

Study on the Impact of Green Finance Reform on Enterprise Green Innovation

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Abstract:

Green finance reform is an important driving force to promote green innovation and achieve coordinated development of environment and economy. This paper takes the first batch of green finance reform and innovation pilot zones established in 2017 as the research objects to carry out quasi-natural experiments, and on this basis, examines the actual policy effects of green finance reform. It is found that the green finance reform can significantly promote the green innovation of enterprises by reducing the information asymmetry and agency cost of enterprises. Green patents are divided into green invention patents and green utility model patents. Further research finds that green finance reform promotes enterprises to carry out green innovation, but also increases the risk of enterprises' green bleaching, thus weakening the actual policy effect. Finally, the incentive effect of green finance reform on green innovation is more obvious in labor-intensive areas with stronger environmental regulations and heavily polluting enterprises.

Keywords:

Green Finance Reform, Green Innovation, Information Asymmetry, Agency Costs, Greenwashing Risk

1. Introduction

The report to the Party's 20th National Congress clearly pointed out that the central task of the Communist Party of China is to unite and lead the Chinese people of all ethnic groups in building a great modern socialist country in an all-round way and promoting the great rejuvenation of the Chinese nation through Chinese-style modernization. Chinese modernization is the modernization of harmonious coexistence between man and nature. This means that in the context of promoting Chinese-style modernization, how to balance the relationship between environmental governance and economic development is the key issue facing China. With the dual externalities of knowledge spillover effect and environmental spillover effect, green innovation can create new economic growth points while improving environmental effect, and ultimately achieve long-term win-win results of material growth and environmental protection.

However, compared with traditional innovation, green innovation has the characteristics of long cycle, slow return, difficult evaluation and high risk. These characteristics make green innovation face a series of financing obstacles, and the financial system must be guided by the market mechanism to provide the necessary financial support for green innovation. Green finance refers to economic activities designed to support environmental improvement, response to climate change and efficient use of resources, which help the capital in the market flow and tilt to greener and more environmentally friendly areas, ease the financing constraints of enterprises, and promote green innovation of enterprises. At present, green innovation and green finance are becoming the two major fulcrum to promote green and sustainable development. In this context, the reform of green finance and the improvement of green finance system have become an important issue in front of all economies.

In order to implement the important concept of harmonious coexistence between man and nature, accelerate the greening of pollution industries, low-carbon transformation, and promote sustainable economic development, relevant government departments in our country have formulated a series of policies and institutional arrangements.

In September 2015, The State Council proposed the establishment of a green financial system and an environmental information disclosure system in the Overall Plan for Ecological Civilization System Reform. In August 2016, seven ministries and commissions issued the Guiding Opinions on Building a Green Financial System, proposing to gradually establish and improve the mandatory environmental information disclosure system for enterprises and the green credit rating mechanism for banks. In June 2017, The State Council decided to build green finance pilot zones in Zhejiang, Jiangxi, Guangdong, Guizhou and eight districts in five provinces, each with its own focus and characteristics. The green finance pilot policy is an important measure to promote China's green finance reform and build a green financial system. Therefore, this paper takes the green finance pilot policy as an exogenous impact, and uses the differentially differential method to evaluate the implementation effect of the green finance pilot policy.

Compared with the existing research, the marginal contribution of this paper is mainly reflected in the following aspects: First, this paper provides empirical evidence that green finance can promote green innovation of Chinese enterprises. Secondly, this paper integrates the theory of information asymmetry, stakeholder theory and principal-agent theory to explore the mechanism of green finance reform on corporate green innovation, and uncovers the "black box theory" that green finance pilot policies affect corporate green innovation. Finally, in the extended analysis, this paper classifies green patents and introduces the concept of greenwashing risk to study the impact of green finance reform on strategic innovation, substantive innovation and enterprise greenwashing behavior, so as to more comprehensively test the implementation effect of green finance pilot policies.

2. Review and Mechanism Analysis are Presented

2.1. Literature Review

Whether green finance can induce enterprises to carry out green innovation has always been a research hotspot at home and abroad. However, there is no unified

conclusion on the impact of green finance on enterprise green innovation. The existing research results are mainly divided into three different viewpoints.

