The Expansion of Monetary Policy Collateral Promotes Green Innovation of Heavily Polluting Enterprises

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Abstract. Since the reform and opening up, China's economy has developed rapidly, and behind the high growth is the problem of inefficient energy consumption and environmental pollution. China's economy has entered a stage of high-quality development, focusing on innovation-driven and green development, and the Fifth Plenary Session of the 19th Central Committee proposed to promote green development and develop green credit. In this paper, we use a difference-in- difference model to verify the impact of green credit assets on the green innovation of heavily polluting A-share listed enterprises in accordance with the quasi-natural experiment of the inclusion of green credit assets in the MLF qualified collateral framework in June 2018. Results: (1) The expansion policy improved the level of green technology innovation of heavily polluting enterprises; (2) R&D investment intensity plays a strong intermediary role and can promote the green transformation of enterprises; (3) The nature of property rights affects the micro effect of the policy, and the expansion policy has a greater impact on the state-owned heavy polluting enterprises.

Keywords: Monetary policy collateral expansion, heavy polluting enterprises, green innovation Difference-in-difference method.

1. Introduction

Since the reform and opening up, China's economic development has been rapid, but behind the high growth is the inefficient consumption of energy and the aggravation of environmental pollution, and it is urgent to change the extensive high-energy-consuming economic growth model driven by energy consumption and investment, and to transform the economic growth momentum. The report of the 19th National Congress of the Communist Party of China pointed out that China's economy is moving towards a stage of high-quality development, which is in line with the new development concept of "innovation, coordination, green, openness and sharing", and pays more attention to innovation-driven and green development. The problem of capital is one of the major obstacles to improving the level of green innovation of enterprises, and it is urgent to break through the bottleneck of enterprise capital.

On June 1, 2018, the People's Bank of China issued an announcement to appropriately expand the scope of medium-term lending facility (MLF) collateral in order to increase support for small and micro enterprises, green economy and other fields, and promote the healthy development of the credit bond market. There are three main types of new collateral: small and micro, green and "three rural" financial bonds with no less than AA rating; AA+, AA-rated corporate credit bonds (including corporate bonds, medium-term notes, short-term financing bonds, etc.); High-quality small and micro business loans and green loans. Among them, the inclusion of green credit assets in the scope of MLF collateral combines green finance policies and collateral-based structural monetary policy tools to guide the flow of financial resources to the green economy.

In China, bank loans are the main way for enterprises to obtain external financing, and heavily polluted industries have always been the key industries in the allocation of credit resources [1]. An analysis of bank loan data from listed companies shows that six of the top 10 industries in terms of credit access are highly polluting industries. The green credit policy guides the flow of credit funds to green enterprises, and heavily polluting enterprises face higher financing constraints, and as a major difficulty in pollution control, they are greatly affected by the collateral expansion policy [2]. However, the policy is not to restrict the development of heavily polluting enterprises, but to promote

them to accelerate technological upgrading and innovation, and transform to green, low-carbon, clean and environmentally friendly, that is, to force heavily polluting enterprises to carry out green technology innovation.

Theoretically, in the face of tightened environmental regulations and financial constraints, companies will increase their R&D innovation capabilities and intensity to adapt to the new conditions. Therefore, under the incentives of the new policy, heavier polluting enterprises should have a stronger incentive to improve their "green" level through innovation than non-heavily polluting enterprises, that is, the inclusion of green credit assets in the collateral framework has a more obvious effect on the green innovation of heavily polluting enterprises. At present, there are studies to explore the relationship between the collateral expansion policy and green innovation in 2018. Deng Xiang et al. (2023) found that the MLF collateral expansion policy can reduce the financing cost of green bonds in some industries [3]; Guo et al. (2021) found that the policy increases the availability of credit for green credit enterprises and reduces the cost of credit [4]. Meng Hao (2022) conducted a mechanism analysis and found that collateral expansion has a significant effect on the non-invention and innovation of heavily polluting enterprises [5]. On the basis of the existing research, this paper takes the quasi-natural experiment of the central bank to include green bonds in MLF collateral in June 2018, sets heavily polluting enterprises as the experimental group and non-heavily polluting enterprises as the control group, and further explores the role of the central bank's collateral expansion in promoting the green innovation of heavily polluting enterprises with the help of difference-in-difference (DID) model.

2. Theoretical Mechanisms and Research Hypotheses

2.1. Analysis of the Impact Mechanism of MLF Collateral Expansion on the Green Innovation of Heavily Polluting Enterprises

The traditional monetary policy can only control the amount of bank liabilities and affect the amount of credit, but cannot affect the direction of investment, and has a limited effect on the upgrading of industrial structure. The new monetary policy can make up for it, taking MLF as an example, its collateral system can regulate the direction of credit allocation. The inclusion of green credit assets in the MLF collateral framework can make up for the lack of orientation of traditional monetary policy and enhance the green effect of new monetary policy.

