

The Impact of Green Financial Policies on Enterprises' Green Technological Innovation

——A Quasi-Natural Experiment Based on China's Green Finance Reform Pilot Zone

Yanling Zhao ^{1, a}, Jin Chen ^{2, b, *}

¹ School of Finance, Anhui University of Finance and Economics, Bengbu 233000, China

² School of Accountancy, Anhui University of Finance and Economics, Bengbu 233030, China

*Corresponding Author: ^a 3507185148@qq.com, ^b 1730607338@qq.com

ABSTRACT

In this paper, to investigate the impact of green financial policies on corporate green technology innovation, a double difference model is constructed using the data of A-share listed companies from 2017 to 2021. The research results show that the establishment of green financial reform pilot zones greatly promotes enterprise green technology innovation. Meanwhile, through the heterogeneity analysis, it is found that the above conclusion works more significantly on state-owned enterprises. The findings of this paper provide new evidence that green financial policies have a facilitating effect on corporate green technological innovation, and also provide empirical support for the further development of green financial pilot policies.

KEYWORDS

Green finance; Difference-in-differences model; Corporate green technology innovation

1. INTRODUCTION

Green finance, as a financial innovation aimed at saving resources and protecting the environment, plays a pivotal role in building a green and low-carbon industrial system. In August 2016, seven ministries and commissions, including the People's Bank of China (PBOC), jointly issued the Guiding Opinions on the Construction of a Green Financial System, which highlighted the construction of a green financial system, including green credits, green bonds, green insurance, and carbon finance. Subsequently, in June 2017, the seven ministries and commissions further set up pilot zones for green financial reform and innovation in eight regions in five provinces, namely Zhejiang, Jiangxi, Guangdong, Guizhou, and Xinjiang. Thereafter, in November 2019 and August 2022, Lanzhou New Area in Gansu Province and Chongqing Municipality were successively added as the second and third batches of green financial reform and innovation pilot zones, signaling that China's green financial development has stepped into a brand-new stage driven by the dual wheels of top-level design and regional practice.

For enterprises, in the face of increasing environmental pressure and the urgent need to improve productivity and economic efficiency, it is particularly critical to implement green innovation strategies to reduce carbon emissions and promote the transformation and upgrading of production technologies. Technological innovation, as the core driving force of green innovation, can effectively

achieve carbon emission reduction targets, thus contributing to the sustainable development of enterprises.

2. LITERATURE REVIEW

In economics, there are two distinct views on the impact of green finance on green innovation, namely, promotion and hindrance. On the one hand, some scholars believe that the development of green finance not only provides more financial support for enterprises but also advocates the fashion of green saving in the whole society, which in turn promotes enterprises to carry out green innovation and enhance green innovation capacity. It is found that there is a positive correlation between the degree of diversification of the green financial system and green technology innovation capability (Ana et al., 2008). This conclusion is also supported by empirical analysis (Woo et al., 2008). Further research finds that the increase in green credit from banks helps to enhance the level of green innovation in enterprises (Fan et al., 2021).

On the other hand, it is also argued that green finance may limit the financing ability of high-energy-consuming and high-polluting enterprises and, through stricter conditional constraints, cause financial difficulties for these enterprises, which is not conducive to the development of their green innovation capability. Studies have shown that mandatory green insurance may have a negative impact on corporate green innovation (Yan et al., 2014). Meanwhile, under the carbon financial system, the two high-end enterprises may need to use the funds originally used for technology research and development to purchase carbon emission rights (Market et al., 2015), thus affecting their green innovation capability. And the issuance of green credit has a negative impact on the green innovation of heavy-polluting enterprises (Ding Jie et al., 2019; Yu Bo et al., 2021). Further research finds that financial development enhances the green innovation level of low-polluting enterprises more significantly than that of high-polluting enterprises (Li Rong et al., 2021).