The first view holds that green finance has a crowding out effect on corporate green innovation and will increase the risk of green bleaching. By summarizing relevant literature, we find that the crowding out effect of green finance on enterprises' green innovation is mainly manifested in two aspects: financing penalty and investment inhibition effect. The implementation of green finance policies will cause enterprises to face higher environmental regulation costs, increase their production costs and uncertainties, crowd out their "productive investment" and delay their investment decisions. "Greenwashing" risk means that investors or enterprises will invest green funds obtained from financing into green projects. When the cost of environmental regulation is too high for an enterprise, in order to reduce its own environmental regulation cost or obtain the national green financial support policy to obtain hidden high profits, the enterprise has the motivation to cover up adverse environmental information or selectively disclose environmental information that is beneficial to itself. In this case, the enterprise has a good environmental performance on the surface, but in fact the product produced is inconsistent with the concept of green development. This results in environmental "face projects" such as greenwashing behavior in enterprises.

The second view is that green finance has a compensatory effect or porter effect on corporate green innovation. Because the implementation of green finance policy will make enterprises face higher environmental regulation costs, resulting in a substantial increase in production costs. Once marginal revenue approaches marginal cost, they consider stopping production, relocating, or local green innovation. For companies in the market, choosing to stop production or relocate means that specific investments based on previous corporate strategies become ineffective and sunk costs. Therefore, based on the consideration of cost and benefit, most enterprises are unwilling to give up the original production base because of path dependence. Under such pressure, companies have to increase research and development spending and are forced to embark on the road of green innovation.

The third view is that green finance has no significant impact on green innovation of enterprises, which may be the result of the crowding out effect caused by the increase in production cost of enterprises and the compensation mechanism of technological innovation counterbalancing each other. Some scholars believe that the policy effect of green finance depends on the specific policies implemented.

2.2. Mechanism Analysis

Green innovation has the characteristics of long cycle, slow return, difficult evaluation and high risk. These characteristics make it difficult for endogenous financing to support enterprises to carry out a series of green innovation activities, leading enterprises to turn to external financing methods such as equity financing and debt financing [1]. However, due to the high cost of external financing and the imperfect capital market, many external investors and bank credit hold a cautious and conservative investment attitude towards green innovation, resulting in high external financing constraints on green innovation activities. Information asymmetry and agency cost are the two main factors that affect the financing constraints of enterprises. Therefore, this paper takes information asymmetry and agency cost as the

transmission mechanism of green finance reform affecting enterprises' green innovation.

2.2.1. The mediating effect of information asymmetry on enterprises' green innovation

The source of financing constraints faced by enterprises lies in information asymmetry. On the one hand, external investors will judge their own risks according to the environmental information disclosed by enterprises, and then decide whether to continue to invest more or to terminate investment. For external investors, the decline of information asymmetry reduces the risks they face and the uncertainty of environmental policies, and they will continue to invest more in green innovation of enterprises, and the financing cost of enterprises will decrease, alleviating the financing constraints of enterprises. On the other hand, creditors usually make credit decisions based on the environmental information disclosure of enterprises. In the case of imperfect capital market, bank credit can obtain less information about corporate environmental performance, and creditors are faced with serious information asymmetry. Therefore, many banks hold a cautious and conservative investment attitude towards green innovation, resulting in high external financing constraints on green innovation activities, and the funds flowing to green industries in the market are far from the funds needed for green innovation.

2.2.2. Intermediary role of agency cost on enterprise green innovation

Because of the separation of ownership and management, there are a series of principal-agent relationships. According to the principal-agent theory, the goal inconsistency between shareholders and managers will lead to conflicts of interest and agency costs. The innovation cycle of green technology is often long, the return is slow and the risk is high. Therefore, enterprise managers have strong motivation to pay more attention to short-term interests and give up green innovation projects that are unfavorable to themselves in the short term, resulting in conflicts of interest between shareholders and managers, that is, the existence of agency costs will hinder enterprises from carrying out green innovation.