Specifically, this is achieved through bank credit and corporate balance sheet channels. From the perspective of banks, commercial banks holding qualified green assets can obtain low-cost financing from the central bank to increase their willingness to allocate and lend scale, and may also increase the proportion of green credit assets or reduce financing costs due to the improvement of asset liquidity, so as to improve the availability of financing in related fields and reduce the premium of external financing. At the same time, the collateral system affects the assets and liabilities of financial institutions, the central bank uses national credit to endorse enterprises, and financial institutions can use green credit assets to collateral to obtain liquidity.

From the perspective of corporate balance sheet channels, the inclusion of green credit assets in the framework releases a signal that the green credit assets held by enterprises can be pledged and financed more easily, and will increase the proportion of holdings and invest in green energy-saving projects. For heavily polluting enterprises, when the credit scale is stable, the expansion of collateral restricts their financing, and the enterprises will innovate to improve the green level.

It can be seen that the central bank's collateral expansion policy is conducive to the innovation and green transformation of heavily polluting enterprises from the credit and balance sheet channels, and has a positive promoting effect. According to the "financial accelerator mechanism" hypothesis [6], the policy "endorses" the credit of enterprises, improves the balance sheets of heavily polluting enterprises, reduces financing costs, and improves convenience and scale.

In summary, hypothesis 1 is proposed: H1: MLF collateral expansion can effectively improve the level of green innovation of heavily polluting enterprises.

2.2. Analysis of the mediating effect of R&D input intensity

The purpose of the MLF collateral expansion policy is to stimulate the intrinsic motivation of green technology innovation of heavily polluting enterprises, and then promote the green transformation of heavy polluting enterprises. There is a consensus in the academic community on the relationship between R&D investment and green innovation, and R&D investment is a key factor in promoting green technology innovation, and there is a positive correlation between R&D investment and green innovation (Xu Xiaoyan 2013) [7]. R&D investment as an innovation resource determines the independent innovation ability of enterprises to a certain extent, and the investment in independent R&D is positively correlated with green innovation of enterprises (Du Hongyu 2017) [8].

After the implementation of the expansion policy, the more unfavorable the situation of heavily polluting enterprises, the stronger the driving force for green innovation, the more it can drive enterprises to increase R&D investment, enhance green innovation capabilities, and accelerate green transformation. There is reason to believe that the collateral expansion policy will improve the green innovation ability of enterprises by increasing the R&D investment of heavily polluting enterprises.

In summary, hypothesis 2 of this paper is proposed: H2: R&D investment has a positive mediating role between collateral expansion policy and corporate green innovation.

2.3. Analysis of Heterogeneity of Property Rights Nature

The property rights of heavily polluting enterprises are different, and they are mainly divided into state-owned and non-state-owned. The performance of green innovation capabilities of enterprises with different property rights is different. Compared with state-owned enterprises, non-state-owned enterprises do not have strong support from the state, and cannot get rid of the problem of credit discrimination by commercial banks, and the financing channels are limited, and the difficulty and high cost of financing are problems that non-state-owned enterprises cannot escape. The biggest obstacle to corporate green innovation is funding, so the development of green innovation activities of non-state-owned enterprises will be constrained by too little capital investment. In summary, hypothesis 3 of this paper is proposed: H3: The effect of MLF collateral expansion policy on green technology innovation of heavily polluting enterprises is affected by the nature of property rights.

3. Empirical analysis

3.1. Data sources and variable selection

The data sample of this article is all A-share listed companies in the Shanghai and Shenzhen stock markets. Firstly, process the sample by: (1) removing financial industry enterprises; (2) Remove ST, ST *, and PT stocks; (3) Remove the missing enterprise from the key variables. All data in this article, except for enterprise patents, are sourced from the CSMAR database. The patent data of each enterprise is sourced from the China Research Data Service Platform (CNRDS). The time span of the data in this article is from 2013 to 2022.

