

Research on the Impact of Green Finance on Corporate Green Technology Innovation

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Abstract. The development of green finance has brought new opportunities and challenges to enterprises' green technology. However, whether green finance can positively promote enterprises' green innovation still needs further examination. Based on the panel data of A-share listed companies from 2008 to 2018, this paper constructs an empirical model by using dummy variables before and after the implementation of policies and the attributes of enterprises to analyze the impact of green finance on enterprises' green technology innovation. Through regression analysis, the establishment of intermediary effect model and placebo test, the relationship between the two is further explored. The research shows that green finance has a positive impact on enterprises' green technology innovation. When green finance rises by 1 unit, enterprises' green technology rises by 0.12. Therefore, we should actively promote green finance, strengthen the infrastructure construction of green finance, improve the coverage of green finance, and deepen the deep joint supervision of the government, banks and enterprises.

Keywords: Green Finance, Enterprises' Green Technology, Virtual Variable, Mediation Effect Test.

1. Introduction

1.1. Research Background and Significance

1.1.1. Research Background

Over the past five decades of reform and opening, China's economic development has achieved remarkable achievements that attract worldwide attention, with its economic aggregate ranking the second in the world in terms of gross national product. However, the industrialization drive, while promoting scientific and technological progress and improving productivity, has led to an increasingly prominent contradiction between economic development and the ecological environment. Problems such as environmental pollution, resource scarcity and unbalanced regional development have gradually emerged with the rapid growth of economic scale and speed. In particular, the emission of greenhouse gases such as carbon dioxide by human beings has caused global warming, triggering a series of secondary climate disasters such as sea level rise and land desertification.

In 2015, 195 countries signed the Paris Agreement at the Paris Climate Conference, proposing that all countries should strengthen their response to the threats brought by climate change, promote greenhouse gas emission reduction, and ultimately achieve zero emissions. As the world's largest responsible developing country, China has actively promoted the green transformation of the economy, undertaken social responsibilities, and made Chinese contributions to the global environment. The Central Economic Work Conference has clearly stated that China should take sustainable development as the requirement and the construction of a community with a shared future for mankind as its mission, and develop the green economy through corporate green technology innovation.

The promotion of industrial green transformation and upgrading is inseparable from financial support, and there is a huge gap between China's current green investment supply and demand. How to guide more social capital to invest in the green field has become an urgent problem to be solved. Corporate green technology innovation is characterized by large capital investment and long cycle, and the problem of information asymmetry leads to severe external financing constraints for enterprises' innovation activities. Enterprises are mainly dependent on internal funds for innovation,

which brings great risks: the breakage of the capital chain will lead to the suspension of innovation activities, and the high adjustment cost of innovation activities will cause huge losses to enterprises when innovation is interrupted and resumed.

Green finance can effectively alleviate the financing constraints of enterprises, optimize resource allocation, and support enterprises to carry out production transformation and innovation activities with high risks. Government subsidies, as an important administrative means in the development of green finance, can play a "leverage effect" to promote corporate R&D investment and technological transformation and upgrading, reduce the short-term and long-term investment costs of corporate innovation activities, and further release the innovation vitality of enterprises. Against the background of China's economic transformation and upgrading and green development, exploring the mechanism of green finance promoting corporate green technology innovation has important theoretical and practical value.

1.1.2. Research Significance

(1) Theoretical Significance: This paper further analyzes the internal relationship between green finance and corporate green technology innovation because of existing research, deepens the understanding of the policy effect of green finance, and provides a more in-depth theoretical support for promoting corporate green technology innovation. At present, the research on the driving effect of green finance on corporate green innovation is relatively scarce. This paper uses empirical research methods to test the impact of green finance policy tools on corporate green technology innovation, and verifies its impact on the "quantity" and "quality" of green technology innovation respectively, thus enriching the research results in the existing field.

(2) Practical Significance: This paper empirically verifies that green finance policies can effectively improve the level of corporate green technology innovation, which not only provides a decision-making reference for relevant government departments to formulate and improve green finance policies and accelerate the professional green transformation of industries, but also helps to optimize the allocation direction of social capital, guide enterprises to improve production processes and promote the green and ecological development of Chinese enterprises, thus promoting China to become a modern power with the coordinated development of economic and ecological progress.

1.2. Literature Review

1.2.1. Research Status of the Impact of Green Finance on Corporate Green Technology Innovation

The report to the 20th National Congress of the Communist Party of China pointed out that promoting the greening and low-carbonization of economic and social development is a key link in achieving high-quality development. The recently held Central Financial Work Conference clearly identified "green finance" as one of the themes for building a financial power, and hoped to optimize the capital supply structure to channel more financial resources into promoting scientific and technological innovation, advanced manufacturing, green development, and the development of micro, small and medium-sized enterprises.