The green finance pilot policy mainly reduces the agency cost of enterprises from the following aspects. First of all, the green finance pilot policy will urge enterprises in the pilot zone to disclose their specific environmental information and fulfill their corporate social responsibilities. The disclosure of environmental information and the fulfillment of social responsibility by enterprises in accordance with the law can make shareholders feel that the strategic decisions of the operators are made based on the goal of sustainable development and the original intention of maximizing the value of the enterprise, which helps to alleviate the conflict of interest between the shareholders and the operators and reduce the cost of supervision and agency of the enterprises. Secondly, the implementation of green finance policy drives enterprises to pay more attention to their long-term development, and operators have higher moral standards. The use of moral and ethical methods to solve agency problems can more effectively restrain the short-sighted behaviors of management than the use of institutional mechanisms, so as to better restrain the short-term opportunistic behaviors of operators and reduce agency conflicts. Finally, the green finance pilot policy has significantly increased the environmental regulation cost of enterprises. Faced with the high cost of environmental regulation, shareholders have a strong incentive to urge enterprises to carry out green technology research and development

to reduce the production cost caused by environmental regulation. As agents, operators will inevitably hold a firm investment attitude towards green innovation and take the initiative to seek green transformation. This reduces the conflicts between shareholders and operators, and reduces the supervision and governance costs faced by enterprises.

3. Research Design

3.1. Sample selection and data sources

This paper takes all the industrial enterprises listed on the main board of Shanghai and Shenzhen A-shares from 2009 to 2021 as the research object. In order to avoid the influence of outliers and bad data points, the initial data are processed as follows: (1) The data of financial enterprises are excluded; (2) Company data with PT, ST and ST* status excluded; (3) Eliminate listed enterprises with serious missing of relevant variable data; (4) The main continuous variables were winsorize by 1%, and finally 19,421 samples were obtained.

Data sources in this paper mainly include two parts: First, enterprise innovation data. We retrieved patent data from China Research Data Service Platform (CNRDS) and the State Intellectual Property Office (SIPO). To accurately measure the ability of green innovation, we only consider invention patents and utility models. The second is corporate financial data, mainly from CSMAR.

3.2. Model Construction

In order to investigate the relationship between green finance reform and enterprises' green innovation ability, based on the panel data of listed industrial enterprises from 2009 to 2021, this paper uses the green finance reform and innovation pilot zone established in 2017 as a quasi-natural experiment, and draws on existing practices to build the following differential regression model:

$$Y_{it} = \beta_0 + \beta_1 DID_{it} + \beta_2 CONTROLS_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

In model (1), Y_{it} is the explained variable, and subscripts i and t represent enterprise and year respectively. DID is the differential term, equal to $TREAT \times PERIOD$. The virtual variable $TREAT$, which reflects that the province where the enterprise is registered belongs to the experimental zone, is 1; otherwise, it is 0. The virtual variable $PERIOD$ reflects the year in which the province where the enterprise is registered becomes the pilot area and the years after that during the sample period, the value is 1, otherwise it is 0. $CONTROLS$ are other control variables, μ_i represents firm fixed effect, λ_t represents time fixed effect, and ε_{it} represents random error term. In this paper, robust standard error of clustering to individual firm is used to exclude the possible influence of firm level clustering effect on estimation.

3.3. Variable Selection

Explained variable: Green innovation. With reference to the existing literature, this paper measures the green innovation capability (GPAT) of enterprises by the number of green patents applied for in the current year. Green patents are divided into green invention patents (GIPAT) and green utility model patents (GDPAT).

Explanatory variable: DID of the green finance reform pilot policy, equal to $TREAT \times PERIOD$; dummy variable $TREAT$, reflecting that the province where the enterprise is registered belongs to the pilot zone, is 1; otherwise, it is 0; The virtual variable $PERIOD$ reflects the year in which the province where the enterprise is registered becomes the pilot area and the years after that during the sample period, the value is 1, otherwise it is 0.

A mediator variable. In order to test whether the development of green finance will have an impact on corporate green innovation through asymmetric information channels, ASY index is selected as the intermediary variable in this paper. With reference to relevant literature, the principal component analysis of liquidity ratio, illiquidity ratio and yield inversion is carried out to obtain the information asymmetry (ASY) index. In order to test whether the development of green finance will have an impact on the green innovation of enterprises through the agency cost channel, this paper chooses the ratio of management expenses to operating income as the intermediary variable.