The definitions of the main variables in this article are shown in the table below:

Table 1. Definition of main variables

variable	Variable Name	Variable definition and calculation method
Dependent variable	Proportion of Green Patent Applications (GP)	Number of green patent applications/total number of patent applications in the current year
Core explanatory variables	Industry dummy variable (Treat)	For heavily polluting enterprises, take 1; otherwise, take 0
	Time dummy variable (Time)	Value 1 for 2018 and beyond, otherwise value 0
	Treat*Time	Treat and Time interaction term
Intermediary variable	R&D investment intensity (Input)	R&D expenses/operating income
Control variable	Cash asset ratio (cash)	Closing cash and cash equivalents balance/total assets
	Asset liability ratio (Lev)	Total liabilities/total assets
	Growth rate of total operating revenue(Growth)	(Total operating revenue for the current year - Total operating revenue for the same period last year)/Total operating revenue for the same period last year
	Fixed assets to income ratio (FA)	Fixed assets/operating income
	Return on Assets (ROA)	(Total profit+financial expenses)/average total assets

3.2. Empirical result analysis

3.2.1. DID Model Analysis

According to Table 2, it can be seen that the MLF collateral expansion policy can significantly improve the green innovation level of heavily polluting enterprises. Hypothesis H1 of this article has been verified. The establishment of H1 in this article indicates that policy implementation can indeed force heavily polluting enterprises to innovate green.

Table 2. Regression result analysis

	(1)	(2)
	GP	GP
treat_time	0.0101***	0.00951***
	(3.71)	(3.48)
cash		-0.0242***
		(-2.85)
growth		0.00266
		(1.15)
lev		0.0184**
		(2.23)
fa		-0.00340
		(-1.06)
roa		-0.0386***
		(-2.64)
_cons	0.0744***	0.0742***
	(176.51)	(15.94)
μ_i	control	control
λ_t	control	control
N	32040	32040
R^2	0.556	0.556
adj. R^2	0.484	0.485

3.2.2. Analysis of intermediary effect

The test results of this article are shown in Table 3, where columns 1-3 represent the regression results without control variables. Columns 4-6 show the regression results after adding control variables. From the table, it can be concluded that the impact of the MLF collateral expansion policy on the green innovation of heavily polluting enterprises is partially mediated by the R&D investment intensity input. Hypothesis H2 in this paper is supported.

Table 3. Testing the intermediary mechanism of R&D investment

	(1)	(2)	(3)	(4)	(5)	(6)
	gp	input	gp	gp	input	gp
treat_time	0.0101***	0.00620***	0.00959***	0.00951***	0.00645***	0.00900***
	(3.71)	(8.55)	(3.50)	(3.48)	(9.27)	(3.28)
cash				-0.0242***	-0.00794***	-0.0236***
				(-2.85)	(-2.73)	(-2.77)
growth				0.00266	-0.00730***	0.00323
				(1.15)	(-12.27)	(1.39)
lev				0.0184**	-0.0197***	0.0200**
				(2.23)	(-6.97)	(2.41)
fa				-0.00340	0.00628***	-0.00390
				(-1.06)	(5.13)	(-1.20)
roa				-0.0386***	-0.0772***	-0.0326**
				(-2.64)	(-15.58)	(-2.20)
input			0.0853***			0.0784**
			(2.66)			(2.30)
_cons	0.0744***	0.0437***	0.0707***	0.0742***	0.0554***	0.0699***
	(176.51)	(389.05)	(48.65)	(15.94)	(33.51)	(14.11)
N	32040	32040	32040	32040	32040	32040
R^2	0.556	0.861	0.556	0.556	0.874	0.557
adj. R^2	0.484	0.839	0.484	0.485	0.854	0.485

3.2.3. Analysis of Property Heterogeneity

As shown in Table 4, regardless of the property rights nature of the enterprise, the coefficient of the core explanatory variable is significantly positive at 1%, indicating that the MLF collateral expansion policy can significantly improve the green innovation level of heavily polluting enterprises. After the implementation of the MLF expansion policy, the proportion of green patent applications from state-owned heavy polluting enterprises increased by 1.48%, while the proportion of green patents from non-state-owned heavy polluting enterprises increased by 1.18%. The results indicate that the nature of property rights has an impact on the micro effects of the MLF expansion policy on enterprises, and the MLF expansion policy has a slightly stronger promoting effect on state-owned enterprises. Hypothesis H3 of this article has been validated.

