

Research on the influence of green finance policy on enterprise green innovation

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Abstract. At present, China's economy has entered a new normal, and policies with economic growth as the core can no longer meet the needs of social development. In recent years, China has vigorously promoted the green transformation of economic development, and the construction of a green innovation system has become the only way to improve the ecological environment and promote green development. Green finance, as a financial tool providing services for green industries such as energy conservation, emission reduction and pollution prevention and control, plays an important role in the process of economic green transformation. Green Finance Reform and Innovation Pilot Zone is the latest practice of green finance policy system construction. Under this background, this paper takes the establishment of our country's Green Finance Reform Innovation Experimental Zone as a quasi-natural experiment, and adopts the panel data of Shanghai and Shenzhen A-share listed companies from 2011 to 2022, this paper discusses the impact of Green Finance Policy on enterprise green innovation by means of multi-period double difference model. The study found that the policy has an obvious driving effect on enterprise green innovation, and the conclusion passed the parallel trend test and placebo test; in addition, the mechanism test results show that the stronger the financing constraints, the promotion effect of green financial innovation policy may weaken.

Keywords: Green finance policy; green innovation; financing constraint.

1. Introduction

China's economic development has entered a new normal. In the past, economic development consumed a lot of energy and resources, and environmental damage and resource depletion have surfaced. People's voice for green development is growing louder. Green innovation is the basic support and key driving force of green development, but green innovation needs to rely on a large amount of funds, and there are certain risks. In order to promote green economic development, the seven ministries and commissions officially launched the work of green finance reform and innovation pilot zone in 2017, taking some regions of Zhejiang, Jiangxi, Guangdong, Guizhou and Xinjiang provinces (regions) as the first batch of pilot innovation pilot zones with their own emphasis and characteristics. The establishment of the pilot area marks the implementation and implementation of China's pilot green finance reform, and is also an important indicator for China to actively explore the development of green finance.

At present, the research on the green finance pilot zone mainly analyzes and summarizes the implementation effect of the first batch of green finance reform and innovation pilot zone. Fan Decheng and Zhang Xiufan (2022) believe that the green financial reform and innovation experimental zone can significantly promote high-emission enterprises to actively implement emission reduction activities, and this impact will be realized through financing punishment and investment suppression mechanism. Sun Ying and Meng Yao (2021) used the dual difference model to prove that the policy of green finance reform and innovation pilot zone has a certain promotion effect on the green technology innovation of enterprises, but did not deeply analyze its mechanism of action. Shen Lu et al. (2020) used the dual difference model to find that the green finance pilot zone could alleviate the inefficiency and excessive investment of enterprises by reducing agency costs,

increasing R&D investment and other mechanisms, and force heavily polluting enterprises to fulfill their social responsibilities by improving the efficiency of enterprise investment.

This paper takes the pilot policy of green finance as a quasi-natural experiment, and uses the multi-stage double difference method to test its influence and mechanism on the green innovation of micro enterprises. The contribution of this paper is to test the impact of green finance pilot policy on the green innovation of micro enterprises from the perspective of green innovation, evaluate the implementation effect of green finance reform policy, and provide theoretical support for the further improvement of the green finance pilot zone. In addition, it is proved that broadening the green financing channels and reducing the financing constraints of enterprises are the important channels for the green finance pilot policies to promote the green transformation of enterprises.

2. Theoretical analysis and research hypothesis

2.1. Influence of green finance innovation policy on green innovation of enterprises

The Green finance innovation policy and the green innovation ability of enterprises are both important factors to promote the development of green finance. Policy support and the innovation ability of enterprises jointly promote the development of green finance.

First, the green finance innovation policy provides financial support for enterprises. The government has reduced the cost of enterprise innovation by providing financial subsidies, tax breaks and green funds, encouraged enterprises to increase investment in green innovation, and improved their green innovation capacity. Secondly, the green financial innovation policies will promote the green innovation of enterprises through incentive measures. The government gives enterprises exclusive rights to green innovation projects, gives relevant intellectual property rights protection, or enhances enterprise innovation motivation through commendations and bonuses to encourage enterprises to increase green innovation efforts. Finally, the green financial innovation policy is committed to creating a good environment for innovation. The government can establish a green innovation research and development center to provide green innovation resources for enterprises. It can also strengthen the policy and regulatory support for green innovation, simplify the approval process of green innovation projects, reduce innovation risks, stimulate the innovation vitality of enterprises, and speed up the process of green innovation. Therefore, this paper proposes hypothesis 1.