Green finance is conducive to promoting green technology innovation. Green development does not require an immediate complete cessation of production in high-pollution and high-energy-consuming industries, but mainly focuses on promoting internal green technological innovation of enterprises, especially heavily polluting ones. Green finance can guide capital to flow to enterprises that have successfully achieved green transformation, and this demonstration effect will encourage other enterprises in the industry to continuously innovate green technologies to gain advantages in green transformation, thus promoting the green transformation of the entire industry. In addition, green finance can help enterprises that have made progress in the field of green technology innovation obtain more returns through technology transfer and other means. Transactions in the green finance market enable the effective discovery and circulation of the value of new green technologies in the market, thereby further motivating profitable enterprises to carry out innovation activities.

XING C et al. (2021) evaluated the effectiveness of China's green credit policy through the panel data of Chinese manufacturing listed companies, and found that enterprises with high environmental information disclosure quality did not obtain more loans, and only green innovation could promote enterprises to access bank loans. Long Feng et al. (2022) empirically examined the impact of economic policy uncertainty on corporate performance using the difference-in-differences method, and the research found that the implementation of the environmental protection tax significantly reduced the performance of heavily polluting enterprises in the short term. Ahmed Danish et al. (2023) found that green finance has a positive impact on corporate green innovation, and the availability of special resources for green innovation projects helps to minimize the financing constraints of innovation projects. Ali Kishwar et al. (2023) adopted a two-stage sequential technique combining linear panel data models and the generalized method of moments to solve the endogeneity problem. The research found that economic policy uncertainty, financial development, economic growth, energy consumption and trade reduce environmental quality by increasing CO₂ emissions, while green technology innovation and institutional quality reduce environmental degradation by cutting CO₂ emissions. The research provides important results for the role of green technology innovation and institutional quality regulation in reducing carbon emissions in OECD economies. Yu Hongyang et al. (2022) used the difference between the economic growth target and the actual growth rate of the previous year to represent economic growth pressure, and examined its impact on green technology innovation. The results showed that economic growth pressure has a negative impact on green technology innovation. Porter and Linde (1995) proposed that if green finance tools are designed flexibly and reasonably, they will help improve the market competitiveness of enterprises.

At present, research in the financial field on the relationship between green finance and green technology innovation mainly focuses on the following aspects: Wang Liping et al. (2021) analyzed the mechanism of green finance policies promoting corporate innovation from both internal and external aspects. The results showed that on the one hand, green finance policies provide internal financing channels for enterprises from the perspectives of capital allocation and risk control to diversify risks; on the other hand, combining green finance policies with green consumption and competitive incentives provides support for enterprises to expand the market and build competitive advantages externally. Wang Xin and Wang ying (2021) used the difference-in-differences method to test the green innovation performance of enterprises in green credit-restricted industries relative to non-green credit-restricted industries before and after the implementation of the Green Credit Guidelines, to analyze the impact of green credit policies on green innovation. Shen Yue et al. (2023) pointed out that exploring whether green bonds can effectively exert the supporting role of the green financial market on green technology innovation through direct financing and empower enterprises to achieve green and low-carbon development is an important practical issue. Jiang Yufeng and Tian Hong (2014) found that corporate environmental responsibility and environmental ethics have a positive promoting effect on corporate competitive advantage, and green innovation plays a certain regulatory role in this process. Chen Kaijun and Shi Zhibo (2024) based on the data of China's A-share listed companies from 2014 to 2021, tested the impact of the establishment of green finance reform and innovation pilot zones on the scale and efficiency of corporate environmental investment. The research found that the establishment of green finance reform and innovation pilot zones significantly increased the scale of corporate environmental investment, and the improvement of environmental investment efficiency was mainly reflected in enterprises with insufficient environmental investment. Song Yuegang and Jin Songlin (2023) constructed a theoretical model of green credit policies and corporate environmental performance, and used the matched data of China's industrial enterprise database, enterprise patent database and China's enterprise pollution emission database from 2000 to 2014 to test the impact and mechanism of green credit policies on corporate environmental performance, and further verified the robustness of the research conclusions using the listed company data from 2000 to 2020. Jia Ning and Zhang Zhichao (2024) hypothesized that China's green finance reform and innovation can promote corporate green innovation; however, when distinguishing various incentive factors, it is found that green finance in pilot areas can promote

