therefore can turn the external pressures of short selling as an impetus for greener innovation.

Table 9. Heterogeneity Analysis by Ownership Nature

	(1)	(2)
VARIABLES	SOEs	Non-SOEs
did	0.097***	0.075***
	(2.840)	(3.358)
Size	0.303***	0.373***
	(6.892)	(14.295)
Lev	0.057	-0.017
	(0.393)	(-0.244)
ROA	0.199	-0.279**
	(0.719)	(-2.374)
Board	-0.139	0.030
	(-1.100)	(0.418)
Indep	0.059	0.256
	(0.170)	(1.254)
Dual	-0.028	0.043**
	(-0.780)	(2.217)
Top1	-0.473**	-0.213
	(-1.978)	(-1.366)
Age	0.440*	-0.047
	(1.815)	(-0.316)
Inst	0.681***	0.092
	(4.219)	(1.096)
CashFlow	-0.004	-0.020
	(-0.031)	(-0.231)
Constant	-7.251***	-7.444***
	(-5.720)	(-10.529)
Observed values	12,094	27,951
R^2	0.775	0.707
Firm fixed effects	YES	YES
Year fixed effects	YES	YES
Chow test on group differencess	51.73***	

T values is in round bracket and *,**,*** mean signifficant at 10%,5%,1% level respetively.

5.2 Heterogeneity of Industry attributes

Table 10 shows the results from regrouping according to the type of industry. In the non-heavily polluting industry group, the value of DID coefficient is 0.069 with statistically significant positive correlation at 1%, but for heavily polluted industries the same variable did not pass significance at 10%. It's showing some short selling mechanism, they're kind of promoting the corporate green innovation, we can see that for the less polluted corporations, they do have some effect, but there still hasn't been anything with heavy polluters. Maybe because it is hard for companies within those heavily polluted industry groups as a whole, there would be stricter environ mental restrictions put on them along with very high costs associated with going green, plus these types of companies usually display quite noticeable path dependency so it isn't always easy to get this outward pressure that short-sellers cause to become something that truly drives a push toward new innovations related to our planet's wellbeing. Also negative env info abt heavily pollluting firms is easier to find by shorts, so may have more fin constraining them, hence lower inv in ginnov.

Table 10. Analysis of Industry Attribute Heterogeneity

	(1)	(2)
VARIABLES	Heavily Polluting Industries	Non-heavy Pollution Industries

did	0.092	0.069***
	(1.466)	(3.466)
Size	0.301***	0.355***
	(4.578)	(15.155)
Lev	-0.381*	-0.066
	(-1.828)	(-0.981)
ROA	0.229	-0.039
	(0.706)	(-0.340)
Board	-0.198	-0.001
	(-1.094)	(-0.010)
Indep	0.375	0.189
	(0.763)	(0.907)
Dual	0.002	0.028
	(0.042)	(1.563)
Top 1	0.321	-0.139
	(0.974)	(-1.010)
Age	-0.499	-0.012
	(-1.163)	(-0.092)
Inst	0.594***	0.116
	(2.685)	(1.536)
Cash Flow	-0.400**	-0.023
	(-2.018)	(-0.301)
Constant	-4.618**	-7.056***
	(-2.139)	(-10.910)
Observed values	3,869	36,176
R^2	0.704	0.735
Firm fixed effects	YES	YES
Year fixed effects	YES	YES

Note: The t-value is given in parenthesis and *,** and *** show the significant level at 10%, 5% and 1% significance level respectively.

5.3 Regional Heterogeneity

Table 11 reports the regression results by regional subsamples. For firms located in the eastern region, the coefficient on did is 0.082 and statistically significant at the 1% level. In contrast, the coefficients for the central and western regions are 0.045 and 0.024, respectively, neither of which is statistically significant.

These findings suggest that the positive effect of the short-selling mechanism on corporate green innovation is primarily concentrated in the eastern region.

This pattern is consistent with the uneven regional development in China. The eastern region is characterized by a higher degree of marketization and more developed capital markets, which may enhance the effectiveness of the short-selling mechanism as an external governance tool. In addition, firms in the eastern region typically face more intense market competition and stricter environmental requirements, making them more responsive to the external pressure induced by short selling and more likely to engage in green innovation as a strategic response.

Table 11. An Analysis on Regional Heterogeneity

	(1)	(2)	(3)
VARIABLES	Eastern	Central	West
did	0.082***	0.045	0.024
	(3.766)	(0.862)	(0.429)
Size	0.340***	0.422***	0.271***
	(13.581)	(7.256)	(4.248)
Lev	-0.108	0.033	-0.024
	(-1.490)	(0.180)	(-0.135)
ROA	-0.146	0.309	0.311
	(-1.173)	(0.937)	(0.972)
Board	-0.046	0.291*	-0.207
	(-0.633)	(1.842)	(-1.044)
Indep	0.085	1.222***	0.056
	(0.397)	(2.744)	(0.108)
Dual	0.028	0.021	-0.017
	(1.508)	(0.407)	(-0.336)
Top 1	-0.193	0.178	-0.077
	(-1.393)	(0.505)	(-0.193)
Age	0.071	-0.738**	0.056
	(0.500)	(-2.033)	(0.151)
Inst	0.156*	0.092	0.261
	(1.934)	(0.461)	(1.053)
Cash Flow	-0.084	-0.250	0.308
	(-1.033)	(-1.192)	(1.306)
Constant	-6.830***	-7.590***	-5.146***
	(-10.139)	(-4.567)	(-2.652)
Observed values	29,543	5,961	4,541
R^2	0.741	0.710	0.702
Firm fixed effects	YES	YES	YES
Year fixed effects	YES	YES	YES

Note that t-values are shown in brackets here, and *,**,*** stand for the significance of 10%,5%,1% levels correspondingly.

5. Conclusions

Drawing on the effective market hypothesis and information asymmetry theory, this study employs a multi-period difference-in-differences approach to examine the impact of the short-selling mechanism on corporate green innovation, using data from A-share listed firms over the period 2010–2024.

The empirical results yield several main findings. First, the introduction of the short-selling mechanism is associated with a significant increase in corporate green innovation. Firms

included in the margin trading and short-selling program exhibit higher levels of green patent applications, and this result remains robust across a range of sensitivity checks, including parallel trends tests, placebo tests, alternative variable specifications, and PSM-DID estimations.

Second, the analysis identifies two underlying channels through which the short-selling mechanism promotes green innovation. Specifically, short selling contributes to improvements in firms' ESG performance and attracts greater analyst coverage, both of which facilitate green innovation by enhancing resource availability and improving the external information environment.

Third, the effect of the short-selling mechanism exhibits notable heterogeneity. It is more pronounced among state-owned enterprises, possibly reflecting their stronger social responsibility mandates and relative advantages in resource access. In terms of industry characteristics, the effect is primarily observed in non-polluting sectors, while it remains insignificant in heavily polluting industries, where stricter environmental regulations and higher transition costs may constrain firms' responses. From a regional perspective, the effect is concentrated in the eastern region, where higher levels of market development and more mature capital markets provide a more conducive environment for the mechanism to operate effectively.Overall, this study offers new insights into the role of capital market institutions in shaping firms' green innovation behavior. The findings carry important policy implications, suggesting that further development of the margin trading and short-selling system can enhance its functions in external monitoring and information intermediation. Such improvements may help guide firms toward more sustainable practices and contribute to the achievement of China's carbon neutrality goals.

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