In the existing literature, although green finance covers a wide range of tools such as green bonds, green credit, green insurance, and carbon emissions trading systems, green credit has become the focus of research due to its large scale and extensive impact. Green credit is mainly issued by commercial banks, financial institutions, and government-related organizations, and compared with green bonds, its issuing body is more unified and the related research is more abundant. Studies have shown that an increase in the number of green bonds and green credits issued by companies can help improve the level of corporate innovation. However, the specific mechanisms and paths through which green finance contributes to corporate green innovation still need to be further explored.

3. THEORETICAL ANALYSIS AND RESEARCH HYPOTHESES

Green finance, as an innovative means of resource allocation, guides the flow of funds to green innovation through market mechanisms. Compared with traditional policy instruments, green finance pays more attention to market incentives and can effectively optimize resource allocation. The study found that green credit policies can optimize enterprise resource allocation and improve the investment efficiency of heavily polluting enterprises (Wang et al., 2021). At the same time, the implementation of green credit can help reduce bank credit risk and improve the efficiency of resource allocation (Ding et al., 2020).

Green patents, as an important outcome of green innovation, not only enhance the economic performance of enterprises but also strengthen their social responsibility. It has been found that the green innovation of group members can also significantly enhance the performance of enterprises (Lin et al., 2021). Meanwhile, some studies show that green innovation not only improves the environmental performance of enterprises (Wang et al., 2023) but also enhances their financial performance. Green finance provides strong support for enterprises' green innovation by optimizing

resource allocation, reducing capital costs, and stimulating market enthusiasm. With the continuous improvement and development of the green financial system, the level of green innovation in enterprises is expected to be further improved, thus promoting the sustainable development of the economy and society.

In summary, this paper puts forward the following hypotheses:

H1: Green finance can promote the development of enterprise green technology innovation.

4. RESEARCH DESIGN

4.1. Data Sources And Sample Selection

China initiated the construction of financial reform and development pilot zones in 2017, and the first eight pilot regions were selected, namely Huzhou City, Quzhou City, Guangzhou City, Hami City, Changji State, Karamay City, Guiyang City's Gui'an New District, and Nanchang City's Ganjiang New District. Based on this quasi-natural experiment, this paper sets the enterprises in these eight regions as the treatment group and the enterprises in the rest of the regions as the control group, which are used to carry out double difference analysis. At the same time, in order to deeply investigate the impact of financial reform on enterprises, this paper selects the relevant data of China's A-share listed companies between 2014 and 2021 as the research object. The data were obtained from the China Research Data Service Centre (CNRDS) and the Cathay Pacific Database (CSMAR).

In this paper, the sample selection is mainly carried out through the following steps: (1) ST and PT enterprises are excluded to eliminate the data bias that may be brought about by enterprises with special status; (2) financial enterprises are excluded due to the fact that the financial industry is quite different from other industries in terms of operation mode, financial structure, etc., which may lead to the inconsistency of the data; (3) enterprises with serious data missing are excluded to ensure the data completeness and accuracy; (4) 1% tailing of all continuous data to control the impact of controlling extreme data on the analysis results. Through the above data processing steps, 25,906 sample data were finally obtained.

4.2. Definitions Of The Variables

4.2.1. Explained variables

Proxy variables for green innovation. In order to visualize the ability of enterprises to engage in green innovation, this paper chooses the number of green invention patents applied by enterprises in the same year (IndInvPatent) and the sum of the total number of green invention patents and green utility model patents filed (Patent) as the main indexes to measure green innovation. Referring to the existing literature, this paper takes the logarithm of the number of patents filed in the year after adding one to the number of patents filed in the year for measurement and takes the logarithm calculated data as the explanatory variables.

4.2.2. Explanatory variable

Interaction term ($Treat_i * Time_t$). As of 2017, China chose to set up green finance reform experimental zones in eight regions: Huzhou City, Quzhou City, Guangzhou City, Hami City, Changji State, Karamay City, Guiyang City's Gui'an New District, and Nanchang City's Ganjiang New District. In this paper, Treat included in the independent variable is defined as whether the enterprise is located in the experimental zone; if it is located, then $Treat=1$, otherwise $=0$. At the same time, 2017 is selected as the policy implementation year. Time indicates whether the year belongs to the carbon trading policy implementation year, and at a later point in time, if it belongs to $Time=1$, otherwise $=0$. The interaction term between them ($Treat_i * Time_t$) indicates the degree of influence of the green financial reform pilot zone on the green innovation of enterprises.