enterprises' strategic green innovation, but has little effect on substantive green innovation. Lv Xiaoqi (2023) based on China's industrial enterprise database, customs database and other sources, systematically analyzed the impact of China's green finance development on enterprises' embedding in the global value chain. Meng Weifu and Liu Jinghan (2023) used the entropy method to measure the green finance development index and the high-quality economic development index, and tested the effect and mechanism of green finance boosting China's high-quality economic development from the perspective of technological innovation and industrial structure upgrading. Zhang Detao and Zhang Jingjing (2022) pointed out that the behavior of local governments setting economic growth targets like those of neighboring regions is contradictory to the unbalanced development among regions. Exploring the impact of this phenomenon on green technology innovation can to a certain extent reveal whether the current economic growth target strategy is still applicable to China's new pattern of green development.

1.2.2. Concept Evolution and Measurement of Green Finance

Existing studies have pointed out that green finance policies are rules and regulations formulated by the government or relevant competent departments for the financial industry and related enterprises regarding standards, processes, conditions and incentive measures, aiming to regulate and promote the development of green finance. Scholars generally believe that green finance policies are policy guidelines and institutional arrangements that channel social capital to environmental protection, clean energy and green industries through a series of financial services such as loans, bonds and tax reductions and exemptions. Green finance policies are tools for government macro-control, and many existing scholars have defined green finance policies from different aspects. From the perspective of policy objectives, policies formulated by the government with the goal of guiding financial institutions to integrate the concepts of environmental protection and energy conservation and emission reduction into financial activities are collectively referred to as green finance policies. From the perspective of policy content, green finance policies are an institutional arrangement for the state to intervene in the market, aiming to overcome the difficulty of internalizing environmental pollution costs under market-oriented pricing, and provide incentives and support for green industries that generate positive externalities to promote the development of the green economy. From the perspective of policy effects, green finance policies are institutional arrangements to support corporate green transformation and encourage the development of the national green economy, a requirement for the high-level development of the financial field in the new era, and a key to realizing regional green development.

1.2.3. In Relevant Research on Corporate Green Technology Innovation innovations and Deficiencies

On this basis, this paper discusses the connotation of corporate green science and technology innovation in China, and puts forward specific measures for enterprises to implement green science and technology innovation in China. First, integrate the development of science and technology into the category of scientific and technological research. Based on this, existing research results are mostly carried out from the perspectives of environmental protection and economy. Scholars such as Zhang Shengli and Lu Hui believe that separating environmental factors from economic activities can not only enable enterprises to gain competitive advantages in environmental protection, but also create new profit growth points, obtain additional benefits, and generate good economic benefits. Second, integrate it into the company's development strategy when formulating the company's internal strategy. Under environmental regulation, enterprises can gain their own competitive advantages through environmental technology innovation, and promote their own development and the construction of competitive advantages. Third, realize the transformation of scientific research achievements into sustainable development capacity. On this basis, a new energy management model based on intellectual property rights is proposed. Although there is no consensus in academic circles on the definition and connotation of ecological civilization, it is generally believed that ecological civilization can effectively improve the ecological environment and enhance the overall economic

benefits. At present, the global economy is in a period of a new scientific and technological revolution, and enterprises should build their own competitive advantages by taking the initiative to carry out green technology innovation.

1.2.4. Correlation Analysis between Corporate Green Technology Innovation and Green Finance

The theory of economic growth holds that scientific and technological innovation has a huge driving effect on economic growth, and the financial mechanism promotes technological progress and affects economic growth. Under the guidance of the government's top-level design, mobilizing more social capital to participate in green development through market-oriented governance mechanisms is the basic logic of constructing a green finance system. Existing studies have regarded green loan policies as a "quasi-natural" experiment and a "quasi-natural experiment" to promote corporate green innovation; however, because of distinguishing the severity of corporate environmental pollution, some scholars hold the opposite view that green loan systems increase corporate financing costs by raising financing constraints on polluters, thus crowding out corporate innovation investment. In essence, green finance is a way to regulate the environment by using financial tools, which to a certain extent constitutes environmental regulation. On this basis, through combing the relevant literature, we can see that domestic and foreign scholars still have different views on how environmental regulation affects corporate green technology innovation. Some put forward the inhibitory effect of environmental regulation on corporate green technology innovation, some proposed the promoting effect on corporate green technology innovation, and others put forward the conclusion of an "inverted U" shape or "uncertainty". On this basis, this study intends to take China's listed companies as the research object to study their impact on corporate R&D and innovation behavior. The credit channel plays a guiding role especially through differentiated financing costs: on the one hand, it can prompt green capital to flow to more clean energy sources, thus encouraging them to increase investment in scientific and technological innovation; on the other hand, it restricts the financing of polluters, either "forcing" polluters to carry out technological innovation or "shutting down" polluters. At the same time, after the implementation of green finance policies, the term mismatch is corrected through market mechanisms, the proportion of corporate long-term loans is increased, and more funds are matched with the term of innovation projects, thus encouraging enterprises to invest more funds in green projects. In addition, this study also finds that green finance can transmit the policy signal of the country's vigorous development of the green economy, thus prompting enterprises to carry out environmental protection behaviors and further promoting corporate green technology innovation. At the same time, green finance can also convey market information on green competition to enterprises, prompting them to take it as a source of competition and increase investment in green innovation projects. Overall, China's green finance has a positive guiding role in corporate green competition and has achieved remarkable results in practice. In addition, the introduction of systems such as environmental information disclosure, rewards and punishments in China plays an important role in promoting corporate technological innovation.

