Fiscal-Financial Policy Coordination and Green Innovation among SMEs: Quasi-Natural Evidence from Government Procurement Contract Loans in China

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Abstract. Driven by China's dual-carbon goals, easing the resource constraints faced by small and medium-sized enterprises (SMEs) in green innovation and strengthening their internal incentives for such innovation have become important policy issues. Using firms listed on China's STAR Market and ChiNext Board from 2011 to 2024, this study treats the implementation of government procurement contract loan policies as a quasi-natural experiment and estimates a staggered difference-in-differences model to examine the relationship between fiscal-financial policy coordination and SME green innovation. The results show that government procurement contract loans significantly promote green innovation among SMEs. Mechanism tests indicate that the policy operates mainly by alleviating financing constraints, increasing firms' environmental attention, and strengthening external monitoring. Heterogeneity analysis further shows that policy responses are stronger among firms facing higher peer pressure, firms located in regions with heavier local government debt, and firms in the maturity stage of their life cycle. Additional tests suggest that the policy primarily increases the quantity, rather than the quality, of green innovation. This study provides new evidence on the applicability of resource dependence theory in China and offers practical implications for improving fiscal-financial coordination systems.

Keywords: government procurement contract loans, green innovation, financing constraints, fiscal-financial policy coordination.

1. Introduction

As global climate governance deepens, green development has moved from a broad normative consensus to a concrete strategic agenda in China. At a recent Central Economic Work Conference, the central leadership emphasized that the heavier the development task, the more attention should be paid to ecological and environmental protection and to the comprehensive green transformation of economic and social development. Green innovation is a key link between environmental protection and economic growth (Van Leeuwen and Mohnen, 2017)[1]. It carries the technological promise of industrial upgrading and energy-structure transition, while also enabling firms to gain competitive advantage (Porter and Kramer, 2006)[2] and pursue sustainable development.

However, green innovation is characterized by long investment cycles, substantial information asymmetry, and high risk (Wang et al., 2019)[3]. SMEs already face more difficult financing conditions than larger firms, and thus encounter more severe financing constraints when undertaking green innovation. In addition, green innovation involves double externalities: firms must bear the high costs of environmental R&D and equipment investment, whereas the ecological benefits are shared by society as a whole. As a result, SMEs may fall into a situation of insufficient expected returns and weak internal motivation in environmental investment (Jiang et al., 2024)[4]. It is therefore theoretically and practically important to identify ways to use inclusive financial instruments to ease SMEs' operating-finance pressures while also stimulating their endogenous incentives for green innovation.

To strengthen the coordination between fiscal and financial policies and address SMEs' financing difficulties, local governments in China have promoted government procurement contract financing in recent years. Under this policy, winning suppliers can use the future receivables associated with government procurement contracts as collateral and apply for loans from financial institutions

through a closed-loop account structure linking government, firms, and banks. The policy connects government credit on the fiscal side with bank credit resources on the financial side. By relying on government credit endorsement, it reduces information asymmetry between banks and firms; by removing the need for additional collateral, it also eases cash-flow pressures for SMEs. Government procurement contract loans have therefore become an important channel for alleviating SME financing constraints and, objectively, have created a form of resource dependence on government orders among beneficiary firms.

China's green government procurement system has already been shown to pressure firms into green innovation (Huang and Zhu, 2023)[5]. Yet SMEs often lack sufficient internal motivation because of resource constraints. Government procurement contract loans play an enabling role in this context. They not only directly increase firms' operating cash flow, but also strengthen SMEs' incentives to upgrade environmental technologies in order to meet the environmental standards embedded in government procurement. Moreover, the government-credit endorsement attached to these loans labels firms as high-quality counterparties and attracts greater external market attention. This study therefore argues that government procurement contract loans can promote SME green innovation not only by directly relaxing financing constraints for green R&D, but also by interacting with green procurement standards to increase firms' internal environmental attention and by sending government-credit signals that attract analyst attention and strengthen external monitoring.

Using firm-level data from China's STAR Market and ChiNext Board during 2011-2024, this study examines the relationship between the implementation of government procurement contract loans and SME green innovation. It also identifies three mechanisms: financing constraints, internal environmental attention, and external monitoring. The heterogeneity analysis shows that the effect is stronger for firms facing greater peer pressure, suggesting that a stronger industry-level environmental atmosphere enhances the green innovation effect of the policy. It is also stronger in regions with heavier local government debt, implying that when traditional credit resources are more difficult to obtain, government procurement contract loans generate higher marginal benefits for green innovation. In addition, firms in the maturity stage respond more strongly than firms in the growth or decline stages, indicating that firms with stable operations have stronger incentives to pursue green technological upgrading. Further analysis suggests that the policy mainly induces strategic, rather than substantive, green innovation.

This study makes two main contributions. First, it enriches the literature on policies that coordinate fiscal and financial instruments. Existing studies show that government procurement contract loans can expand firms' bank borrowing (Wang et al., 2023)[6] and increase fixed-asset investment and labor employment (Yu et al., 2025)[7]. However, their implications for firms' ESG-related investment activities remain underexplored. By examining green innovation, this study extends the research boundary on the economic consequences of government procurement contract loans from a firm-environment perspective and provides practical evidence for evaluating the policy's role and value. It also examines heterogeneous policy incentives from multiple dimensions. While previous research often studies the effects of policies on green innovation from the perspectives of ownership type (Duan et al., 2024)[8] or polluting-firm status (Cheng et al., 2025)[9], this study identifies the marginal benefits of government procurement contract loans in specific economic contexts and shows that their green innovation effect is stronger when traditional regional credit resources are scarce, industry-level environmental pressure is high, and firms operate relatively stably.

Second, this study extends the perspective on the drivers of green innovation. Existing research usually examines green innovation either from the supply side of financial credit (Bai et al., 2019[10]; Dogah et al., 2025)[11] or from the demand side of government regulation (Wang et al., 2023[12]; Cheng et al., 2025[13]). This study argues that government procurement contract loans are neither a simple order-pull mechanism nor a pure capital-injection mechanism. Instead, they operate through the coordination and binding of government procurement demand and financial credit supply. On this basis, the study explores the mechanisms through which the policy affects SME green innovation from the perspectives of financing constraints, internal incentives, and external monitoring, and

provides evidence that firms convert part of the credit support into innovation output in pursuit of financing dividends.