Hypothesis 1: Green financial innovation policies can promote the development of green innovation in enterprises.

2.2. Mechanism analysis of green finance policy influencing enterprise green innovation

The pilot policy of green finance provides more green capital financing channels for enterprises' green technology innovation activities, and can effectively alleviate the financing problems of green technology innovation enterprises. For example, the green finance innovation policy provides financial support for enterprises. By setting up special funds, providing loan guarantee and discount interest, it solves the shortage of funds, reduces the financing cost of enterprises, and increases the feasibility of green innovation projects.

At the same time, the degree of enterprise financing constraints will affect the ability and effect of enterprises to obtain green innovation support under the green financial innovation policy. Green innovation usually requires a large amount of funds for research, testing and promotion, and the high degree of financing constraints will lead to the challenge of capital shortage and restrict green innovation; increased financing costs will also increase the risk of green innovation projects and reduce their enthusiasm for green innovation. Therefore, this paper examines the function mechanism between the green finance pilot policy and the enterprise green innovation from the perspective of the degree of financing constraint. Based on this, this paper proposes hypothesis 2.

Hypothesis 2: The stronger the financing constraints, the role of green financial innovation policies in promoting their green innovation may be weakened.

3. Study design and statistical analysis

3.1. Data source

In this paper, Shanghai and Shenzhen A-share listed companies from 2011 to 2022 are selected as the research sample. The financial status of enterprises comes from the CSMAR, and the green innovation data comes from the State Intellectual Property Office. In addition, the original data is processed as follows: excluding ST, PT and *ST enterprises; excluding financial enterprises; excluding enterprise samples with serious data loss; and reducing 1% of the original data. Finally, 23,831 valid observations were obtained.

3.2. Variable definitions

3.2.1. Independent variable

The independent variable of this paper is Green Finance Reform Innovation Pilot Zone Policy (Gf_Policy). The Enterprises in the province where the pilot area is located were set as a treatment group to 1, and other enterprises as a control group to 0. According to the policy before and after the establishment of a virtual variable, before the implementation of 0, after the implementation of 1. The interaction term Gf_Policy between virtual variables and policy implementation time in the pilot area indicates whether the enterprises are affected by the establishment of the pilot area.

The green finance reform and innovation pilot zone was established in batches since 2017, and the time virtual variables of different treatment groups are inconsistent; in June 2017, the State Council decided to establish the first batch of green finance reform and innovation pilot zones in Zhejiang, Jiangxi, Guangdong, Guizhou and Xinjiang Uygur Autonomous Region provinces (autonomous regions); in December 2019, Gansu Province was added as the second batch of innovation pilot zones; Chongqing set up Green Finance Reform and innovation experimental zone in 2022, which was not included in the scope of this article because of its short time.

3.2.2. Dependent variable

The patent application data is more stable, reliable and timely than the number of patent grants. Therefore, this paper uses the number of green invention patent application to measure the green technology innovation of enterprises. Green invention patent data are from the Intellectual Property Office, PRC. According to the "Green List of International Patent Classification" launched by the World Intellectual Property Organization (WIPO), and the classification of green patent retrieval items according to the United Nations Framework Convention on Climate Change, the environmentally friendly technology related patents are retrieved to identify and calculate the number of green invention patents of enterprises. Since the patent data is right-skewed, the natural log to the original data. Enterprise green innovation (GP) is measured by the number of green invention patent applications occurring in that year.

3.2.3. Adjustment variables

Financing constraints (FC). This paper selects FC index to reflect the financing constraints of enterprises to verify whether the degree of financing constraints of enterprises can play a regulating role between green financial innovation policy and green innovation of enterprises. The larger the FC, the higher the degree of corporate financing constraints.

3.2.4. Control variables

In order to control other factors that can affect the green performance of enterprises, this paper refers to the practices of Su Dongwei and Lian Lili (2018), Wang Xin and Wang Ying (2021), and introduces control variables from the financial and management level of enterprises.

Financial level: enterprise size (Size), corporate leverage (Lev), corporate profitability (ROA), cash flow (FCF), operating growth rate (Growth), bankruptcy risk Z value (Z) and Tobin Q value (TobinQ); enterprise management level: top ten shareholders shareholding ratio (Top10), two positions (Dual) and audit status (Opinion).