1.3. Literature Review

To sum up, there may be differences in the research status at home and abroad due to the differences in the economic and financial systems of various countries and the differences in policy environments. However, with the rapid development of green finance, domestic and foreign research has been continuously deepened and expanded, providing valuable theoretical and empirical support for the development of this field.

The impact of green finance on green technology innovation still faces challenges and problems, such as the need to improve green finance standards, strengthen the incentive and restraint mechanism of green finance, and enhance the capacity of green technology innovation. Therefore, on the premise of ensuring the rational use of green finance policies, it is necessary to continue to actively explore solutions to promote the impact and development of green finance on corporate green technology innovation.

1.4. Chapter Arrangement and Research Content

This paper is structured into five chapters, with the following arrangement of research content:

Chapter 1: Introduction

Explain the research background and significance of this topic. Secondly, comb the domestic and foreign literature on the impact of green finance policies on technological innovation of micro, small and medium-sized enterprises, analyze the existing research status and deficiencies, and highlight the necessity of the topic selection of this paper.

Chapter 2: Relevant Theories and Impact Mechanisms

Analyze the impact mechanism of China's listed corporate performance from both theoretical and empirical perspectives. Because of defining the connotation of green finance and corporate green technology innovation, this study intends to sort out and analyze relevant theories to provide theoretical support for explaining the mechanism of green finance policies promoting technological innovation of micro, small and medium-sized enterprises.

Chapter 3: Research Methods and Data Sources

Select research methods and data. Because of theoretical analysis, reveal the mechanism of green finance policies promoting corporate green technology innovation, select appropriate variables, and construct relevant models.

Chapter 4: Result Analysis

Carry out empirical analysis. Because of theoretical analysis and model construction, select data samples, incorporate green finance policies into a unified analysis framework, adopt the difference-in-differences model, construct the impact mechanism of green finance policies on corporate green technology innovation, and test the relevant research hypotheses.

Chapter 5: Conclusions and Suggestions

Draw corresponding conclusions through the analysis of the above empirical results. On this basis, put forward countermeasures and suggestions according to the current actual situation in China.

(1) Literature Analysis Method: This study systematically sorts out the domestic and foreign literature on green finance policies and technological innovation of micro, small and medium-sized enterprises, and finds that existing research mainly focuses on the impact of green finance policies on corporate technological innovation, and has not incorporated green finance policies and technological innovation of micro, small and medium-sized enterprises into a unified analysis framework. In view of this, this study attempts to explore the mechanism of green finance policies promoting technological innovation of micro, small and medium-sized enterprises in theory by systematically combing the existing literature and clarifying its research content.

(2) Combination of Theoretical and Empirical Methods: Because of combing the long tail theory, Porter hypothesis and sustainable development theory, this paper analyzes the current situation of China's green finance policies and technological innovation of micro, small and medium-sized enterprises, explores the impact mechanism of green finance policies on technological innovation of micro, small and medium-sized enterprises, and puts forward corresponding hypotheses. Based on the data of A-share listed companies from 2008 to 2018, this study intends to use econometric methods such as the difference-in-differences method and Stata15 software to empirically test the impact path of green finance policies on technological innovation of micro, small and medium-sized enterprises.

2. Relevant Theories and Impact Mechanisms

2.1. Relevant Concepts

Green Finance refers to the government guiding more social capital to flow to enterprises that consider the protection of the ecological environment and the governance of environmental pollution in their business activities, and promoting the sustainable development of society through the guidance of social and economic resources. Against the background of severe global climate

problems, a green financial system with the participation of many countries, promoted by the government and led by financial institutions, is gradually being improved.