2. Institutional Background and Literature Review

2.1. Institutional background

In September 2011, the Ministry of Finance issued the Notice on Piloting Credit Guarantees for Government Procurement, marking the formal launch of local pilot programs for government procurement credit financing from January 1, 2012. In 2020, after successful local experimentation, the government procurement contract loan policy began to be promoted nationwide. In May 2022, provinces started to build online government procurement contract loan platforms. In 2024, the State Council issued the Three-Year Action Plan for the Government Procurement Sector (2024-2026), calling for information sharing between government procurement agencies and financial institutions. Since then, the policy has developed toward digitalization and intelligent operation. Through continuous experimentation, it has evolved from offline to online models and from contract-based lending to pre-approved credit based on historical winning projects.

Regarding the policy objective, officials from the Ministry of Finance have emphasized that SMEs participating in government procurement bidding often face pressure from performance-bond deposits. Introducing a government-credit guarantee mechanism can broaden corporate financing channels, address the difficulty and high cost of financing for SMEs and micro enterprises, stimulate market vitality, and create a fairer and more efficient business environment.

Government procurement contract loans have several features that distinguish them from other credit policies. First, aside from guarantees by legal representatives, firms are generally not required to provide property collateral or third-party guarantees when the loan amount does not exceed the government procurement contract value. According to information released by the Hubei provincial government, Hubei completed 2,979 financing transactions in 2024, with loan amounts totaling RMB 12.3 billion; 99% of disbursements were completed online, realizing zero collateral and zero offline visits. Second, many local governments require preferential interest rates for winning firms, with some stipulating that the interest rate for government procurement contract loans should be at least 20% lower than the rate for comparable working-capital loans. According to data released by the Jilin Provincial Department of Finance in November 2024, the average executed interest rate of products offered through the platform was only 3.45%, 97 basis points lower than the 4.42% national average rate for small and micro enterprise loans in the third quarter of 2024. Third, repayment accounts are locked to ensure that procurement payments are used first for loan repayment. According to the Sichuan Provincial Department of Finance, by September 2024, Sichuan had 47 partner banking institutions and had issued 11,538 loans totaling RMB 17.957 billion. These reforms have substantially improved the willingness and accessibility of government procurement credit financing.

Existing studies of government procurement contract loans mainly affirm their role in alleviating SME financing constraints and examine their economic consequences for firms' bank loan scale (Wang et al., 2023)[6], labor employment, and fixed-asset investment (Yu et al., 2025)[7]. However, little attention has been paid to their environmental consequences. Since previous research identifies the alleviation of financing constraints as an important mechanism for promoting corporate green innovation (Zhang et al., 2024)[14], government procurement contract loans may be closely related to SME green innovation.

2.2. Literature review

Recent studies on macro policies and corporate green innovation have mainly followed three directions. The first focuses on the innovation-inducing effect of environmental regulation. Zhang et al. (2022)[15] find that de-capacity policies can improve green efficiency. Li et al. (2023)[16] show that the central environmental inspection policy significantly promotes substantive corporate green innovation. Zheng et al. (2024)[17] identify a U-shaped relationship between environmental regulation

and corporate green innovation. The second direction concerns financial support policies. For example, green credit policies mainly promote the quantity, rather than the quality, of green innovation by relaxing financing constraints (Liu and Dong, 2022)[18]. Other scholars show that green finance reform and innovation pilot zones also increase green innovation activity by improving financing convenience (Qi and Liu, 2023)[19]. The third direction emphasizes demand-side mechanisms. As an important component of public fiscal expenditure, the market-pull effect of government procurement has attracted increasing attention. Studies show that government procurement can pressure firms to improve green innovation through mechanisms such as the threat of procurement termination (Huang and Zhu, 2023)[5], and that green government procurement mainly stimulates green innovation by improving firm profitability (Jiang et al., 2024)[4].

Research has also examined digitalization and information disclosure. Digital transformation can increase corporate green innovation (Hoque and Lee, 2025[20]; Zhang et al., 2025[21]), digital inclusive finance can promote green R&D investment by easing financing constraints (Zhong et al., 2022)[22], and artificial intelligence applications can improve both the quality and quantity of green innovation by broadening firms' cognition (Farmanesh et al., 2025)[23]. From an information disclosure perspective, the publication of ESG information increases public attention and raises firms' willingness to innovate (Zhou and Ren, 2025)[24]. By contrast, greenwashing by peer firms squeezes firms' profitability and financing space and reduces their willingness to engage in green innovation (Cai et al., 2025)[25]. Tang et al. (2025)[26] further show that managerial short-termism weakens the incentive effects of policies.

In summary, existing studies of government procurement contract loans are largely confined to their general economic effects under the framework of inclusive finance, while rarely examining their potential environmental spillovers. Likewise, research on corporate green innovation has not fully connected this topic with the credit-amplification and financing-support functions of government procurement contract loans. In practice, when the financing empowerment of these loans is tied to increasingly stringent green requirements in government procurement, it may have far-reaching effects on firms' innovation behavior. This study therefore constructs a difference-in-differences model to examine the specific effects of government procurement contract loans on SME green innovation.

3. Theoretical Hypothesis

As an innovative tool for fiscal-financial coordination, the core function of government procurement contract loans is to transform government procurement credit into corporate financing credit and thereby alleviate SMEs' financing difficulties. In effect, the policy amplifies the economic returns associated with green government procurement. According to resource dependence theory, firms seeking to maintain continued financing benefits will increase green innovation to meet the environmental requirements of government procurement. Meanwhile, under signaling theory, the high-quality credit signal released by government procurement contract loans can reduce market information asymmetry. This study therefore argues that the policy jointly promotes SME green innovation through three channels: easing financing constraints, increasing firms' environmental attention, and strengthening external monitoring.

First, SMEs face severe financing constraints in green R&D, and government procurement contract loans directly target this constraint. The policy generally does not require property collateral or third-party guarantees, which alleviates the financing dilemma of SMEs that are asset-light and lack collateral. It also requires preferential interest rates; in some regions, the lending rate is more than 20% lower than that of comparable working-capital loans. Lower financing costs promote firms' R&D investment (Brown et al., 2009)[27]. In addition, government credit endorsement reduces information asymmetry between banks and firms and makes loans easier for SMEs to obtain (Yu et al., 2025)[7]. These mechanisms jointly relax financing constraints and allow firms to allocate more

internal funds and credit resources to green technology R&D, environmental equipment purchases, and clean production-process upgrading, thereby improving SME green innovation.