4.2.3. Control variables

Referring to the past literature, corporate innovation is more closely related to the basic characteristics of the firm. In this paper, we mainly choose to control for firm size (Size), gearing ratio (Lev), growth rate of operating income (Growth), years of establishment (FirmAge), proportion of fixed assets (Fixed), two jobs (Dual), board size (Board), and proportion of independent directors (Indep).

4.3. Model Construction

In order to study the policy effect of green financial reform as a policy, this paper constructs the following double difference model:

$$Gi_{i,t} = \alpha_0 + \alpha_1 \text{Treat}_i * \text{Time}_t + \alpha_i \text{control}_{i,t} + \mu_i + \gamma_t + \varepsilon_{i,t} \quad (1)$$

Where, i and t denote the enterprise and year, respectively, for the enterprise green technology innovation indicators; Treat_i denotes the treatment group, i.e., enterprises located in the provinces where the first financial reform pilot was located in 2017 take the value of 1, and the rest take the value of 0. Time_t denotes the time of the policy implementation, which takes the value of 1 in 2017 and later and 0 in other years; the coefficients of the cross-multiplier terms denote the policy effects; and control denotes the control variable. $\varepsilon_{i,t}$ denotes the random perturbation term, μ_i denotes the time fixed effect, and λ_t denotes the individual fixed effect.

5. EMPIRICAL ANALYSIS

5.1. Descriptive Statistics

Table 1 shows the descriptive statistics of the main variables. The results show that the mean values of the total number of green invention patents and green patents per year of enterprises are 1.271 and 1.687, i.e., the average number of patents filed by Chinese enterprises per year is 2.455 ($e^{1.271}-1$) and 3.586 ($e^{1.687}-1$), which suggests that the comprehensive green innovation capacity of enterprises is low and needs to be improved. Meanwhile, the average value of did is 0.039, indicating that 3.9 percent of the sample observations in the sample received the influence of the green financial reform pilot zone.

5.2. Baseline Results

Table 2 demonstrates the impact of green financial reform on firms' green innovation. Controlling only for individual and time effects in columns (1) and (3), the did coefficients are all positive and the significance levels are all 5 percent, indicating that the establishment of green financial reform pilot zones has a good facilitating effect on enterprises' green technological innovation. Meanwhile, the coefficients are still positive after the introduction of control variables, which ensures that the impact of green financial reform on enterprise green innovation is not affected by the internal characteristics of enterprises. In summary, hypothesis H1 is proved.

5.3. Parallel Trends Test

The premise of using double differencing is that the treatment and control groups have the same development trend before the policy shock, and after the policy shock, there is a significant difference in the development of the treatment and control groups, i.e., it is consistent with the parallel trend test. The test in this paper is shown in Figures 1 and 2. After the year of policy implementation, whether it is the number of green invention patent applications or the total number of green patents, the treatment group and the control group show obvious differences. Therefore, the result has stability.

Table 1. Descriptive statistics

Variable	N	Mean	Std dev	Min	Max
IndInvPatent	25,906	1.271	1.410	0	9.028
Patent	25,906	1.687	1.632	0	9.513
did	25,906	0.039	0.193	0	1
Size	25,906	22.230	1.298	19.630	26.450
Lev	25,906	0.413	0.202	0.051	0.908
Growth	25906	0.176	0.430	-0.658	4.024
FirmAge	25,906	2.946	0.302	1.946	3.611
FixED	25,906	0.201	0.155	0.002	0.710
Dual	25,906	0.305	0.460	0	1
Board	25,906	2.110	0.196	1.609	2.708
Indep	25,906	37.73	5.378	28.57	60