Corporate Green Technology Innovation refers to the innovative behaviors of enterprises in relevant patents and production methods supported by the green financial system. It is a technological innovation that integrates environmental principles and aims to minimize the total life cycle cost of products. Green technology is a new modern technological system coordinated with the ecological environment system.

2.2. Relevant Theories

2.2.1. Sustainable Development Theory

The concept of "sustainable development" was put forward in the book *Our Common Future*, reflecting the environmental protection and health issues concerned by all human beings today. Sustainable development is a universal, coordinated, efficient, fair and multi-dimensional development model. Sustainable development is not only an essential condition for the socialist market economy, but also its goal. To realize sustainable development, we must attach equal importance to both "quantity" and "quality". High-quality sustainable development requires a good ecological environment as support, and this premise requires full consideration of the carrying capacity of the ecological environment in the overall process of economic and social development, changing the previous inefficient development model, improving energy utilization efficiency, and minimizing the impact on the environment. Green finance is of great significance for promoting the coordinated development of China's economy and ecological environment, advancing high-quality development, protecting the ecological environment, and boosting green and low-carbon development. By introducing social capital and alleviating corporate financing constraints, green finance enables enterprises to change their original inefficient production and operation modes and realize green transformation. This paper makes a beneficial exploration on the realization of sustainable development from both theoretical and practical perspectives.

2.2.2. Porter Hypothesis

The Porter hypothesis holds that environmental regulation of enterprises can promote their production efficiency, save costs, and thus gain greater competitive advantages. This theory was put forward by the famous economist Michael Porter of Harvard University in 1995. Porter believes that the constraints of environmental regulations can "force" companies to innovate, prompting them to develop new technologies and processes with higher efficiency, lower pollution and greater profitability. This can not only reduce the compliance costs of enterprises, but also win favorable conditions for enterprises in market competition, achieving a "win-win" situation of environmental protection and economic development, thus providing certain theoretical support for the subsequent research. As an eco-oriented financing method, green finance is essentially a financing method under environmental constraints, which to a certain extent reflects the connotation of environmental regulation, and has important practical significance for promoting corporate green technological innovation and realizing high-quality development.

2.2.3. Long Tail Theory

The concept of the "long tail" first appeared in statistical data, which is a business economic theory put forward by Chris Anderson. It refers to the sum of the tail of the demand for goods and services in the Internet age, whose proportion is much larger than that of the first category of products and services. Traditional business models and sales channels are more suitable for mainstream products or services due to their large demand and relatively stable sales volume. However, with the progress of information technology and production technology, the production cost, transaction cost and communication cost of commodities have been greatly reduced, and the basic functions of the market have been enhanced. Thus, the "disadvantaged" customers who were ignored by the market in the past have become an important direction for companies to expand their business and market. In some specific cases, the overall impact of the "long tail" market may be greater than that of the

"mainstream" consumers. The "long tail theory" is closely related to small and medium-sized enterprises. Specifically, the "long tail" theory holds that although the market demand for "long tail" products and services is relatively small, they occupy a considerable market share. In the "long tail market", small and medium-sized enterprises have become important participants in the market because they can provide more professional and segmented products and services. At the same time, due to the wide application of network technology, small and medium-sized enterprises can better complete the sales and distribution of "long tail" products and services. In the Internet age, small and medium-sized enterprises can communicate and interact with consumers more through e-commerce platforms, social media and other tools, understand their needs, feedback and preferences, and provide them with better products and services. In addition, the long tail theory encourages small and medium-sized enterprises to adopt a more flexible and open business model, give full play to their own strengths and advantages, implement differentiated market positioning and resource utilization, improve market share and competitiveness, and gradually grow and develop in the segmented market.

2.3. Impact Mechanisms

2.3.1. Green Finance Policies and Corporate Green Technology Innovation

At the macro level, a series of green finance policies have been put forward, laying a solid theoretical foundation for promoting the development of China's green finance. Optimizing the composition of green loans, increasing the proportion of corporate green credit, establishing a corporate environmental protection information sharing platform, and improving the corporate financial environment enable green finance to play a role as a "booster" of behavior beyond its basic functions, helping to correctly identify loan borrowers, alleviate information asymmetry between loan supply and demand sides, reduce corporate capital costs, improve the quality of corporate financial services, and promote corporate technological innovation. In addition, after the implementation of green financing, local governments will also increase environmental protection investment and diversify environmental protection investment channels. At the same time, local governments will provide corresponding subsidies, and give some financial interest or tax reductions in finance, to reduce the R&D costs of micro, small and medium-sized enterprises, promote their technological innovation and transformation, and enhance their motivation for scientific and technological innovation. On this basis, this paper puts forward: Green finance can have a positive impact on corporate green technology innovation.