Second, compared with fiscal subsidies or green credit alone, government procurement contract loans more effectively stimulate firms' internal motivation to increase environmental attention through a coordinated mechanism of fiscal-side credit endorsement and financial-side credit supply. On the one hand, the Government Procurement Law clearly states that government procurement should help protect the environment (Huang and Zhu, 2023)[5], and some financial institutions have launched green winning-bid loan products. This coordinated mechanism amplifies the economic returns to green innovation and pushes firms that wish to continue obtaining such loans to improve environmental management, including reducing pollutant emissions and strengthening green transformation. On the other hand, obtaining government procurement contract loans means not only receiving a fiscal-payment commitment but also gaining government credit endorsement and recognition from financial institutions. To maintain this reputation, firms have incentives to improve environmental performance. Strong environmental performance can attract green investors and long-term capital, further alleviating innovation financing constraints (Zhang et al., 2024)[28]. It also enables firms to accumulate technical experience and data during environmental capacity building, which can guide green R&D and reduce the marginal cost of patent development (Cheng et al., 2025)[9].

Third, when the information environment is less transparent and information asymmetry is stronger, the market's demand for analysts as information intermediaries increases (Wu et al., 2017)[29]. Government procurement contract loans release a salient credit signal precisely in the SME financing domain, where information asymmetry is particularly severe, and thus naturally attract more analyst attention. Greater analyst attention can promote green innovation through two mechanisms. Through information revelation, it reduces information asymmetry between firms and external investors and strengthens the willingness of financial institutions and social capital to support corporate green innovation, indirectly easing financing constraints (Derrien and Kecskes, 2013)[30]. Through monitoring and governance, it constrains managers, weakens the possibility that managers reduce green R&D investment for self-interested reasons, and helps ensure that policy-related credit resources are used for green technological innovation (Jing et al., 2024)[31].

Accordingly, this study proposes the following hypothesis:

H1: The implementation of government procurement contract loans promotes SME green innovation by alleviating financing constraints, increasing firms' internal environmental attention, and strengthening external monitoring.

4. Research Design

4.1. Sample selection and data sources

Because data on unlisted SMEs and micro enterprises in China are difficult to obtain, this study uses firms listed on the STAR Market and ChiNext Board during 2011-2024 as the research sample. Firms listed on these two boards are mainly technology-oriented SMEs. They are typically asset-light, high-growth, and financially constrained, and they are highly covered by government procurement contract loan policies. They therefore provide a representative setting for the analysis. The starting year is 2011 because it is the year before the first policy pilots were launched, allowing the construction of a complete time series before and after implementation. Policy implementation data were manually collected from local government websites and official media reports. Green patent data come from the Chinese Research Data Services Platform (CNRDS). Financial data of listed firms are mainly obtained from the China Stock Market and Accounting Research (CSMAR) database and supplemented by the Wind database. The initial sample contains 13,241 firm-year observations. After excluding financial firms, ST and *ST firms, observations with asset-liability ratios greater than 1, and observations with missing key variables, the final sample contains 12,296 firm-year observations.

To reduce the influence of outliers, all continuous variables are winsorized at the 1st and 99th percentiles.

4.2. Model specification

Following Yu et al. (2025)[7], this study estimates the relationship between government procurement contract loans and corporate green innovation using the following staggered difference-in-differences model:

$$patt_{i,t} = \alpha + \beta_1 treatpost_{i,t} + \gamma Controls_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \quad (1)$$

where patt_i,t denotes the green innovation level of firm i in year t; treatpost_i,t is the policy dummy for government procurement contract loans; Controls_i,t is a vector of control variables; μ_i and λ_t denote firm and year fixed effects, respectively; and ε_i,t is the random error term. To mitigate heteroskedasticity and serial correlation, standard errors are clustered at the firm level.

According to the hypothesis, the coefficient on the core explanatory variable treatpost is expected to be significantly positive, indicating that government procurement contract loans significantly promote SME green innovation.

4.3. Variable construction

4.3.1. Dependent variable

The dependent variable is corporate green innovation. Following Wang and Wang (2021)[32], this study uses the number of green patent applications by listed firms as a proxy for green innovation. Patent examination periods are often long, and application data reflect contemporaneous green R&D output more promptly than granted patents. In addition, compared with voluntarily disclosed environmental performance or social responsibility reports, patent applications meet a certain quality threshold.

4.3.2. Explanatory variable

The explanatory variable is the implementation of government procurement contract loan policies. Based on government procurement credit financing documents and media reports released by local government websites, this study identifies treatment status according to whether the policy had been implemented in the city where a firm is located. Cities in which the policy was implemented are classified as treated cities, while cities without implementation or without effective business rollout are classified as control cities. The dummy variable treatpost equals 1 in the implementation year and subsequent years for treated firms, and 0 otherwise.

4.3.3. Control variables

Following Zhang et al. (2024)[33], the study controls for firm size (size), leverage (lev), return on assets (roa), firm value (tobinq), shareholding of the largest shareholder (top1), managerial shareholding (mshare), listing age (age), and R&D intensity (rd), all of which may affect corporate green innovation. The variable definitions are reported in Table 1.

Table 1. Variable definitions

Variable	Variable name	Definition and calculation
patt	Corporate green innovation	ln(total green invention and utility-model patent applications + 1)
treatpost	Policy dummy	1 for treated firms after policy implementation; 0 otherwise
size	Firm size	Natural logarithm of total assets
lev	Leverage	Total liabilities / total assets
roa	Return on assets	Net profit / average net assets
tobinq	Firm value	Market value / replacement value of capital
top1	Shareholding of the largest shareholder	Shares held by the largest shareholder / total shares
mshare	Managerial shareholding	Shares held by management / total shares
age	Listing age	ln(years since listing + 1)
rd	R&D intensity	R&D expenditure / operating revenue

5. Empirical Results

5.1. Descriptive statistics

Table 2 reports the descriptive statistics of the main variables. The median value of corporate green patent applications is 0.693, indicating that most firms still have relatively low green innovation output. The maximum value is 4.190, and the mean value is 0.834, which is higher than the median. This pattern suggests substantial differences in green innovation across firms and a typical right-skewed distribution. The mean value of the government procurement contract loan policy dummy is 0.763, indicating that about 76.3% of observations were exposed to the policy during the sample period. This reflects the broad implementation and expanding coverage of the policy. The remaining control variables are all within reasonable ranges.