Table 2. The impact of green finance on enterprise innovation

Variable	(1)	(2)	(3)	(4)
	IndInvPatent	IndInvPatent	Patent	Patent
did	0.121** (0.064)	0.127** (0.071)	0.147** (0.079)	0.215** (0.087)
Size		0.090*** (0.022)		0.098*** (0.028)
Lev		-0.255*** (0.068)		-0.363*** (0.082)
Growth		-0.021* (0.011)		-0.042*** (0.014)
FirmAge		-0.186** (0.074)		-0.485*** (0.087)
FixED		0.048 (0.123)		0.051 (0.147)
Dual		-0.033 (0.021)		-0.022 (0.025)
Board		0.027 (0.086)		0.049 (0.103)
Indep		0.000 (0.002)		0.001 (0.003)
YearFE	Yes	Yes	Yes	Yes
FirmFE	Yes	Yes	Yes	Yes
control	1.267*** (0.002)	-0.157 (0.512)	1.690*** (0.003)	0.954 (0.639)
Obs.	25906	25906	25906	25906
R-squared	0.000	0.003	0.000	0.006

Note: ***, ** and * denote significant at the 1%, 5% and 10% levels respectively, with robust t-statistics in brackets.

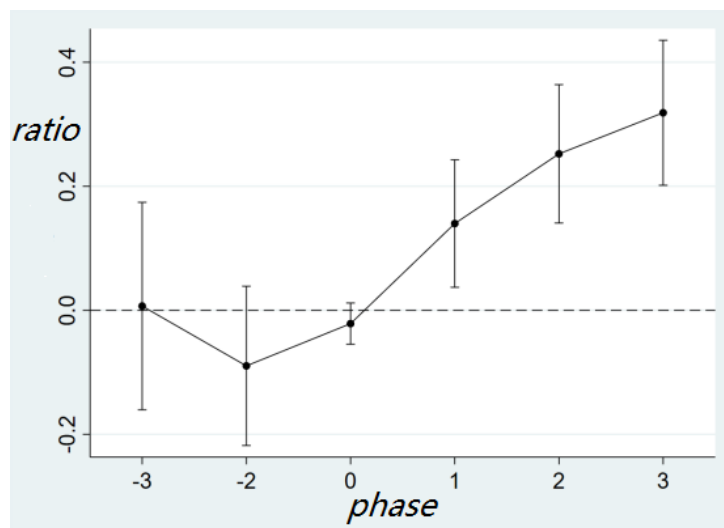


Figure 1. IndInvPatent

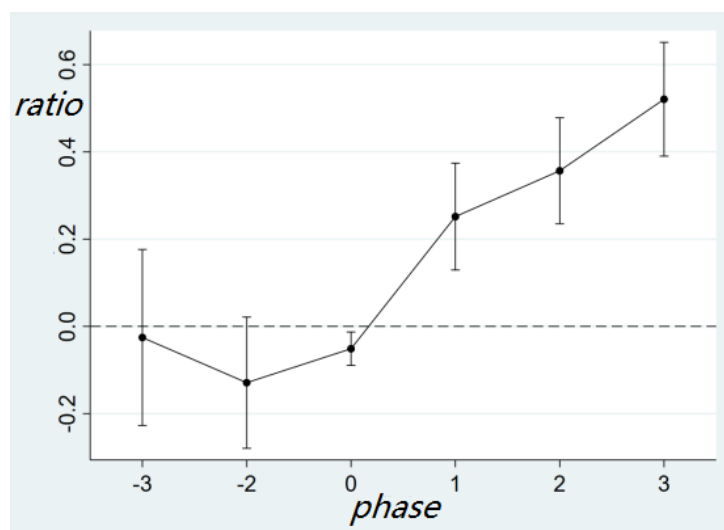


Figure 2. Patent

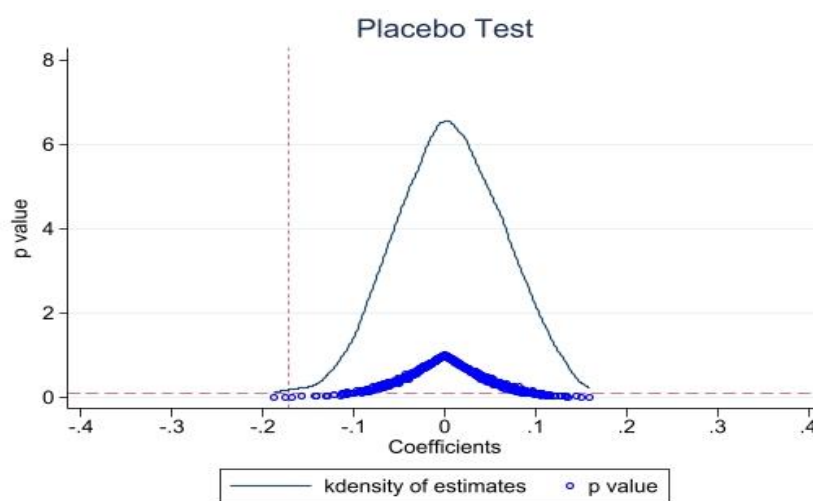


Figure 3. Placebo test

5.4. Placebo Test

In order to further verify the impact of green finance on corporate green innovation and prevent the regression results from being affected by other observed factors, this paper uses the placebo test to further ensure the stability of the results. In the test, it is randomly divided into treatment and control groups, and the regression coefficients are re-estimated accordingly. At the same time, in order to ensure the stability of the results, the above random regression process is repeated 500 times, which is plotted in Figure 3. According to the distribution of the p-value in Figure 3, which is centered on 0, the randomly selected samples have no effect on the regression results. It shows that the baseline regression results passed the placebo test, and green finance has a significant impact on corporate green innovation.

5.5. Heterogeneity Analysis

All enterprises are divided into state-owned enterprises and non-state-owned enterprises according to property ownership and regressed again according to model (1), and the benchmark regression results are shown in Table 3. The results show that green finance has a facilitating effect on both state-owned enterprises and non-state-owned enterprises, but the significance levels presented by the two are different, with state-owned enterprises significantly higher than non-state-owned enterprises. The significant effect of green finance on state-owned enterprises is significantly higher than that of non-state-owned enterprises, which may be due to the fact that state-owned enterprises are subject to more government intervention than non-state-owned enterprises, and property rights are more stable and are not prone to property rights changes, while green financial reform requires government participation, and state-owned enterprises are easily affected in comparison.