Control variables. This paper introduces the following control variables by referring to the practice of existing literature: firm size ($SSIZE$), measured by the natural logarithm of firm's net fixed assets; Business AGE (AGE), measured using the natural logarithm of business age plus 1; Corporate profitability (ROA), as measured by corporate return on equity; $DEBT$ ($DEBT$), measured by dividing the total liabilities of the business by the total assets; Total assets turnover (TAT), measured by dividing sales revenue by total assets; The operating CASH flow ratio ($CASH$) is measured by dividing net operating cash by total assets. Independent Directors Ratio ($INDEP$) is measured by dividing the number of independent directors by the proportion of total directors.

3.4. Descriptive Statistics

The descriptive statistics of the main variables in this paper are shown in Table 1. The results show that the average value of the number of green patents applied by enterprises is 0.413, which indicates that the green innovation ability of Chinese enterprises is still low. From the maximum and minimum values, there is a large difference in the level of green innovation among enterprises, indicating that the green innovation among listed industrial enterprises in China presents an unbalanced situation. The mean value of DID was 0.175, indicating that about 17.5% of the sample enterprises were affected by the pilot policy. The descriptive statistics of other control variables were basically consistent with the existing studies.

Table 1. Descriptive statistics of main variables.

Variables	Obs	Mean	SD	Min	Max
GPAT	19421	0.413	0.846	0.000	6.905
DID	19421	0.175	0.380	0.000	1.000
SSIZE	19421	20.385	1.589	9.461	27.279
DEBT	19421	0.398	0.198	0.007	0.995
ROA	19421	0.024	1.044	-66.535	2.324
INDEP	19421	0.375	0.055	0.143	0.800
AGE	19421	2.848	0.358	0.693	4.159
TAT	19421	0.621	0.411	0.004	7.609
CASH	19421	0.049	0.073	-1.938	0.726

4. Empirical Results and Analysis

4.1. Impact of real green finance on green innovation of enterprises

In order to investigate the impact of green finance development on corporate green innovation, the total number of green patents, GPAT, was substituted into model (1) as the explained variable for regression, and the regression results were shown in Table 2. Among them, column (1) is the estimated result without consideration of control variables, and column (2) is the estimated result with consideration of control variables. The results show that under all circumstances, the regression coefficient of DID is significantly positive at the level of 1%, which indicates that the development of green finance has significantly increased the number of green innovation of enterprises. According to the regression coefficient in the second column of Table 2, after the establishment of the green finance reform pilot zone, the green innovation of enterprises in the city will increase by about 8.1 percentage points. The possible reason is that the policy of the green finance reform pilot zone encourages more resources to the green sector through effective allocation of financial resources through market-oriented means. To stimulate more industrial enterprises to carry out green innovation to maintain their market position, and the environmental regulation cost brought by the implementation of green finance policy will increase the production cost of enterprises, forcing enterprises to carry out green technology innovation. The empirical regression results of this paper confirm that the incentive or porter effect brought by green finance reform is greater than its negative effect, and finally significantly promote green innovation.

Table 2. Influence of green finance policy on green innovation of enterprises.

	(1)	(2)
	GPAT	GPAT
DID	0.0825***	0.0819***
	(0.0274)	(0.0274)
SSIZE		0.0292***
		(0.0102)
DEBT		-0.0348
		(0.0503)
ROA		0.0038**
		(0.0015)
INDEP		-0.1544
		(0.1459)
AGE		-0.1496
		(0.0954)
TAT		-0.0002
		(0.0207)
CASH		-0.0134
		(0.0684)
cons	0.3984***	0.3024
	(0.0048)	(0.3191)
Firm FE	Yes	Yes
Year FE	Yes	Yes
N	19421	19421
F	9.0595	3.6907
Adj. R2	0.6415	0.6419

Note: Standard error in brackets, ***, ** and * indicate significance levels of 1%, 5% and 10% respectively, same as in the table below.