Table 2. Descriptive statistics

Variable	N	Mean	S. D.	Min.	P25	P50	P75	Max.
patt	12,296	0.834	1.052	0.000	0.000	0.693	1.386	4.190
treatpost	12,296	0.763	0.425	0.000	1.000	1.000	1.000	1.000
size	12,296	21.536	0.850	19.966	20.923	21.429	22.021	24.147
lev	12,296	0.316	0.183	0.040	0.166	0.286	0.446	0.808
roa	12,296	0.040	0.076	-0.273	0.014	0.046	0.080	0.228
tobinq	12,296	2.231	1.270	1.015	1.423	1.813	2.559	8.219
top1	12,296	0.297	0.129	0.075	0.200	0.279	0.381	0.675
mshare	12,296	0.256	0.205	0.000	0.046	0.249	0.417	0.700
age	12,296	1.375	0.790	0.000	0.693	1.386	2.079	2.708
rd	12,296	0.090	0.088	0.003	0.040	0.059	0.105	0.541

5.2. Correlation analysis

As shown in Table 3, the correlation coefficient between the government procurement contract loan policy and corporate green innovation is 0.106. This preliminary result indicates a significantly positive correlation between policy implementation and SME green innovation. In addition, firm size, leverage, listing age, and other control variables are significantly correlated with green innovation, supporting the relevance of the selected controls. The absolute values of pairwise correlations are all below 0.5, suggesting that the model does not suffer from severe multicollinearity and can be used for further analysis.

Table 3. Correlation matrix

	patt	treatpost	size	lev	roa	tobinq	top1	mshare	age	rd
patt	1.000									
treatpost	0.106***	1.000								
size	0.386***	0.171***	1.000							
lev	0.300***	0.064***	0.395***	1.000						
roa	-0.062***	-0.088***	-0.026***	-0.363***	1.000					
tobinq	-0.093***	0.031***	-0.155***	-0.107***	0.132***	1.000				
top1	-0.062***	-0.098***	-0.076***	-0.104***	0.192***	-0.092***	1.000			
mshare	-0.127***	-0.109***	-0.289***	-0.211***	0.187***	-0.088***	0.115***	1.000		
age	0.139***	0.110***	0.325***	0.323***	-0.331***	0.169***	-0.279***	-0.259***	1.000	
rd	0.002	0.177***	-0.038***	-0.226***	-0.232***	0.190***	-0.136***	-0.011	-0.028***	1.000

5.3. Baseline regression

Columns (1) and (2) of Table 4 report the regression results for the effect of government procurement contract loans on SME green patent applications before and after adding control variables. In column (1), the coefficient of treatpost is significantly positive at the 10% level. After adding controls, column (2) shows that the coefficient of treatpost remains significantly positive at the 5% level. The estimates indicate that green patent applications increase by 6.2% after policy

implementation. These results show that government procurement contract loans significantly promote SME green innovation, supporting H1.

Table 4. Baseline regression results

	(1)	(2)
Variables	**patt**	**patt**
treatpost	0.059*	0.062**
	(0.072)	(0.043)
size		0.370***
		(0.000)
lev		0.155*
		(0.098)
roa		-0.096
		(0.475)
tobinq		0.018**
		(0.026)
top1		0.277
		(0.163)
mshare		-0.104
		(0.304)
age		0.029
		(0.325)
rd		0.522***
		(0.004)
Observations	12,296	12,296
FIRM&YEAR F.E.	YES	YES
Adjusted R^2	0.669	0.685

Notes: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. Values in parentheses are robust p-values based on standard errors clustered at the firm level. The same convention applies below.

5.4. Robustness tests

5.4.1. Parallel trend test

The difference-in-differences model requires that treated and control groups have no significant differences in pre-policy trends. This study uses the period immediately before implementation as the baseline period to examine the dynamic trend of government procurement contract loan policies. Specifically, using the implementation year in the city where the firm is located as the reference point, the study generates dummy variables for one to five years before the policy and one to four years after the policy. Observations five years or more after implementation are combined to avoid long-tail effects.

After omitting the base period, these dummy variables are included in the regression model. The results in Figure 1 show that pre-policy coefficients are insignificant, while most post-policy coefficients are significantly positive. This indicates that the policy had a significant effect on firms' green patent applications and that the parallel trend assumption is reasonably satisfied.

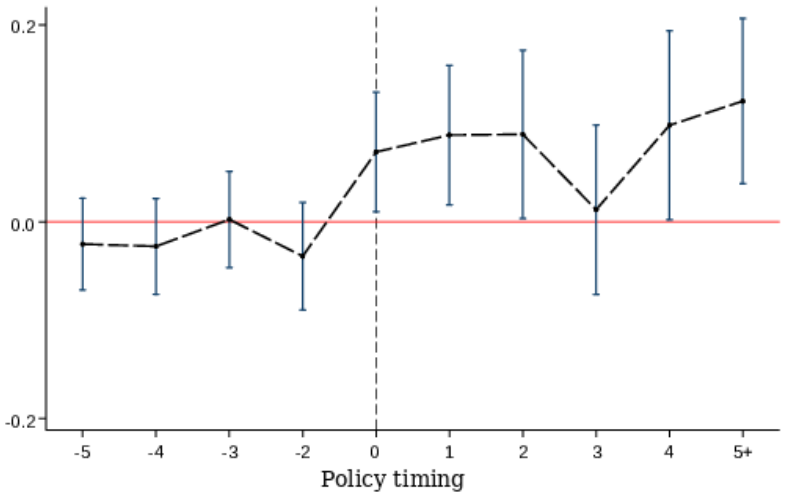


Figure 1. Parallel trend test

5.4.2. Propensity score matching

The implementation of government procurement contract loans may be subject to sample selection bias: firms benefiting from the policy may already be of higher quality and have stronger green preferences. To identify the net policy effect more precisely, this study uses all control variables from the baseline regression as covariates and applies 1:1 pooled nearest-neighbor matching to construct a control group with similar characteristics. The model is then re-estimated. Table 5 shows that after matching, most covariate differences between groups are no longer significant, indicating that the matched sample passes the balance test. The regression result in column (1) of Table 6 is broadly consistent with the baseline result, confirming the robustness of the positive effect of government procurement contract loans on SME green innovation.

Table 5. PSM balance test

Variables	Unmatched	Mean	Mean	T-test	T-test
	Matched	Treated	Control	t	p>|t|
size	U	21.617	21.275	19.27	0.000
	M	21.399	21.450	-2.08	0.038
lev	U	0.323	0.295	7.10	0.000
	M	0.313	0.315	-0.45	0.653
roa	U	0.036	0.052	-9.84	0.000
	M	0.048	0.046	0.80	0.424
tobinq	U	2.253	2.160	3.47	0.001
	M	2.183	2.202	-0.50	0.620
top1	U	0.290	0.320	-10.92	0.000
	M	0.308	0.308	-0.16	0.875
mshare	U	0.243	0.296	-12.12	0.000
	M	0.267	0.267	0.03	0.975
age	U	1.423	1.219	12.28	0.000
	M	1.311	1.341	-1.29	0.196
rd	U	0.098	0.062	19.97	0.000
	M	0.070	0.067	1.70	0.090

5.4.3. Placebo test

To rule out the influence of unobservable omitted variables or time-varying systematic factors, this study conducts a random-permutation placebo test. Specifically, a false treatpost dummy is randomly generated according to the actual proportion of the DID treatment variable and included in the baseline model. This procedure is repeated 1,000 times. As shown in Figure 2, the estimated coefficients are centered around zero, while the true coefficient, 0.062, lies far from zero. Most p-

values are greater than 0.1, suggesting that omitted variables and systematic factors do not drive the main results.