2.3.2. Green Finance Policies and Corporate Liquidity Debt Financing

From the corporate perspective, before the issuance of the Green Credit Guidelines, banks' support for enterprises was insufficient, leading to enterprises obtaining more funds than they invested. Through positive policy guidance and incentives, the Guidelines encourage enterprises to increase investment in environmental science and technology innovation, reduce loan costs, and realize corporate innovation benefits. By implementing environmental protection technological innovation, enterprises can not only obtain the benefits of reducing CO₂ emissions, but also gain Ricardian rent, thus promoting the development of the environmental protection industry, enhancing their position in the industry, further expanding their market share, and then increasing their carbon emission benefits, which has a positive effect on the company's operating performance. At the same time, sufficient capital can also promote the development of green technology. Therefore, the Guidelines help environmental protection enterprises carry out environmental protection technological innovation and improve the economic effects brought by environmental protection. Due to the uncertainty of the results of corporate green technology innovation, as well as a series of financing constraints and income uncertainty risks, enterprises reduce relevant R&D expenditures to ensure corporate income, thus reducing corporate green output. Based on this, this paper puts forward: The reduction of liquidity debt financing costs is an important positive transmission mechanism for green finance to encourage enterprises to carry out green technology innovation, which can be used as a variable for mediation effect test.

3. Research Methods and Data Sources

3.1. Variable Selection and Data Sources

After reviewing many literatures, this paper refers to the research of Zhou Xiaoxiao et al. on green finance policies and corporate green technology innovation. Therefore, the dependent variable in this paper, green patent technology innovation, is replaced by the number of green utility model patent applications filed by enterprises in the current year, denoted as $lnuma$.

The independent variable is the interaction term of green credit policy and corporate attributes treated $\times$ time. Among them, time is a dummy time variable before and after the implementation of the policy: the years before the introduction of the green credit policy in 2012 are defined as 0, and the years after the policy introduction in 2012 are defined as 1. treated is a dummy variable reflecting whether an enterprise is a pilot object of the green finance policy, taking the value of 1 if the enterprise is a pilot object of the green finance policy, and 0 otherwise.

Table 1. Variable Summary

Variable Type	Name	Symbol	Definition
Dependent Variable	Green Patent Technology Innovation	$lnuma$	$\ln$ (Number of green utility model patent applications filed by the enterprise in the current year + 1)
Independent Variable	Difference-in-Differences Term	treated $\times$ time	Interaction term of green credit policy and corporate attributes
Mediating Variable	Liquidity Debt Financing	fr	Current Liabilities / Total Assets at the Beginning of the Period
Control Variables	Tobin's Q Value	tq	Corporate Market Value / Corporate Replacement Capital
Corporate Performance	Corporate Performance	roa	Net Profit / Average Balance of Total Assets
	Asset-Liability Ratio	lev	Total Liabilities / Total Assets
	Book-to-Market Ratio	mtb	Total Assets / Corporate Market Value
	Enterprise Size	ta	Natural Logarithm of Corporate Total Assets
	Enterprise Age	age	Natural Logarithm of the Number of Years the Enterprise Has Been Established
	Fixed Asset Ratio	ppe	Fixed Assets / Total Assets
	R&D Expenditure Ratio	rd	Corporate R&D Investment / Operating Income
	Cash Ratio	cash	(Monetary Funds + Marketable Securities) / Current Liabilities

In terms of the mediating variable, according to the theoretical and impact mechanisms, this paper selects corporate liquidity debt financing as the mediating variable, denoted as fr. In terms of independent variables, other factors related to the dependent variable will also have an impact on it. Therefore, to reduce the impact of omitted variables on the dependent variable, this paper selects Tobin's Q value (tq), corporate performance (roa), asset-liability ratio (lev), book-to-market ratio (mtb), enterprise size (ta), enterprise age (age), fixed asset ratio (ppe), R&D expenditure ratio (rd), and cash ratio (cash) as control variables, as detailed in Table 1 above.

Considering the availability and usability of data, this paper selects the relevant data of China's listed enterprises from 2007 to 2019 for empirical research. All data in this paper are from the China Stock Market & Accounting Research (CSMAR) Database. After data cleaning and sorting, 807 enterprises are finally selected as the research objects.

