

The Expansion of Central Bank Collateral and Green Innovation of Enterprises

-- From the Perspective of Green Bonds

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Abstract: This article takes the policy event of green bonds being included in the MLF (Medium Term Lending Facility) qualified collateral framework in June 2018 as a quasi natural experiment, and analyzes the impact of the expansion of the collateral framework of the new monetary policy on the credit spread of green bonds and the green innovation output of enterprises issuing green bonds based on a two period and multi period double difference model. The research results indicate that, firstly, the expansion of collateral by the central bank will significantly reduce the credit spread of green bonds and lower the financing costs of enterprises. Secondly, the expansion of collateral by the central bank will promote the improvement of green technology innovation capabilities of green enterprises, and alleviate their financing problems by issuing green bonds and green bonds themselves.

Keywords: Green bonds, Medium term lending convenience, Collateral framework, Credit spread, Green innovation.

1. Introduction

Green is the distinct foundation for high-quality development, and finance is the core of modern economy. The organic combination of green and finance is an inherent requirement for improving resource allocation efficiency, expanding financial supply, and achieving high-quality economic development. The report of the 20th National Congress of the Communist Party of China proposes to adhere to the theme of promoting high-quality development, actively promote green development, enhance the momentum of innovative development, and build a market-oriented green technology innovation system. Green credit and green bonds are important components of China's green finance market. Compared to green credit, green bonds are mainly issued by enterprises and require strict information disclosure and supervision. Their expenditure on risk premium is also relatively low, making them more suitable for long-term development of enterprises. But currently, in the green finance market, the proportion of green bonds in green financing is less than 10%, which has good development space.

The research significance of this article mainly includes the following aspects: Firstly, by studying the impact of expanding the collateral framework on the credit spread of green bonds, it provides new ideas for enterprises to reduce financing costs. Secondly, using a multi period double difference model to analyze in detail the policy impact of expansion policies on green innovation of enterprises issuing green bonds, providing theoretical support for enterprises to use green financial tools to solve production and operation problems. Thirdly, explore the effectiveness of collateral expansion policies from the perspectives of financing costs and financing credit, providing empirical evidence for the central bank to formulate practical and feasible monetary policies and promote the stable development of enterprises.

2. Literature Review and Theoretical Framework

2.1. Literature Review

Wang Xin et al. (2021) found that green credit guidance policies can significantly reduce the financing costs of enterprises and enhance the output of green practical innovation, based on the background of green credit policies. Wang Ying and Feng Jiahao (2022) explored the impact of green bond pilot programs on corporate green innovation and found that the green innovation ability of issuers of green bonds has been significantly improved after the green bond pilot policy. However, as a part of green finance, the green reform pilot zone policy, although it increases corporate R&D investment, has a more restrictive effect on innovation than an incentive effect (Wang Xiuhua et al., 2021). Su Dongwei and Liu Ziming (2023) also took the green reform pilot zone as the research object and found that green finance policies will increase the risk of enterprises turning green and inhibit the development of green innovation. Zhang Xueying et al. (2022) linked green bonds, green drift risk and green innovation, and found that green bonds promote green innovation and reduce green drift behavior of enterprises by alleviating financing constraints of enterprises and reducing information asymmetry. Tao Feng et al. (2021) explored the impact of environmental regulation policies on the incremental improvement of green innovation from the perspective of environmental regulation policies, and found that although the implementation of environmental regulation policies can promote the increase of innovation quantity, it will reduce the quality level of enterprise green innovation. In recent years, the new monetary policy has gradually entered the public's vision. As an innovation of the new monetary policy, the collateral framework. Chen Guojin et al. (2021) combined the collateral expansion policy with brown enterprises and found that green finance policies can force

polluting enterprises to transform. Guo Ye and Fang Fang (2021) studied the green effect of green credit as an expanded asset on enterprises, which can effectively improve the credit availability of green enterprises.

2.2. Theoretical Framework

This article starts from the perspective of incorporating green bonds into the collateral framework of the new monetary policy. Firstly, it studies the changes in the credit spread of green bonds after the expansion policy from the perspective of financing costs; Secondly, the green innovation output is represented by the number of green invention patents and green utility patents, and the green innovation output effect of collateral expansion policies on enterprises issuing green bonds is measured from the perspectives of quality and quantity; Then, financing costs and financing credit are used as intermediary variables to test the transmission mechanism of collateral expansion policies on green innovation; Finally, a detailed analysis of the heterogeneity characteristics of expansion policies is conducted to distinguish the differences in quality assurance expansion policies from the perspective of the enterprise's lifecycle. Based on the policy event of green bonds being included in the MLF (Medium Term Lending Facility) qualified collateral framework in June 2018 as a quasi-natural experiment, a model was set up to study the relationship between collateral expansion policies and green bond credit spreads, as well as the relationship between collateral expansion policies and green innovation of issuing enterprises, in order to analyze the impact of collateral expansion policies on green bond credit spreads and green technology innovation.