Table 1. Control variables

Variable name	Symbol	Variable-definition
Scale	Size	Total assets take logarithm
Debt paying ability	Lev	Total year-end liabilities / total year-end assets
Profitability	ROA	Net income / the average balance of total assets
Corporate cash flow	FCF	Net cash flows from operating activities / total assets
Growth ability	Growth	Current year revenue/previous year revenue -1
Clean risk of liquidation	Z	Calculated according to the Z-score model of the Altman
Tobin Q	TobinQ	Market value of the company/replacement cost of assets
Major shareholder shareholding	Top10	Top10 shareholders holding shares / total number of shares
Two jobs in one	Dual	The chairman and the general manager are the same person to take 1, otherwise take 0
Audit status	Opinion	The financial report of the company issued in the current year is 1, otherwise it is 0

In addition, the fixed effects of year and individual firm are included in the regression.

3.3. Model setting

3.3.1. Multi-period double difference model

Because the pilot policy of green finance is only set up in some provinces (regions), and the establishment of the pilot area is a quasi-natural experiment born in the economic system, it meets the exogenous conditions. Therefore, to test the study hypothesis 1, the following multi-period double difference model is constructed:

$$GP_{it} = \beta_0 + \beta_1 Gf_Policy_{it} + \gamma Control_{it} + CodeFE + YearFE + \varepsilon_{it} \quad (1)$$

Among them, GP_{it} is the green innovation of the enterprise i in year t , that is, the number of green invention patent applications filed by the enterprise in that year. Gf_Policy_{it} represents whether the enterprise i will implement the policy of green finance reform and innovation pilot zone in the t year; $Control_{it}$ is the control variable; $CodeFE$ and $YearFE$ are individual fixed effect and year fixed effect respectively; and ε_{it} is the random disturbance item. If the estimated coefficient β_1 is greater than 0, the establishment of green finance reform and innovation pilot zone will help improve the green innovation of enterprises in the pilot area; otherwise, the green development of enterprises will be inhibited.

3.3.2. Mechanism testing

According to the theoretical analysis, on the basis of the benchmark regression, the financial constraint index term and the multiplicative term of the independent variable and the financial constraint index are added, testing whether FC adjusts the impact of green finance policy on green

innovation, the aim is to obtain more comprehensive and accurate information to support more effective research. Based on this, this paper constructs the following model:

$$GP_{it} = \beta_0 + \beta_1 Gf_Policy_{it} + \beta_2 M_{it} + \beta_3 FC_{it} + \gamma Control_{it} + CodeFE + YearFE + \varepsilon_{it} \quad (2)$$

Among them, FC_{it} indicates the degree of enterprise financing constraint, the greater the variable, the greater the financing constraint; M_{it} represents the intersection of green financial innovation policy and the degree of enterprise financing constraint; if β_1 and β_2 are significant and the same plus or minus sign, there is positive regulatory effect; if both significant and different Plus and minus signs, the inhibitory effect; the symbols of other variables are consistent with formula (1).

3.4. Descriptive statistics

Table 2 reports the descriptive statistical results for the main variables. In terms of the number of green invention patents applications (GP), The mean value was 0.2814, The minimum value is 0, The maximum value was 3.5264, It shows that the overall level of green innovation of the sample enterprises is relatively low, There are great differences in the green innovation level among enterprises; The mean corporate financing constraint index (FC) was 0.4031, The standard deviation was 0.2780, More concentrated, It shows that the financing constraints of different enterprises vary somewhat, but the difference is not very big; The standard deviation of enterprise size (Size) is 1.3377, It shows that there are some differences in business model; The minimum corporate profitability (ROA) is -0.2205, Means that some companies have negative net earnings over a given period, There were losses in the operating activities.

Table 2. Descriptive statistics

Variable	Obs	Mean	Std.dev.	Min	Max
GP	23831	0.2814	0.6816	0	3.5264
Gf_Policy	23831	0.1460	0.3531	0	1
FC	23388	0.4031	0.2780	0	0.9851
Size	23831	22.4702	1.3377	19.8893	26.4218
Lev	23831	0.4496	0.2079	0.0540	0.9091
ROA	23633	0.0343	0.0619	-0.2205	0.2139
Dual	23831	0.2286	0.4199	0	1
Top10	23831	55.7012	15.3471	22.1468	89.7637
Growth	23626	0.1531	0.4117	-0.5704	2.6352
Z	23755	4.4766	5.3357	-0.0108	34.7855
TobinQ	23388	1.9584	1.3094	0.8270	8.6001
Opinion	23831	0.9681	0.1757	0	1
FCF	23831	0.0447	0.0685	-0.1609	0.2419

4. Empirical test and result analysis

4.1. Foundation regression

In order to verify the research hypothesis 1 of this paper, model (1) is used to test the impact of green finance pilot policy on the green innovation level of enterprises. From table 3 report regression results,

in the column (1) and (2), in the coefficient of item is 0.032 and 0.028 respectively, at 1% and 5% level, shows that the green financial pilot policy stimulated the enthusiasm of green innovation, verify the research hypothesis 1, namely green financial innovation policy can promote the development of enterprise green innovation.