3.2. Model Design

This paper mainly discusses how green finance affects corporate green technology innovation in China, and the selected data is panel data, so a DID model is established as follows:

$$\lnumait = \alpha_{it} + \beta_{itreatedt} * timet + \lambda_{icontrolsit} + \delta_i + \lambda_i + \varepsilon_{it} \quad (1)$$

To test the mediating effect of liquidity debt financing (fr), the following equations are established by using the stepwise regression method:

$$frit = \alpha_{it} + \beta_{itreatedt} * timet + \lambda_{icontrolsit} + \delta_i + \lambda_i + \varepsilon_{it} \quad (2)$$

$$\lnumait = \alpha_{it} + \beta_{itreatedt} * timet + \eta_{ifrit} + \lambda_{icontrolsit} + \delta_i + \lambda_i + \varepsilon_{it} \quad (3)$$

Among them, lnuma is the dependent variable, the independent variable treated×time is the interaction term of green credit policy and corporate attributes, fr is the mediating variable, controls represent each control variable, δ represents the time fixed effect, λ represents the enterprise fixed effect, and ε represents the random error of the model.

4. Result Analysis

4.1. Descriptive Statistics

It can be seen from Table 2 below that the mean value of the dependent variable lnuma is 0.765, the standard deviation is 1.219, the maximum value is 4.736, and the minimum value is 0. The gap between the standard deviation and the mean value is large, which indicates that the green patent technology innovation of listed enterprises has changed significantly during the sample period; the mean value of the interaction term of the independent variable treated×time is 0.233, and the standard deviation is 0.423, which indicates that the treated×time of listed enterprises has changed significantly from 2007 to 2019. The mean value of the mediating variable liquidity debt financing (fr) is 0.378, the standard deviation is 0.168, the maximum value is 0.773, and the minimum value is 0.0510, which shows that the gap between the standard deviation and the mean value is large, indicating that the liquidity debt financing of China's listed enterprises has changed significantly from 2007 to 2019. The mean value of the control variable tq is 1.933, the standard deviation is 1.196, the maximum value is 7.722, and the minimum value is 0.855, with a large gap between the standard deviation and the mean value, which means that Tobin's Q value of China's listed enterprises has changed significantly during the sample period. Similarly, other control variables have also changed significantly during the sample period.

Table 2. Descriptive Statistical Analysis

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
tq	10,491	1.933	1.196	0.855	7.722
roa	10,491	0.0427	0.0472	-0.102	0.204
lev	10,491	0.484	0.188	0.0750	0.860
mtb	10,491	0.313	0.143	0.0714	0.758
ta	10,491	22.48	1.349	19.90	26.39
fr	10,491	0.378	0.168	0.0510	0.773
ppe	10,491	0.255	0.182	0.00238	0.752
age	10,490	2.775	0.351	1.792	3.401
cash	10,490	0.589	0.831	0.0289	5.565
lnuma	10,491	0.765	1.219	0	4.736
treated*time	10,491	0.233	0.423	0	1
rd	10,491	0.0132	0.0234	0	0.119
Number of id	807	807	807	807	807

4.2. Correlation Analysis

A correlation test is conducted here to lay a foundation for the subsequent multiple regression analysis. The Pearson correlation coefficient is a method to measure the correlation between two

variables and express the tightness between two variables. This paper uses the Pearson correlation coefficient to conduct a correlation analysis on all variables. The results are shown in Table 3 below:

Table 3. Correlation Analysis

	lnuma	treated*time	fr	tq	roa	lev	mtb	ta	age	ppe	rd	cash
lnuma	1											
treated*time	0.094**	1										
fr	0.146**	-0.104***	1									
tq	-0.161**	-0.065***	0.236**	1								
roa	0.044**	-0.037***	0.305**	0.348**	1							
lev	0.171**	-0.031***	0.797**	-0.395**	-0.402**	1						
mtb	0.038**	0.111***	0.431**	0.532**	-0.005	0.428**	1					
ta	0.403**	0.167***	0.176**	0.443**	0.033**	0.432**	0.138**	1				
age	0.133**	0.241***	0.009	0.104**	0.141**	0.070**	0.076**	0.263**	1			
ppe	0.025*	0.221***	0.164**	0.140**	0.065**	0.012	0.153**	0.075**	0.099**	1		
rd	0.188**	0.064***	0.079**	0.162**	0.036**	0.167**	0.033**	0.058**	0.048**	0.129**	1	
cash	0.134**	-0.028***	0.528**	0.333**	0.266**	0.581**	0.121**	0.249**	0.064**	0.145**	0.121**	1

It can be seen from Table 3 above that the correlation coefficient between the dependent variable green technology innovation (lnuma) and the independent variable treat×time is 0.094, whose absolute value is far less than 0.85, and significant at the 1% level, which can initially judge that lnuma and treat×time are positively correlated without serious multicollinearity. The correlation coefficient between green technology innovation (lnuma) and the mediating variable liquidity debt financing (fr) is 0.146, whose absolute value is far less than 0.85, and significant at the 1% level, indicating that there is a positive correlation between the two without serious multicollinearity. The correlation coefficient between the dependent variable green technology innovation (lnuma) and tq is -0.161, less than 0.85, and significant at the 1% level, which shows that lnuma and tq are negatively correlated without serious multicollinearity; similarly, the correlation coefficients between the dependent variable lnuma and other control variables are all less than 0.85, so there is no serious multicollinearity among the variables.