Table 3. Heterogeneity of property rights

variable	(1)	(2)	(3)
	IndInvPatent	IndInvPatent (SOEs)	IndInvPatent (non-SOEs)
did	0.121** (0.064)	0.178*** (0.069)	0.483* (0.25)
control	1.267*** (0.002)	1.295*** (0.003)	0.669*** (0.003)
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Observations	25906	23115	2793
R-squared	0.000	0.001	0.005

Note: ***, ** and * denote significant at the 1%, 5% and 10% levels respectively, with robust t-statistics in brackets.

6. CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

Based on the 2014-2021 Shanghai and Shenzhen A-share data, this paper uses a double difference model to study the green financial reform pilot policy in 2017. The results of the study show that the green finance policy demonstrates an obvious policy effect, with a specific effect value of 0.12. It indicates that the green finance policy plays a positive role in promoting enterprises' green innovation and that the government's macro-control policy effectively guides enterprises to pay attention to green development and stimulates the motivation of enterprises to carry out green innovation activities in the case of market failure. This finding passes the placebo test while satisfying the parallel trend,

proving that this result is valid and stable. Finally, the heterogeneity analysis reveals that the green finance policy is more effective for SOEs to implement; therefore, the state should make more efforts to explore more incentives in order to fully stimulate the willingness of non-SOEs to participate in green innovation and provide the necessary support and guarantee for their innovation activities.

6.2. Recommendations

Based on the above research results, this paper puts forward the following recommendations: gradually expand the scope of the implementation of green finance policies. In 2017, China's State Council set up green finance reform pilot zones in six provinces and nine regions, aiming to explore a new model of "top-down" local financial development. Under the guidance of national policies, these pilot zones have been closely aligned with local industrial characteristics and green financing needs and have continued to optimize corporate standards and regulatory systems, which have significantly contributed to the development of sustainable technological innovations for enterprises in the pilot zones.