4.2. Robustness test

4.2.1. Parallel trend test

The actual estimation of DID is based on the premise that the experimental group and the control group can pass the parallel trend tes. In order to test this hypothesis, this paper draws on the research of existing literature and adopts the event research method to conduct parallel trend test, which can be expressed as:

$$Y_{it+1} = \beta_3 + \sum_{t=-6}^5 \theta_t DID_{it} + \beta_2 CONTROLS_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

The parallel trend test results shown in Figure 1 show that the coefficient estimates of each period before the implementation of the green finance pilot policy are not significant. This shows that there is no significant difference between the listed industrial enterprises in the pilot and non-pilot regions before the implementation of the policy, so the results of this paper pass the parallel trend test.

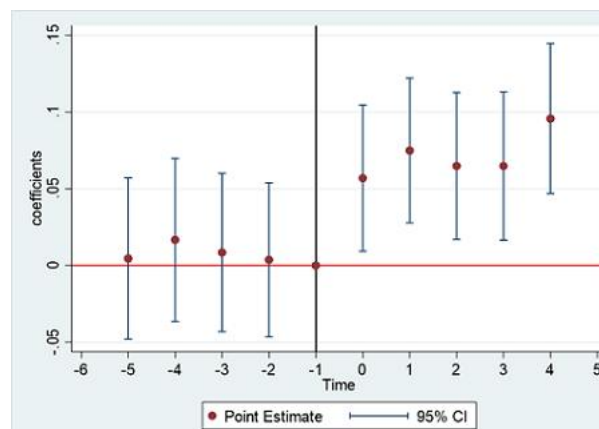


Figure 1. Parallel trend test of the different-difference model.

4.2.2. Placebo test

In order to exclude the characteristic differences between enterprises in other experimental groups and control groups before the implementation of the pilot policy and the influence of other unobservable variables on the research results, this paper adopts the non-parametric substitution test to conduct the placebo test with reference to Chetty et al. (2009). Figure 2 depicts the probability distribution of DID_it estimation coefficients for the interaction term for 500 random samples.

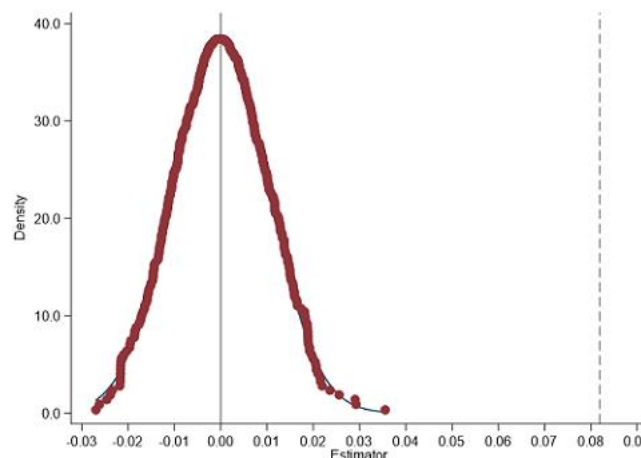


Figure 2. Placebo test.

It can be seen from Figure 2 that the estimated coefficient value based on random sampling is basically distributed around 0, while the estimated coefficient of the benchmark regression (0.0819) is basically outside the distribution of this coefficient. Therefore, the regression results based on random sampling once again show that the significant promotion effect of green finance pilot policy on green innovation is real.

4.3. Mechanism Analysis

Based on the above theoretical analysis, in order to test the mechanism of green finance pilot policies affecting enterprises' green innovation in the pilot zone, this paper constructs the following intermediary effect model:

$$Y_{it} = \beta_0 + \beta_1 DID_{it} + \beta_2 CONTROLS_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (3)$$

$$M_{it} = \beta_0 + \partial_1 DID_{it} + \partial_2 CONTROLS_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (4)$$

$$Y_{it} = \beta_0 + \delta_1 DID_{it} + M_{it}\delta_2 + CONTROLS_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (5)$$

Among them, M is the intermediary variable, that is, the information asymmetry and agency cost faced by the enterprise. The greater the index, the greater the information asymmetry and agency cost faced by the enterprise. The other variable definitions are consistent with model (1). If the ∂_1 coefficient is significant, and after adding an intermediary index to equation (5), the regression coefficient of DID is compared with the DID coefficient β_1 of equation (3), and if the absolute value or significance level of the coefficient decreases, it indicates that the mechanism exists.