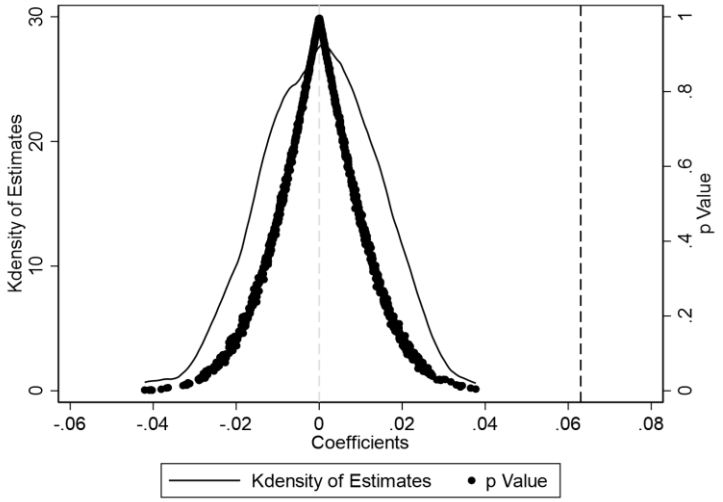


Figure 2. Placebo test

5.4.4. Other robustness tests

Table 6. Robustness tests

	(1)	(2)	(3)	(4)	(5)
Variables	**patt**	**grant_quntity**	**patt**	**patt**	**patt**
treatpost	0.091**	0.050*	0.062**	0.081**	0.062**
	(0.042)	(0.063)	(0.044)	(0.011)	(0.043)
did					-0.002
					(0.984)
size	0.366***	0.315***	0.370***	0.408***	0.370***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
lev	0.025	0.219**	0.155	0.116	0.155*
	(0.856)	(0.013)	(0.110)	(0.229)	(0.098)
roa	-0.271	-0.272**	-0.096	-0.156	-0.096
	(0.259)	(0.021)	(0.508)	(0.250)	(0.475)
tobinq	-0.012	0.007	0.018*	0.014*	0.018**
	(0.439)	(0.289)	(0.069)	(0.080)	(0.026)
top1	0.397	0.372*	0.277	0.162	0.277
	(0.156)	(0.054)	(0.158)	(0.461)	(0.163)
mshare	-0.290**	-0.052	-0.104	-0.074	-0.104
	(0.032)	(0.609)	(0.248)	(0.480)	(0.305)
age	0.001	-0.028	0.029	0.023	0.029
	(0.982)	(0.342)	(0.338)	(0.434)	(0.325)
rd	0.700*	0.244*	0.522***	0.452**	0.522***
	(0.076)	(0.076)	(0.002)	(0.013)	(0.004)
Observations	3,994	12,296	12,296	12,296	12,296
FIRM&YEAR F.E.	YES	YES	YES	NO	YES
FIRM&IND×YEAR F.E.	NO	NO	NO	YES	NO
Adjusted R^2	0.631	0.700	0.685	0.692	0.685

First, the dependent variable is replaced. To avoid bias arising from the measurement of the dependent variable, this study uses the natural logarithm of the number of green patents granted in the current year plus one as an alternative proxy for green innovation. As shown in column (2) of Table 6, the coefficient remains significantly positive at the 10% level, supporting the robustness of the conclusion.

Second, standard errors are clustered at the city level. Firms in the same city may be exposed to the same policy shocks, and their error terms may therefore be correlated. The baseline firm-clustered

standard errors are replaced with city-clustered standard errors. Column (3) of Table 6 shows that the coefficient of the core explanatory variable remains significant at the 5% level, indicating that the policy effect is not driven by city-level autocorrelation.

Third, industry-by-year fixed effects are introduced. Corporate green innovation may follow industry-specific trends independent of the policy, such as green industry subsidies in the new-energy sector. This study therefore further controls for industry-year fixed effects. Column (4) of Table 6 shows that the coefficient remains significantly positive at the 5% level, suggesting that the policy effect is not explained by industry characteristics.

Fourth, interference from other policies is excluded. In 2017, China introduced the green finance reform and innovation pilot zone policy. To eliminate its potential confounding effect, this study includes a DID indicator for whether a city established such a pilot zone in the current and subsequent years. Column (5) of Table 6 shows that the coefficient remains significantly positive at the 5% level, again confirming the robustness of the results.

5.5. Mechanism analysis

5.5.1. Financing-constraint channel

According to the theoretical hypothesis, government procurement contract loans use government credit endorsement to reduce information asymmetry between banks and firms and increase access to low-cost credit, thereby alleviating SMEs' financing constraints. Yang and Wang (2025)[34] show that financing constraints limit firms' ability to undertake long-term and uncertain R&D investment. Easing financing constraints can therefore promote green innovation by addressing the pain point of insufficient funds. To test this mechanism, following Whited and Wu (2006)[35], this study uses the WW index to measure financing constraints and replaces the dependent variable in the baseline regression with the mechanism variable. A negative coefficient indicates that financing constraints decline after policy implementation. Column (1) of Table 7 shows that the coefficient is significantly negative at the 5% level, indicating that the policy significantly alleviates SMEs' financing constraints and thereby promotes their green innovation.

5.5.2. Internal incentive channel

Under the dual incentives of green fiscal procurement requirements and tilted financial credit resources, firms seeking to maintain the long-term benefits of the coordinated policy have incentives to strengthen environmental capacity building. Improvements in environmental capacity are reflected in firms' ESG environmental scores. Meng et al. (2023)[36] show that strong ESG performance can help firms gain government trust, obtain government subsidies, attract external investment, reduce financial burdens, and promote green innovation. Following Zhou et al. (2025)[37], this study uses the environmental dimension score in the CNRDS corporate ESG database to measure environmental performance and examine the internal incentive mechanism. Column (2) of Table 7 shows that the coefficient of treatpost is significantly positive at the 1% level, indicating that the policy significantly promotes firms' environmental capacity building and improves their ESG environmental performance, thereby promoting SME green innovation.