The initial success of this policy not only demonstrates the potential of China's green finance policy to be promoted but also provides valuable experience for the broader implementation of subsequent policies. The advanced practices and innovative models in the pilot zones are gradually showing their demonstration effects, providing useful references for policymakers.

Therefore, the government should further expand the geographical scope of the pilot green finance reform, fully utilize the existing successful experience, and formulate and implement more targeted and focused financial policies, taking into account the differences in economic development, financial development level, industrial structure, and resource endowment of different regions. This will help enhance the allocation efficiency of green funds, reduce the waste of green resources, and promote the coordinated development of green financial policies among different regions.

In addition to this, governments should fully recognize and utilize the positive spillover effects of green finance. By promoting the radiation and driving effect of green financial development in one region, its influence will be extended to the surrounding areas, which will in turn promote the realization of sustainable technological innovation by enterprises in a wider region. This strategy will accelerate the process of green finance and sustainable transformation on a national scale, laying a solid foundation for the realization of green development and sustainable economic growth.

ACKNOWLEDGMENTS

This study was supported by Anhui University of Finance and Economics National College Student Innovation and Entrepreneurship Training Program Project (202210378308).

REFERENCES

- [1] ANA P. Environmental financing in the Republic of Croatia: what are the options?[J]. Croatian International Relations Review, 2008, 46(7): 90-99.
- [2] WOO S J, WOO J C. The impact of financial support system on technology innovation: a case of technology guarantee system in Korea [J]. Journal of Technology Management & Innovation, 2008, 40(1): 10-19.
- [3] FAN H C, PENG Y C, WANG H H, et al. Greening through finance?[J]. Journal of Development Economics, 2021, 152(9): 102683.1-102683.17.
- [4] YAN F, ARTHUR P J, MOL Y, et al. Environmental pollution liability insurance in China: compulsory or voluntary? [J]. Journal of Cleaner Production, 2014, 70(5): 211-219.
- [5] MARK P. Opening the black box of carbon finance "additionality": the political economy of carbon finance effectiveness across Tanzania, Uganda and Moldova [J]. World Development, 2015, 102(5): 462-478.
- [6] Ding Jie. Green credit policy, credit resource allocation and strategic response of enterprises [J]. Economic Review, 2019 (4): 62-75.

- [7] Yu Bo. How does the green credit policy affect the technological innovation of heavily polluting enterprises? [J]. Economic Management, 2021,43 (11): 35-51.
- [8] Li Rong, Liu Luqian. Green Finance and Enterprise Green Innovation [J]. Journal of Wuhan University (Philosophy and Social Sciences edition), 2021,74 (6): 126-140.
- [9] Wang Yanli, Lei Xiaolong, Long Ruyin. Has the green credit policy improve the investment efficiency of enterprises? Based on the perspective of financial resource allocation of heavily polluting enterprises [J]. Chinese Population, Resources and Environment, 2021,31 (1): 123-133.
- [10] Ding Ning, Ren Yinong, Zuo Ying. Green credit policy gains or gains? PSM-DID 1 cost efficiency analysis based on the resource allocation perspective [J]. Financial Research, 2020 (4): 112-130.
- [11] Lin Saiyan, Xu Lian. Cangreen innovation promote the improvement of corporate financial performance? Based on the perspective of the enterprise group and the supply chain [J]. Social Science, Zhejiang Province, 2021 (3): 23-31.
- [12] Wang Yulin, Zhou Yahong. Development of green finance and enterprise Innovation [J]. Financial Research, 2023,49 (1): 49-62.
- [13] Zhuge Ruiyang, CAI Wenxia. Research on the influence of green finance on green innovation of industrial enterprises -- A quasi-natural experiment based on the green finance reform and innovation pilot zone [J]. Financial Theory and Practice, 2022, (11): 49-61.