3. Research Design

3.1. Data Source and Sample Selection

This article selects A-share listed companies in Shanghai and Shenzhen as the research sample, and takes January 2016

$$CS_{it} = \alpha_0 + \alpha_1 Post_t \times Treat_i + \gamma X_{it} + \sum Firm + \sum Year + \sum Ind + \varepsilon \quad (1)$$

Among them, the subscript i represents the bond, and t represents the period. The dependent variable CS represents the credit spread of green bonds. The explanatory variable $Post$ is a time dummy variable, where $Post=1$ indicates that green bonds are included in the collateral framework after collateral expansion, and $Post=0$ indicates the period before collateral expansion. $Treat$ is a dummy variable in the experimental group, where $Treat=1$ represents green bonds and $Treat=0$ represents bonds other than green bonds. The core explanatory variable that the model focuses on is $Post_t \times Treat_i$; and the coefficient α_1 represents the policy impact on the credit spread of green bonds after being

to December 2022 as the sample interval. Secondly, the sample data is divided into bond data and green innovation data. Bonds include corporate bonds and financial bonds in the interbank market, and the issuer information is matched with listed companies; the green innovation data was collected from the China National Intellectual Property Administration, and the IPC number of the listed company's patent was matched with the WIPO green patent list to obtain the green innovation data. In Model 1, considering the frequency of bond issuance, quarterly frequency data is used to avoid potential omissions; In Model 2, due to patent statistics issues and policy timing occurring in half a year, in order to better measure policy effectiveness, semiannual reporting frequency data is used. The sample data is from Guotai'an database and China National Intellectual Property Administration, and the enterprise financial data is from Guotai'an listed enterprise financial statement database. This article separately processes data on bonds and corporate green innovation. The bond data excludes data with missing variables and negative credit spreads, as well as non-listed corporate bonds such as urban investment bonds and progressive interest rate structured bonds. The green innovation data excludes data with missing variables, listed ST companies, financial listed companies, and companies listed after 2016. To avoid the impact of outliers in the sample data, this article applies 1% and 99% truncation to the sample data.

3.2. Model Setting

3.2.1. Relationship between collateral expansion policy and green bond credit spread

This article is based on the quasi natural experiment of incorporating green bonds into the collateral framework of the new monetary policy, and uses a two period double difference model to test the impact of collateral expansion policy on the credit spread of green bonds. Following the approach of Chen Guojin et al. (2021), the model is set as follows:

included in the collateral framework.

The control variable X_{it} mainly includes information on bond subjects such as bond ratings and bond maturities, as well as information on issuing companies such as financial liability ratio, cash flow interest protection coefficient, asset liability ratio, enterprise size, and return on equity. $\sum Firm$ represents fixed effects on enterprises, $\sum Year$ represents fixed effects on time, and $\sum Ind$ represents fixed effects on industries. The definition and calculation method of Model 1 variables are shown in Table 1.

Table 1. Variable definitions and calculation methods

Variable Symbol	Variable Definition	Method of calculation	Variable properties
CS	credit spread	The difference between the bond issuance interest rate and the risk-free treasury bond interest rate in the same period	Dependent variable
Post×Treat	The effect of collateral expansion policy	The cross term between time dummy variables and individual dummy variables	Core explanatory variables
Term	Maturity period	—	Control variables for bond subject attributes
CD	credit rating	Take the values of AAA, AA+, AA-, A+ in the order of 5-1, and take 0 for A and below.	
FDR	Financial debt ratio	Financial liabilities/total assets	Control variables for corporate financial indicators
CIR	Cash flow interest protection factor	Net cash flow generated from operating activities/interest payable by the enterprise	
ALR	Asset liability ratio	Total liabilities/total assets	
LNC	Enterprise scale	The logarithmic value of total assets of a company	
ROE	Return on equity	Net profit/average shareholder equity	

3.2.2. The relationship between collateral expansion policy and green innovation of bond issuing enterprises

Secondly, based on the policy of collateral expansion, a

$$IN_{it} = \beta_0 + \beta_1 After_{it} \times Treat_{it} + \gamma X_{it} + \sum Firm + \sum Year + \sum Ind + \varepsilon \quad (2)$$