5.5.3. External monitoring channel

The theoretical hypothesis also suggests that the financing signal released by government procurement contract loans is likely to attract analyst attention. Li et al. (2025)[38] argue that analyst attention can improve green innovation quality through information-asymmetry reduction and monitoring-governance effects. External attention can also lower agency costs and reduce corporate violations, thereby improving green innovation quality. Following Chu et al. (2019)[39], this study measures analyst attention as the natural logarithm of the number of analysts following the firm plus one. Column (3) of Table 7 shows that treatpost has a significantly positive coefficient at the 1% level, indicating that the policy promotes SME green innovation through the external monitoring mechanism of increased analyst attention.

Table 7. Mechanism analysis

	(1)	(2)	(3)
Variables	**ww**	**e_score**	**analyst**
treatpost	-0.004**	2.027***	0.107***
	(0.011)	(0.002)	(0.005)
size	-0.057***	1.571***	0.749***
	(0.000)	(0.009)	(0.000)
lev	0.019**	-2.145	-0.200*
	(0.012)	(0.340)	(0.060)
roa	-0.236***	4.594*	2.247***
	(0.000)	(0.081)	(0.000)
tobinq	-0.001*	-0.441***	0.208***
	(0.078)	(0.007)	(0.000)
top1	-0.012	16.893***	0.364
	(0.342)	(0.000)	(0.200)
mshare	-0.003	6.728***	0.326***
	(0.579)	(0.002)	(0.008)
age	-0.004*	1.718***	0.101***
	(0.072)	(0.006)	(0.004)
rd	0.197**	-0.610	0.188
	(0.017)	(0.877)	(0.394)
Observations	12,289	12,191	11,802
FIRM&YEAR F.E.	YES	YES	YES
Adjusted R^2	0.413	0.685	0.702

5.6. Heterogeneity analysis

To further evaluate how the effect of government procurement contract loans on SME green innovation varies across industries, regions, and firm life-cycle stages, this study conducts heterogeneity analyses from three perspectives: peer pressure, local government debt, and corporate life cycle.

5.6.1. Peer pressure

Firms in different industries face different degrees of pressure for green innovation. To examine how peer pressure affects the relationship between government procurement contract loans and green innovation, following Wang and Chu (2022)[40], this study measures the peer pressure faced by firm i as the average number of green patent applications by other firms in the same industry and year. Table 8 shows firms above the annual median are classified as the high-peer-pressure group; the others are classified as the low-peer-pressure group. To mitigate reverse causality, the peer green patent application mean is lagged by one period. The grouped regression results show that the policy significantly promotes green innovation in the high-peer-pressure group, while the coefficient is insignificant in the low-peer-pressure group. One possible explanation is that in industries with stronger peer pressure, peer firms place greater emphasis on green innovation and firms are more likely to imitate high green innovation levels, forming a competitive imitation effect (Wang et al., 2025)[41]. In industries with low peer pressure, green innovation levels are generally low, firms lack clear reference points, and the external incentive effect of the policy is weaker.

5.6.2. Local government debt

Local government debt can influence firms' access to credit financing (Ma et al., 2020)[42]. To examine the policy effect in regions with different debt levels, following Carapella and Williamson (2015)[43], this study measures local government debt as the ratio of the sum of local government debt and interest-bearing debt of urban investment companies to city GDP. Firms are divided into high- and low-debt groups according to the provincial-year median. The results of table 8 show that the coefficient of treatpost is significantly positive at the 5% level in the high-debt group, while it is insignificant in the low-debt group. This indicates that government procurement contract loans

significantly promote green innovation only in regions with heavier local government debt. A possible reason is that expanding local government debt occupies large amounts of traditional credit resources and intensifies corporate financing constraints (Hua et al., 2020)[44]. In high-debt regions, the financing environment is tighter, and government procurement contract loans create a new financing channel through contract-based credit endorsement. The marginal effect of easing financing constraints is therefore larger, making the policy effect more significant.

5.6.3. Corporate life cycle

Firms at different development stages have different financial characteristics and strategic orientations, implying that the effect of government procurement contract loans on green innovation may vary over the corporate life cycle. Following Liang et al. (2019)[45], this study uses a comprehensive scoring method to classify firms into growth, maturity, and decline stages and then conducts grouped regressions. The results of table 8 show that only firms in the maturity stage significantly increase green innovation in response to the policy. A possible explanation is that growth-stage firms have limited funds and are more likely to use financing for short-term rigid needs such as fulfilling government procurement orders, rather than for green innovation in winning-bid products, which yields long-term returns. Mature firms have more abundant cash flow and place greater emphasis on the long-term benefits of green innovation, forming a virtuous cycle of government procurement winning bids, procurement-contract credit financing, green innovation, and continued winning bids. Mature firms also have stable operations, making them more likely to obtain government procurement orders and to benefit more from the financing dividends of government procurement contract loans. Decline-stage firms often face operating difficulties and weak innovation willingness. The limited funds obtained through the policy are more likely to be used to maintain production and operations than to invest in green innovation, making it difficult to transform external financing into innovation output.

Table 8. Heterogeneity analysis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	High peer pressure	**Low peer pressure**	**High debt**	**Low debt**	**Growth stage**	**Maturity stage**	**Decline stage**
Variables	**patt**	**patt**	**patt**	**patt**	**patt**	**patt**	**patt**
treatpost	0.093**	0.030	0.088**	0.012	0.056	0.112**	0.083
	(0.047)	(0.537)	(0.018)	(0.835)	(0.308)	(0.037)	(0.241)
size	0.406***	0.304***	0.356***	0.432***	0.383***	0.311***	0.463***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
lev	0.035	0.178	0.118	0.206	0.335**	-0.241	0.045
	(0.818)	(0.200)	(0.230)	(0.371)	(0.023)	(0.186)	(0.846)
roa	-0.359	0.139	0.114	-0.942***	0.153	-0.660***	-0.515
	(0.151)	(0.428)	(0.454)	(0.002)	(0.527)	(0.003)	(0.178)
tobinq	0.009	0.026**	0.016*	0.026	0.030**	0.018	0.000
	(0.489)	(0.018)	(0.058)	(0.233)	(0.021)	(0.271)	(0.998)
top1	0.513*	-0.183	0.215	0.495	0.184	0.502	-0.043
	(0.060)	(0.534)	(0.342)	(0.221)	(0.559)	(0.127)	(0.909)
mshare	-0.152	0.051	-0.174	0.313	-0.336*	-0.013	-0.104
	(0.300)	(0.731)	(0.119)	(0.182)	(0.056)	(0.945)	(0.618)
age	0.081	0.019	0.045	-0.047	-0.116	0.182**	-0.022
	(0.287)	(0.791)	(0.156)	(0.540)	(0.114)	(0.026)	(0.823)
rd	0.255	0.706***	0.618***	-0.259	0.664**	-0.236	0.219
	(0.432)	(0.009)	(0.001)	(0.634)	(0.041)	(0.474)	(0.645)
Observations	5,119	5,065	10,125	2,171	4,872	3,504	2,426
FIRM&YEAR F.E.	YES	YES	YES	YES	YES	YES	YES
Adjusted R^2	0.630	0.756	0.686	0.656	0.713	0.685	0.657