Green innovation as the explained variable and information asymmetry as the intermediary variable were brought into the intermediary effect model for regression, and the regression results were shown in Table 3.

Table 3. Mechanism test: Information asymmetry effect test.

	(1)	(2)	(3)
	GPAT	ASY	GPAT
DID	0.0819*** (0.0274)	-0.0834*** (0.0272)	0.0796*** (0.0273)
ASY			-0.0266** (0.0120)
Controls	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	19421	19421	19421
F	3.6907	33.0878	3.6273
Adj. R2	0.6419	0.3773	0.6420

Column (2) of Table 3 shows that the pilot policy of green finance has a significant inhibitory effect on the information asymmetry of enterprises, and passes the significance test at the 1% level. This may be because after the implementation of the green finance reform pilot policy, the green finance system in the pilot zone has been further improved, the corporate environmental information disclosure system and the credit rating system of financial institutions have become more and more mature, the transparency of environmental information has been strengthened, and the information asymmetry faced by external investors and bank credit has been reduced, thus reducing the risks they face and the uncertainty of environmental policies. It is easier for enterprises to obtain green financing resources from external investors and

banks, and the capital flowing to green technology innovation has increased, and the number of green innovation of enterprises has increased significantly. Column (3) of Table 3 shows that after adding the information asymmetry index ASY, both the absolute value and significance level of DID coefficients decrease, indicating that the establishment of pilot areas may promote enterprises to carry out green innovation by alleviating the potential channel of information asymmetry faced by enterprises.

Green innovation as the explained variable and agency cost as the intermediary variable were brought into the intermediary effect model for regression, and the regression results were shown in Table 4. Column (2) of Table 4 shows that green finance reform has a significant inhibitory effect on the agency cost of enterprises, and passes the significance test at the 1% level. This may be because the implementation of the green finance pilot policy has significantly increased the environmental regulation cost of enterprises. Faced with the high cost of environmental regulation, shareholders have a strong incentive to urge enterprises to carry out green technology research and development to reduce the production cost caused by environmental regulation. As agents, operators will inevitably hold a firm investment attitude towards green innovation and take the initiative to seek green transformation. Accordingly, high-cost environmental regulation will strengthen the supervision function of environmental regulation, and the agency cost that enterprises need to pay will decrease. As shown in column (3) of Table 4, both the absolute value and significance level of DID coefficients decrease after adding the agency cost indicator AC, indicating that the establishment of the pilot area may promote green innovation of enterprises through alleviating the potential channel of agency cost.

Table 4. Mechanism test: agency cost effect test.

	(1)	(2)	(3)
	GPAT	AC	GPAT
DID	0.0819***	-0.0375**	0.0783***
	(0.0274)	(0.0177)	(0.0274)
AC			-0.0446**
			(0.0183)
Controls	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	19421	19421	19421
F	3.6907	52.8448	3.2262
Adj. R2	0.6419	0.8182	0.6419

4.4. Heterogeneity analysis

This paper examines the heterogeneity of the incentive effect of green finance pilot policies on green innovation from three dimensions: capital intensity at the firm level, heavy polluting enterprises or not, and environmental regulation at the regional level. The following three sets of heterogeneity tests all pass the inter-group coefficient difference test.

4.4.1. Differences in capital intensity at firm level

Whereas the effect of the policy on green innovation may be influenced by the resource endowments of the firms themselves. According to the capital intensity of enterprises (net fixed assets/total assets), this paper divides enterprises into two types: capital intensity and labor intensity, and studies whether capital intensity will affect

the degree of green innovation promotion of enterprises. The results of columns (1) and (2) in Table 5 show that although the regression coefficients of both are significantly positive, the absolute value of the coefficient of capital-intensive enterprises is relatively smaller and fails the significance test. The possible reason is that capital-intensive enterprises are relatively rich in tangible assets, which are regarded as high-value collateral in the financial market, and thus enjoy a more relaxed financing environment, so that enterprises can timely raise funds when carrying out innovative activities and obtain sustained capital investment. On the contrary, labor-intensive enterprises are on the contrary, because of the lack of tangible assets, financing discrimination appears in the market.

Table 5. Results of heterogeneity analysis.