Among them, the subscript *i* represents the enterprise, and *t* represents the period. The dependent variable *IN* represents the green technology innovation of the enterprise, which includes invention patents, utility patents, and design patents. Among them, invention patents are the most difficult and time-consuming, while design patents have a lower technical content. Therefore, enterprise technology innovation is mainly reflected in invention patents and utility patents, and is further divided into application and authorization parts. However, authorization usually takes 1-2 years, which cannot effectively match policy effects. The use of patent applications can better reflect the timeliness of policies. This article uses the number of green invention patent applications and green utility patent applications to reflect the green innovation of enterprises, and uses $\ln(\text{number of green patent applications}+1)$ to measure the green innovation output of enterprises. Green invention patent innovation represents the quality of green innovation, and green utility patent innovation represents the quantity of green innovation. The main reason is that green invention patents have high technological content, emphasizing the innovation and

multi period double difference model is used to test the impact of collateral expansion policy on corporate green innovation. Referring to the approach of Wang Ying and Feng Jiahao (2022) on policy effects, the model is set as follows:

breakthrough of patent technology, and reflecting the quality output of enterprises in green innovation; However, utility patents are at a lower level in terms of technological breakthroughs and originality, and place more emphasis on the practicality of patented technology, thus reflecting the quantity output of enterprises in green innovation. The above variables are *ingrit* and *ingriu*, respectively. The definition of the explanatory variable *Treat* is the same as Model 1, where $After_{it}=1$ indicates that enterprises issue green bonds after the expansion policy, and $After_{it}=0$ indicates that enterprises have not issued green bonds. $After_{it} \times Treat_{it}$ is the core explanatory variable of this article.

The control variables *X_{it}* mainly include current ratio, R&D expense ratio, R&D expenditure, capital intensity, number of employees, and enterprise size. $\sum Firm$ represents fixed effects on enterprises, $\sum Year$ represents fixed effects on time, and $\sum Ind$ represents fixed effects on industries. The definition and calculation method of Model 2 variables are shown in Table 2.

Table 2. Variable definitions and calculation methods

Variable Symbol	Variable Definition	Method of calculation	Variable properties
ingri	Green patent innovation	$\ln(\text{number of green invention patent applications}+1)$	Dependent variable
inguo	Green, practical and innovative	$\ln(\text{number of green utility patent applications}+1)$	
After×Treat	The effect of collateral expansion policy	—	Core explanatory variables
LR	Current ratio	Current assets/current liabilities	Control variable
RD	R&D expense rate	R&D expenses/operating income	
RE	R&D expenses	—	
CI	Capital factor investment	Cash/total assets paid for fixed assets, intangible assets, and other long-term assets	
NE	Number of employees	$\ln(\text{number of employees}+1)$	
LNC	Enterprise scale	The logarithmic value of total assets of a company	

3.3. Mechanism Analysis

To further analyze whether the policy of expanding collateral capacity will affect corporate green technology innovation through financing costs and financing constraints, this article uses the three-step method proposed by Wen

$$IN_{it} = \beta_0 + \beta_1 After_{it} \times Treat_{it} + \gamma X_{it} + \sum Firm + \sum Year + \sum Ind + \varepsilon \quad (3)$$

$$Mediator_{it} = \beta_0' + \beta_1' After_{it} \times Treat_{it} + \gamma' X_{it} + \sum Firm + \sum Year + \sum Ind + \varepsilon \quad (4)$$

$$IN_{it} = \beta_0'' + \beta_1'' After_{it} \times Treat_{it} + \beta_2'' Mediator_{it} + \gamma X_{it} + \sum Firm + \sum Year + \sum Ind + \varepsilon \quad (5)$$