Table 4. Analysis of Property Heterogeneity

	state-owned enterprise	Non-state-owned enterprises
treat_time	0.0148***	0.0118***
	(3.20)	(4.02)
cash	-0.0102	-0.0229***
	(-0.54)	(-2.87)
growth	0.00638	0.00168
	(1.51)	(0.69)
lev	0.00102	0.0285***
	(0.07)	(3.25)
fa	-0.00475	-0.00131
	(-0.93)	(-0.33)
roa	-0.135***	-0.0326*
	(-4.11)	(-1.96)
_cons	0.0860***	0.0595***
	(9.63)	(11.91)
N	9582	20743
R^2	0.546	0.609
adj. R^2	0.478	0.534

3.2.4. Robustness Check

The necessary prerequisite for using the difference in differences (DID) method is to satisfy the "parallel trend", which requires that the green innovation performance of the experimental group of heavily polluting enterprises and the control group of non-heavily polluting enterprises should be consistent in time trend before the policy implementation year (2018), so as to better attribute the differences after policy implementation to the impact of the policy itself. After the policy was issued in 2018, there was a trend change in the green innovation capabilities of heavily polluting enterprises compared to non-heavily polluting enterprises, and the time trend could not be consistent, which can be tested through parallel trend analysis. The parallel trend test chart is shown below, with the dashed line indicating the time point of policy occurrence. The test interval is from the three periods before the policy occurrence to the two periods after it occurs. It can be seen that before the policy occurrence, the estimated coefficients of the interaction term are almost not significant, indicating that the green innovation performance time trends of heavy polluting enterprises and non-heavy polluting enterprises before the policy occurrence are generally consistent. After the implementation of the policy, the interaction coefficients were significantly positive, indicating that heavy polluting enterprises showed a trend change relative to non-heavy polluting enterprises, and the green innovation performance of heavy polluting enterprises was better than that of non-heavy polluting enterprises. Explain through parallel trend testing.

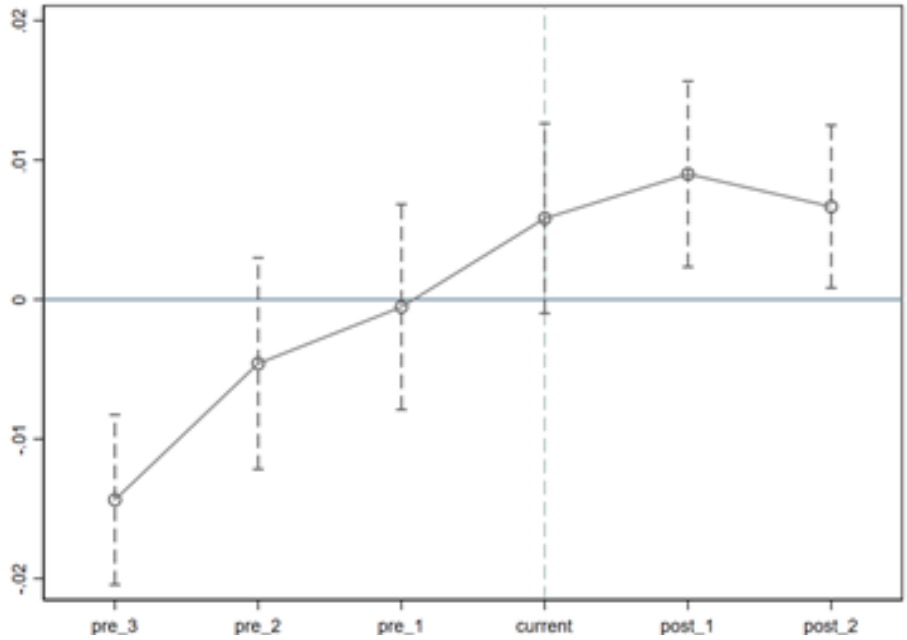


Figure 1. Parallel Trend Test Chart

4. Summary

This article starts from the perspective of corporate green innovation, taking the inclusion of green credit assets in the MLF qualified collateral framework in June 2018 as a quasi-natural experiment. Using data from all A-share listed companies in China from 2013 to 2022, a difference in differences model is used for empirical research on the micro effects of collateral expansion policies on enterprises.

This article draws the following conclusion: (1) Using the proportion of green patent applications by enterprises in the current year to measure their green innovation level, for the entire heavy pollution industry, the MLF qualified collateral expansion policy has a significant effect on improving the green innovation level of heavy pollution enterprises. (2) In the mechanism analysis, this article constructs a mediation effect model and introduces R&D investment intensity as a mediating variable to study how expansion policies can enhance the level of green innovation in enterprises from the perspective of green innovation investment factors. The results showed that R&D investment intensity plays a strong mediating role between the policy of expanding collateral and green innovation in heavily polluting enterprises. The MLF collateral expansion policy can stimulate heavily polluting enterprises to increase their R&D investment intensity, enhance their green innovation level, and promote their green transformation. (3) Consider the type of property ownership of the enterprise. Dividing enterprises into state-owned holding enterprises and non-state-owned holding enterprises for grouping inspection, it was found that the ownership type of enterprises will affect the micro effects of the MLF qualified collateral expansion policy, and the expansion policy will have a greater impact on the green technology innovation level of state-owned heavily polluting enterprises.

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