Table 3. Basal regression

	(1)	(2)
	GP	GP
Gf_Policy	0.032*** (2.906)	0.028** (2.473)
Size		0.047*** (6.429)
Lev		0.002 (0.051)
ROA		0.070 (1.079)
Dual		-0.002 (-0.264)
Top10		-0.000 (-1.254)
Growth		-0.014** (-1.969)
Z		0.000 (0.093)
TobinQ		0.007 (1.627)
Opinion		0.035* (1.950)
FCF		-0.080 (-1.602)
Code /Year	Yes	Yes
N	23830	23118
R2	0.694	0.698

Note: t statistics in parentheses; *p < 0.1, **p < 0.05, ***p < 0.01

4.2. Robustness test

4.2.1. Parallel trend test

The parallel trend hypothesis is the premise of the double difference model, which requires that the experimental group and the control group keep the same trend before the policy impact, so as to ensure that the policy impact is the only vivid cause of the difference between the two groups. Only by meeting the assumption of parallel trend can the double difference model identify the net effect of green financial reform and innovation pilot policy on enterprise green innovation as accurately as possible.

This paper examines the parallel trend from the first three years to the last five years of policy shock. The parallel trend test model is set as follows:

$$\begin{aligned}
 GP_{it} = & \beta_0 + \beta_1 \text{Before3}_{it} + \beta_2 \text{Before2}_{it} + \beta_3 \text{Before1}_{it} + \beta_4 \text{Current}_{it} \\
 & + \beta_5 \text{After1}_{it} + \beta_6 \text{After2}_{it} + \beta_7 \text{After3}_{it} + \beta_8 \text{After4}_{it} + \beta_9 \text{After5}_{it} \\
 & + \gamma \text{Control}_{it} + \text{CodeFE} + \text{YearFE} + \varepsilon_{it}
 \end{aligned} \tag{3}$$

According to the results of the regression, the paper draw figure 1. Current is the time point of policy implementation. We can see that the interaction coefficient is not significant before the implementation of the pilot policy, after the policy shock, the change trend of the two groups of data is obviously different, which accords with the parallel trend hypothesis and satisfies the precondition of double difference regression.

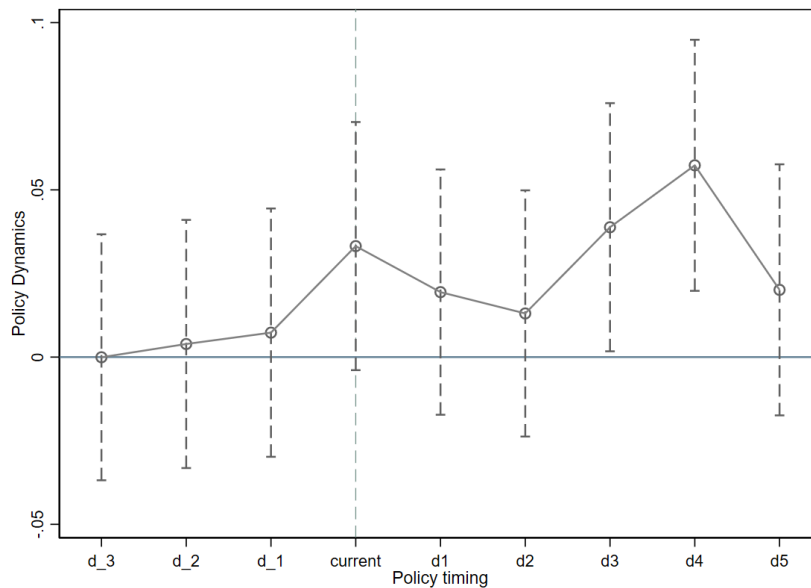


Fig. 1 Two or more Parallel trend test

4.2.2. Placebo test

In addition to the control variables and fixed effects, there may still be other unknown factors that can affect the effect of green finance policy. In order to further eliminate the interference of other factors and ensure the robustness of the study conclusions, the placebo test was used.