4. Conclusion and Suggestions

4.1. Conclusion

The collateral expansion policy, as part of both the new monetary policy and the green finance policy, plays an important role in supporting economic structural adjustment and green development of enterprises. This article takes the policy of incorporating green bonds into the collateral framework of the new monetary policy in June 2018 as a quasi-natural experiment. Using bond data at the level of listed companies and enterprise green innovation data, a two period double difference model and a multi period double difference model are used to test the impact of collateral expansion policy on the credit spread of green bonds and enterprise green innovation, respectively. The intermediary and moderating effect models are used to further analyze the mechanism and moderating effect of collateral expansion policy on green innovation. Based on empirical regression, the following conclusions can be drawn: firstly, the policy of expanding collateral has a reducing effect on the credit spread of green bonds, and the effect of the policy on non-polluting enterprises is more significant compared to that on polluting enterprises. Secondly, by distinguishing whether to issue green bonds, the experimental group and the control group were identified. After the implementation of the collateral expansion policy, the number of green innovations in enterprises increased. After adjusting the policy period, it was found that the expansion policy had a sustained improvement effect and could match the long-term quality of green innovation, promoting the improvement of green innovation quality; the policy of the green reform pilot zone can form a synergistic effect with the policy of expanding collateral, expanding its role in promoting green innovation. Through the analysis of intermediary mechanisms, expansion policies will enhance green innovation in enterprises by reducing financing costs and improving financing credit; The uncertainty of external economic policies can reduce the promoting effect of expansion policies on green innovation, while the level of local scientific and technological development can enhance the promoting effect of expansion policies on green innovation; The policy of expanding collateral capacity still has heterogeneous effects, and the green innovation policy effect is more pronounced in mature enterprises.

4.2. Suggestions

With the deepening of green finance, the importance of green financial instruments for economic development is becoming increasingly prominent. As one of the important green financial instruments, green bonds should be given

Zhonglin and Ye Baojuan (2014) to verify the mediating effect. Use a three-step method to regress each coefficient and test whether the mechanism effect is valid. Mediatorit represents the mediating variable, and the process of mediating effect analysis is as follows.

more attention by the central bank, government, financial institutions, and enterprises to enhance their support for economic development and corporate transformation.

Firstly, the central bank should proactively update the collateral framework to effectively guide market funds towards the areas required for policy and development. By increasing the collateral guarantee ratio and utilizing market mechanisms to reasonably evaluate and adjust the value of qualified assets, we can promote the unique effects of these assets in different industries, thereby strengthening the supporting role of expansion policies for economic growth. Secondly, the government should strengthen supervision and guidance on green bond issuing enterprises, ensuring that the funds raised are specifically used for green sustainable projects. This can not only reduce the financing costs of enterprises, provide convenient and low-cost financial support, promote innovation activities, but also guide the flow of funds to the fields of environmental protection and sustainable development. At the same time, the government should maintain the coherence and stability of economic policies, create a favorable business environment for enterprises, and reduce economic fluctuations caused by policy changes. In addition, the government should increase the driving force of technological innovation on economic development, improve relevant infrastructure, enhance the overall level of science and technology, provide policy support to related industries and enterprises, encourage enterprises to embark on the path of innovative development, and enhance the degree of importance that enterprises attach to invention patents.

Finally, enterprises need to increase investment in innovation and research and development, and firmly pursue the path of sustainable development. Enterprises should actively respond to government policies, adapt to the trend of economic development, and enhance their core competitiveness. At the same time, enterprises should fully recognize the importance of invention patents for their development, avoid short-sighted behavior, and achieve comprehensive and long-term development of the enterprise.

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References

- [1] Shen Hongtao. The Latest Development and Future Trends of Sustainable Finance [J]. Finance and Accounting, 2022 (19): 17-22.

- [2] Zhang Qingjun. Issuing Green Bonds and Corporate Green Innovation: Empirical Evidence from Chinese Energy Listed Companies [J]. Wuhan Finance, 2023 (02): 65-71.
- [3] Li Huimin. Dynamic effects of green credit policies on green innovation in heavily polluting enterprises [J]. China Forestry Economy, 2023 (03): 116-123.
- [4] Chen Guojin. China's Green Finance Policy, Financing Costs, and Enterprise Green Transformation: From the Perspective of the Central Bank's Guarantee Policy [J]. Financial Research, 2021 (12): 75-95.
- [5] Yang Huiyu. Research on the Factors Influencing the Credit Spread of Green Bond Issuance [D]. Shijiazhuang: Shijiazhuang Railway University, 2019.
- [6] Chen Chen. Research on the Impact of Environmental Regulations on Green Innovation and Performance of Enterprises [D] Liaoning: Liaoning University, 2019.
- [7] Deng Xiang Research on the Green Effect of MLF Guarantee Capacity Expansion Policy: Based on the Perspective of Green Bond Financing Cost [J]. International Finance Research, 2023 (10): 74-84.
- [8] Zhang Guofu. Research on Risk Spillovers between Green Bonds and Other Financial Markets: Based on the TVP-VAR Frequency Domain Spillover Model [J]. Journal of Jiangsu University, 2024 (02): 44-80.
- [9] Pan Dapeng. Green Development from the Perspective of Green Preferences: Government Regulation, Enterprise Transformation, and Financial Institution Investment Choices [J]. Systems Engineering Theory and Practice, 2024 (01): 1-19.