6. Further Analysis

Many studies show that, compared with utility-model patents, invention patents better reflect firms' substantive innovation capacity (Li and Zheng, 2016)[46]. This study therefore uses green invention patents to proxy substantive innovation and green utility-model patents to proxy strategic innovation.

Columns (1) and (2) of Table 9 show that the coefficient of the policy is insignificant for invention patents, but significantly positive at the 5% level for utility-model patents. This suggests that government procurement contract loans mainly increase the quantity rather than the quality of corporate green innovation. A possible explanation is that these loans often have relatively short maturities, leading firms to prefer utility-model patents with lower R&D investment and lower risk in order to respond quickly to policy incentives.

Table 9. Further analysis

	(1)	(2)
Variables	**pati**	**patu**
treatpost	0.029	0.058**
	(0.293)	(0.023)
size	0.308***	0.231***
	(0.000)	(0.000)
lev	0.104	0.196***
	(0.201)	(0.010)
roa	-0.075	-0.106
	(0.526)	(0.343)
tobinq	0.013*	0.018***
	(0.052)	(0.005)
top1	0.163	0.349**
	(0.353)	(0.027)
mshare	-0.053	-0.115
	(0.536)	(0.151)
age	-0.025	0.035
	(0.338)	(0.130)
rd	0.480***	0.226
	(0.002)	(0.111)
Observations	12,296	12,296
FIRM&YEAR F.E.	YES	YES
Adjusted R^2	0.651	0.616

7. Conclusions and Policy Implications

Using the implementation of government procurement contract loan policies as a quasi-natural experiment, this study examines the effect of fiscal-financial policy coordination on SME green innovation. The results show that government procurement contract loans, as a typical coordinated policy instrument, significantly improve the green innovation level of SMEs. This effect is stronger among firms facing higher peer pressure, firms located in regions with heavier local government debt, and firms in the maturity stage of their life cycle. Mechanism analysis shows that the policy operates mainly by alleviating financing constraints, increasing firms' environmental attention and capacity building, and strengthening external monitoring. Further analysis indicates that the policy promotes strategic rather than substantive green innovation.

The findings lead to three policy implications. First, policymakers should further develop green government procurement contract loan products and introduce tiered credit mechanisms. For green technology investments involved in contract performance, additional unsecured credit lines can be provided after third-party technical assessment, encouraging firms to participate more actively in green innovation. Second, government procurement contract loans should be linked with green credit policies. For firms winning green government procurement contracts, government procurement contract loans can address short-term contract performance needs, while green credit can support long-term green R&D, thereby forming a financing portfolio that improves the bankability of green innovation projects. Third, for winning firms that make substantial green R&D investments during contract performance, the repayment period of government procurement contract loans can be

appropriately extended to encourage loan funds to flow into long-cycle green product development and production-process upgrading.

This study also has several limitations. First, because of data availability, the sample covers only firms listed on the STAR Market and ChiNext Board and does not include firms listed on the National Equities Exchange and Quotations. Second, the analysis focuses on the mediating mechanisms of green innovation but does not further examine potential moderating mechanisms. Third, the heterogeneous policy effects across specific industries remain to be explored in future research.

References

[1] Van Leeuwen, G., & Mohnen, P. (2017). Revisiting the Porter hypothesis: An empirical analysis of green innovation for the Netherlands. Economics of Innovation and New Technology, 26(1-2), 63-77.

[2] Porter, M. E., & Kramer, M. R. (2006). The link between competitive advantage and corporate social responsibility. Harvard Business Review, 84(12), 78-92.

[3] Wang, K., Sun, X., & Wang, F. (2019). Green finance development, debt maturity structure, and green corporate investment. Finance Forum, 24(7), 9-19. (in Chinese)

[4] Jiang, X., Hu, W., Xu, W., et al. (2024). How green government procurement stimulates corporate green innovation vitality. The Journal of Quantitative & Technical Economics, 41(11), 200-220. (in Chinese)

[5] Huang, J., & Zhu, G. (2023). The Chinese model of green development: Government procurement and corporate green innovation. The Journal of World Economy, 46(11), 54-78. (in Chinese)

[6] Wang, X., Li, J., & Yuan, C. (2023). Does government procurement help improve corporate financing efficiency? Evidence from listed companies. Financial Regulation Research, 1, 22-43. (in Chinese)

[7] Yu, M., Zhang, M., & An, J. (2025). The real-economy promotion effect of fiscal-financial coordination: A credit creation perspective. Economic Research Journal, 60(3), 174-189. (in Chinese)

[8] Duan, Y., Xi, B., Xu, X., et al. (2024). The impact of government subsidies on green innovation performance in new energy enterprises: A digital transformation perspective. International Review of Economics & Finance, 94, 103414.

[9] Cheng, Q., Lin, A. P., & Yang, M. (2025). Green innovation and firms' financial and environmental performance: The roles of pollution prevention versus control. Journal of Accounting and Economics, 79(1), 101706.

[10] Bai, Y., Song, S., Jiao, J., et al. (2019). The impacts of government R&D subsidies on green innovation: Evidence from Chinese energy-intensive firms. Journal of Cleaner Production, 233, 819-829.

[11] Dogah, K. E., Wesseh Jr, P. K., & Adomako, S. (2025). Green credit policy, technological innovation, and corporate financial performance: Evidence from the energy industry. Business Strategy and the Environment, 34(1), 1171-1188.

[12] Wang, A., Si, L., & Hu, S. (2023). Can the penalty mechanism of mandatory environmental regulations promote green innovation? Evidence from China's enterprise data. Energy Economics, 125, 106856.

[13] Cheng, Z., & Wang, L. (2025). The impact of carbon emission trading schemes on corporate green innovation. Journal of Cleaner Production, 514, 145792.