	(1)	(2)	(3)	(4)	(5)	(6)
	GPAT	GPAT	GPAT	GPAT	GPAT	GPAT
DID	0.1059**	0.0537	0.1237***	-0.0054	0.0708*	0.1162**
	(0.0435)	(0.0381)	(0.0377)	(0.0344)	(0.0388)	(0.0491)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	9321	9561	12038	7337	8248	9040
F	2.2473	1.9334	3.4634	1.5721	1.9760	2.0293
Adj. R2	0.6921	0.5866	0.6561	0.5898	0.6624	0.6557

4.4.2. Differences in industry attributes of companies

Under normal circumstances, non-heavy polluting enterprises in the pilot zone have a higher probability of meeting the green credit evaluation standards, stronger market competitiveness, and easier access to green financing, which provides necessary financial support for green innovation of non-heavy polluting enterprises. In contrast, it is difficult for heavy polluting enterprises to obtain green credit support. On the one hand, heavy polluting enterprises will face more serious credit constraint pressure, restricting their green development level; On the other hand, the financing constraints brought by green finance may also produce "innovation compensation effect", forcing heavy polluting enterprises to pay more attention to the improvement of production efficiency and strive to improve their environmental performance, which will help enterprises to obtain environmental qualification certification in the pilot area and improve the probability of winning green financial assistance. Therefore, it remains uncertain which types of firms in the green finance innovation pilot zone are more motivated to innovate to achieve productivity gains. The results of columns (3) and (4) in Table 5 show that non-heavy polluting enterprises fail to pass the significance test, while the coefficient of heavy polluting enterprises is significant at the level of 1%, and the absolute value of the coefficient is large. This shows that the green financial innovation policy has an "innovation compensation effect" on heavy polluting enterprises, forcing heavy polluting enterprises to continuously improve their environmental performance and strive to improve productivity.

4.4.3. Differences in environmental regulation intensity between regions of enterprises

Environmental regulation, as a forcing mechanism, can promote enterprises to carry out green innovation, and green finance, as a market mechanism, is an effective supplement to environmental regulation. In regions with more stringent environmental regulations and effective market mechanisms, enterprises will be more active in green

innovation. The results in columns (5) and (6) of Table 5 show that the estimated coefficient of regions with greater environmental regulation intensity is larger, and is significant at 5% level, indicating that the integrated application of environmental regulation and green financial market mechanism can more effectively promote the level of green innovation of enterprises.

4.5. Expansion analysis

4.5.1. Impact of green finance reform on strategic innovation and substantive innovation

This paper further divides green patents into green invention patents and green utility model patents in the extensibility analysis. Green invention patents have high technical requirements and are difficult to develop, but they can bring better effects on environmental governance in the long run. In contrast, green utility model patents have low technical content and small development difficulty, and the effect on energy conservation and emission reduction of enterprises is not obvious. Based on this, the number of green invention patents applied by enterprises (GIPAT) is used to measure the substantive green innovation of enterprises, and the number of utility model patents applied by enterprises (GDPAT) is used to measure the strategic innovation of enterprises in response to the national policy requirements. In order to investigate the impact of green finance reform on different types of green patents, green invention patents and green utility model patents were substituted into model (1) as individual explanatory variables for regression. Columns (1) and (2) of Table 6 show the regression results. The coefficient of DID in column (1) is 0.0665, but it is not significant. The DID coefficient in column (2) is 0.2272 and significant at the 1% level. This indicates that the pilot policy of green finance mainly promotes the application of green utility model patents, but has no significant impact on the application of green invention patents. The results in Table 6 (1) (2) further show that the development of green finance can significantly promote strategic innovation, but it has no significant effect on substantive innovation with difficulty in R&D and long return cycle, which indicates that green innovation of listed industrial enterprises in China is still in the early stage, and there is a lack of high-quality innovation that has a substantial impact on energy conservation and emission reduction.

4.5.2. Impact of green finance reform on greenwashing risk

The risk of “greenwashing” is that investors or enterprises will invest green funds obtained from financing into green projects. When the cost of environmental regulation is too high for an enterprise, in order to reduce its own environmental regulation cost or obtain the national green financial support policy to obtain hidden high profits, the enterprise has the motivation to cover up adverse environmental information or selectively disclose environmental information that is beneficial to itself. In this case, the enterprise has a good environmental performance on the surface, but in fact the product produced is inconsistent with the concept of green development. Resulting in environmental “face projects” such as greenwashing behavior in enterprises.