Specific methods: By randomly sampling 500 interaction terms, randomly selecting the experimental group and randomly generating the policy impact year, and the selected pseudo experimental group is regressed according to the benchmark model, retaining the regression coefficient and t-value of each time. The estimated results are shown in Fig. 2. It can be seen that the random sampling coefficient is 0 as the mean, which is normally distributed. Most, the absolute value of the t value of the sampling estimation coefficient is less than 1.96, which indicates that the improvement of green

innovation of enterprises is not affected by other policies or random factors, but is caused by the establishment of pilot areas, which confirms the robustness of the conclusion.

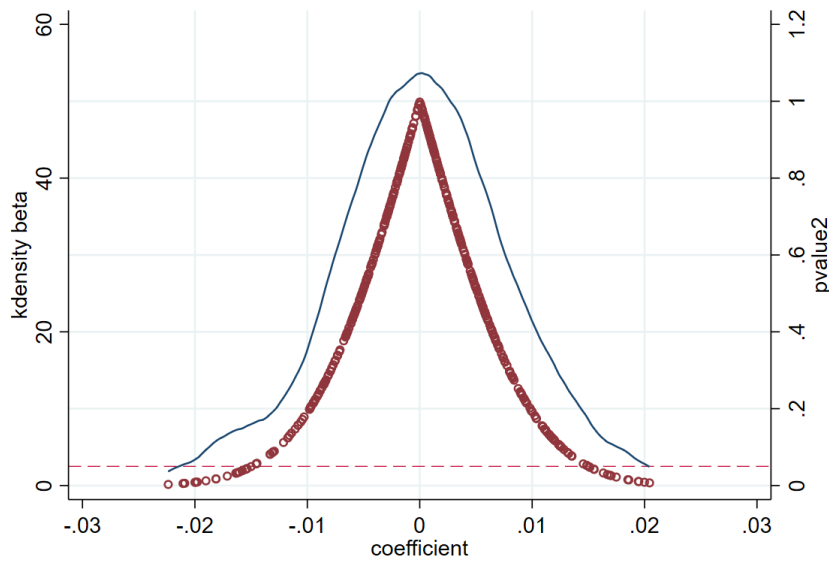


Fig. 2 Placebo test

4.3. Test of the regulatory mechanism

In order to verify whether the degree of enterprise financing constraint plays a regulating role between the green financial innovation policy and the enterprise green innovation level, the regression analysis of formula (2) is conducted, and the results are shown in Table 4(2). The coefficient of Gf_Policy is 0.099, which is significantly positive at the 1% level, and the coefficient of the interaction term is -0.194, and significantly negative at the 1% level, indicating that enterprise financing constraint plays an inhibitory role between green financial innovation policy and enterprise green innovation. Since the larger the FC index, the stronger the financing constraint, it can be concluded that the stronger the financing constraint, the effect of green financial innovation policy in promoting green innovation may be weakened, which is in line with hypothesis 2.

Table 4. The moderating effect

	(1)	(2)
	GP	GP
Gf_Policy	0.028** (2.473)	0.099*** (5.646)
M		-0.194*** (-5.345)
FC		-0.015 (-0.542)
Control variables	Yes	Yes
Code /Year	Yes	Yes
N	23118	23118
R2	0.698	0.698

Note: t statistics in parentheses; *p < 0.1, **p < 0.05, ***p < 0.01

5. Research conclusions and policy implications

This paper takes the Green Finance Reform and Innovation Pilot Zone policy as a quasi-natural experiment, and uses the multi-period double difference method to examine the impact of the green finance pilot policy on the green innovation of enterprises, the conclusions are as follows: the policy has a significant driving effect on the green innovation of enterprises, and the conclusion has passed the parallel trend test and the placebo test; moreover, the mechanism test results show that the stronger the financing constraint, the role of green financial innovation policies in promoting their green innovation may be weakened.

Based on the above findings, this paper proposes the following policy recommendations:

First, the government should actively play a leading role, accelerate the construction of green financial system, improve the green financial reform innovation plan, continue to promote the establishment of the green financial reform experimental zone, increase the support of green funds, stimulate the enthusiasm of enterprise green innovation, to promote the green transformation of enterprises, achieve long-term mechanism of energy conservation and emissions reduction, and achieve high quality development.

Second, we will improve the supporting mechanisms for green finance and give full play to the effects of green finance policies. Diversified financing channels can be launched in the pilot area to improve the financing convenience of green funds, ease the financing constraints of enterprises, and provide sufficient financial support for the green innovation of enterprises.

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