[14] Zhang, C., Chen, X., Cao, W., et al. (2024). Green investor entry and corporate green transformation: A chain-mediating mechanism of financing constraints and green innovation. East China Economic Management, 38(11), 53-63. (in Chinese)

[15] Zhang, R., Qie, X., Hu, Y., et al. (2022). Does de-capacity policy promote the efficient and green development of the coal industry? Evidence from China. Resources Policy, 77, 102717.

[16] Li, Y., Hu, S., Zhang, S., et al. (2023). The power of the imperial envoy: The impact of central government onsite environmental supervision policy on corporate green innovation. Finance Research Letters, 52, 103580.

[17] Zheng, B., Xu, M., & Li, S. (2024). Nonlinear effects of environmental regulation on heterogeneous green technological innovation. Science Research Management, 45(4), 157-165. (in Chinese)

[18] Liu, Q., & Dong, B. (2022). How does China's green credit policy affect the green innovation of heavily polluting enterprises? The perspective of substantive and strategic innovations. Environmental Science and Pollution Research, 29(51), 77113-77130.

[19] Qi, H., & Liu, S. (2023). Do green finance policies promote corporate green innovation? Evidence from green finance reform and innovation pilot zones. Contemporary Finance & Economics, 3, 94-105. (in Chinese)

[20] Hoque, M. M., & Lee, S. J. (2025). How digital transformation drives green innovation: An empirical study. Journal of Cleaner Production, 522, 146236.

[21] Zhang, J., Yu, C. H., Zhao, J., et al. (2025). How does corporate digital transformation affect green innovation? Evidence from China's enterprise data. Energy Economics, 142, 108217.

[22] Zhong, T., Huang, Y., & Sun, F. (2022). Digital inclusive finance and green technological innovation: Dividend or divide? Journal of Financial Economics, 37(3), 131-145. (in Chinese)

[23] Farmanesh, P., Solati Dehkordi, N., Vehbi, A., et al. (2025). Artificial intelligence and green innovation in small and medium-sized enterprises and competitive-advantage drive toward achieving sustainable development goals. Sustainability, 17(5), 2162.

[24] Zhou, Y., & Ren, X. (2025). The impact of corporate social responsibility disclosure quality on green innovation continuity: A stakeholder-theory perspective of public attention. Economic Review Journal, 11, 85-96. (in Chinese)

[25] Cai, Z., Wan, Z., Huo, Y., et al. (2025). The crowding-out effect of greenwashing on green innovation. The Journal of World Economy, 48(11), 97-125. (in Chinese)

[26] Tang, L., Zhao, H., Zhou, Z., et al. (2025). Can government procurement drive corporate green technology innovation? Evidence from Chinese listed companies. Evaluation and Program Planning, 111, 102592.

[27] Brown, J. R., Fazzari, S. M., & Petersen, B. C. (2009). Financing innovation and growth: Cash flow, external equity, and the 1990s R&D boom. The Journal of Finance, 64(1), 151-185.

[28] Zhang, W., Zhao, Y., & Meng, F. (2024). ESG performance and green innovation of Chinese enterprises: Evidence from financing constraints. Journal of Environmental Management, 370, 122955.

[29] Wu, W., Jie, X., & Su, Z. (2017). Information opacity, intensive analyst following, and market response. Management Review, 29(11), 171-182, 195. (in Chinese)

[30] Derrien, F., & Kecskes, A. (2013). The real effects of financial shocks: Evidence from exogenous changes in analyst coverage. The Journal of Finance, 68(4), 1407-1440.

[31] Jing, C., Keasey, K., Lim, I., et al. (2024). Analyst coverage and corporate environmental policies. Journal of Financial and Quantitative Analysis, 59(4), 1586-1619.

[32] Wang, X., & Wang, Y. (2021). Research on green credit policy and green innovation. Management World, 37(6), 173-188, 11. (in Chinese)

[33] Zhang, N., Sun, Y., Zhao, X., et al. (2024). The impact of climate policy uncertainty on corporate green innovation. Climate Change Research, 20(5), 636-650. (in Chinese)

[34] Yang, Y., & Wang, J. (2025). Does the green credit policy promote substantive green innovation of enterprises? Management Review, 37(8), 117–130.(in Chinese)

[35] Whited, T. M., & Wu, G. (2006). Financial constraints risk. The Review of Financial Studies, 19(2), 531-559.

[36] Meng, M., Tan, X., Liu, S., et al. (2023). The impact of corporate ESG performance on green innovation. Technology Economics, 42(7), 13-24. (in Chinese)

[37] Zhou, Q., Sun, J., Ran, L., et al. (2025). Impact of environmental performance on intelligent transformation in Chinese manufacturing enterprises. Scientific Reports, 15(1), 33337.

[38] Li, W., Li, Y., & Zhao, J. (2025). External attention and the quality of corporate green innovation: Evidence from analyst attention. Friends of Accounting, 21, 136-144. (in Chinese)

[39] Chu, J., Qin, X., & Fang, J. (2019). China-style margin trading and short selling arrangements and optimistic bias in analysts' earnings forecasts. Management World, 35(1), 151-166, 228. (in Chinese)

[40] Wang, X., & Chu, X. (2022). Peer effects in green technological innovation of manufacturing firms: The role of multilevel contextual reference. Nankai Business Review, 25(2), 68-81. (in Chinese)

[41] Wang, Q., Xiang, C., Xin, Z., et al. (2025). The peer influence on green innovation: Evidence from product-similarity-based peer firms in China. Emerging Markets Finance and Trade, 61(11), 3595-3611.

[42] Ma, S., Hua, X., & Han, Y. (2020). How local government debt crowds out credit financing of real enterprises: Micro evidence from Chinese industrial firms. Studies of International Finance, 5, 3-13. (in Chinese)

[43] Carapella, F., & Williamson, S. (2015). Credit markets, limited commitment, and government debt. The Review of Economic Studies, 82(3), 963-990.

[44] Hua, X., Ma, S., & Han, Y. (2020). How local government debt affects credit financing of real enterprises: Evidence from heterogeneous microdata of Chinese industrial firms. Journal of Guizhou University of Finance and Economics, 3, 33-39. (in Chinese)

[45] Liang, S., Zhang, Y., & Wang, Y. (2019). Internal pay gap and corporate value: A new exploration based on life-cycle theory. Journal of Financial Research, 4, 188-206. (in Chinese)

[46] Li, W., & Zheng, M. (2016). Substantive innovation or strategic innovation? The impact of macro industrial policies on micro-enterprise innovation. Economic Research Journal, 51(4), 60-73. (in Chinese)