As for the impact of pilot green finance policies on enterprise greenwashing risk, this paper takes DID as the explanatory variable and greenwashing risk as the explained variable, and carries out regression on model (1) again. At present, there is no unified standard for measuring the degree of greenwashing in enterprises in the

academic community. This paper, referring to the practice of Huang Rongbing et al. (2020), constructs an indicator system for greenwashing measurement from four aspects: governance and structure, process and control, input and output, law-abiding and compliance. The greenwashing behavior is divided into two ways: selective disclosure (GWLS) and declarative disclosure (GWLE). The ratio of undisclosed items to all items to be disclosed is used to measure the degree of selective disclosure, and the ratio of symbolic disclosure to disclosed items is used to measure the degree of declarative manipulation. Finally, the greenwashing degree (GWL) of each enterprise is calculated by geometric mean.

$$\text{Selective disclosure GWLS} = 100 \times (1 - \text{Number of disclosures} / \text{number of disclosures})$$

$$\text{Declarative disclosure GWLE} = 100 \times (\text{number of symbolic disclosures} / \text{number of disclosed items})$$

$$\text{Enterprise greenwashing degree GWL} = \sqrt{\text{GWLS} \times \text{GWLE}}$$

Column (3) in Table 6 reports on the impact of green finance reforms on the risk of greenwashing by firms. As can be seen from column (3) of Table 6, the estimated coefficient of DID is 0.1356 and is significant at 5% level, indicating that with the implementation of the green finance pilot policy, the risk of green bleaching of enterprises also increases. This shows that the implementation of green finance policies increases the production costs of enterprises. In order to reduce their own environmental regulation costs or obtain hidden profits, enterprises often cover up their real environmental information and choose to produce products inconsistent with the concept of green development. This also explains the deviation of China's green substantive innovation and strategic innovation from one hand.

Table 6. Results of extensibility test.

	(1)	(2)	(3)
	GIPAT	GDPAT	GWL
DID	0.0665	0.2272***	0.1356**
	(0.0928)	(0.0744)	(0.0573)
Controls	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	1591	1591	1591
F	1.8844	1.6321	1.7262
Adj. R2	0.8010	0.7491	0.3121

5. Conclusions and Policy Recommendations

Developing green industries and promoting green innovation is the key to decoupling economic development, environmental pollution and resource consumption. This paper draws the following conclusions: First, the compensation incentive effect of green finance reform on enterprises' green innovation is greater than the extrusion cost effect, that is, the development of green finance can significantly promote enterprises' green innovation. However, further analysis shows that the promotion effect of green finance development on enterprise green innovation is mainly concentrated in the strategic green innovation level, and the effect on substantive green innovation is not significant. The test results of mechanism analysis show that green finance can promote green innovation by reducing the information asymmetry and agency cost faced by enterprises. Third, the promotion effect of green finance on enterprises' green innovation will have a heterogeneous impact on enterprises with different characteristics. The development of green finance has a

more significant role in driving innovation in labor-intensive regions and heavily polluting enterprises with stronger environmental regulations.

According to the above conclusions, this paper draws the following policy implications. First, the green finance pilot policy has significantly improved the green innovation level of enterprises in the pilot areas, providing a valuable policy reference for the realization of low-carbon economic development. Therefore, China should accelerate the development of green finance, expand the scope of pilot projects, and promote better green innovation behavior of enterprises in energy conservation and emission reduction. This has important implications for China and the global carbon reduction task. Second, establish a sound environmental information disclosure mechanism. The government should establish a mechanism for the full disclosure of green project information, provide credible green credit evaluation indicators, improve the credit rating of enterprises, and strengthen the resistance to “green bleaching behavior” of enterprises. At the same time, the information published by enterprises should be transparent enough to provide useful and timely information to external investors, so as to improve the efficiency of external financing, alleviate the problem of information asymmetry, and provide financial support for enterprises’ green innovation. Third, policymakers should develop better and stronger environmental regulations.

Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this article.

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