However, correlation analysis can only explain the relationship between two variables, not the comprehensive relationship of all variables in one equation, so the specific relationship between variables needs to be further verified in the subsequent regression analysis.

4.3. Parallel Trend Assumption Test

The parallel trend test is one of the commonly used robustness tests for the DID model. When using the DID model, the parallel trend assumption is made. The parallel trend test measures whether two variables have the same upward or downward trend. In practical application, the parallel trend test generally uses an intuitive method to draw a time trend chart of a variable, and judges whether the treatment group and the control group have similar development trends according to the trend of the broken line.

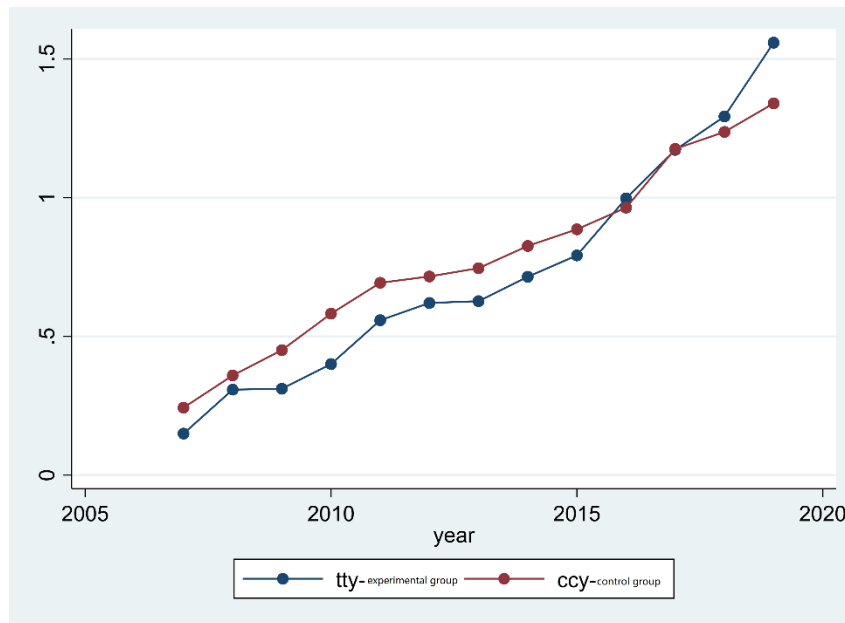


Figure 1. Trend Chart of the Dependent Variable from 2007 to 2019

It can be seen from the figure above that before the implementation of the policy in 2012, the trends of the experimental group and the control group were basically the same. With the implementation of the policy in 2012, the dependent variable *lnuma* of the experimental group showed an upward trend with the continuous implementation of the policy. That is, the introduction of the policy made the trends of the experimental group and the control group show an opposite state, indicating that the implementation of the policy can improve the level of corporate green financial innovation.

4.4. Regression Analysis

This paper will conduct a regression analysis on green finance and corporate green technology innovation from 2007 to 2019, using a two-way fixed effect model, that is, both enterprise individual effects and time individual effects are controlled in the regression. The results are shown in Table 4 below:

Table 4. Regression Results

Variable	lnuma		
	Coefficient	Standard Error	P Value
treated*time	0.118432***	0.0299017	0.000
tq	-0.013739	0.0146227	0.347
roa	-0.141221	0.2364851	0.550
lev	-0.128414	0.1282157	0.317
mtb	-0.071531	0.1390372	0.607
ta	0.288386***	0.0217925	0.000
age	0.149434	0.1168125	0.201
ppe	0.436919***	0.0992489	0.000
rd	3.049651***	0.5756118	0.000
cash	-0.014754	0.0154724	0.340
Observations		10,489	
id fe		Yes	
year fe		Yes	
Number of id		807	
R-squared		0.225	
F test		0	
r2_a		0.159	
F		127.5	

t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

It can be seen from the regression results in Table 4 above that the goodness of fit R-squared of the model is 0.225, indicating that the model has a good fit for the impact of green finance on corporate green technology innovation. The F value is 127.5, with a corresponding P value of 0, which shows that the model constructed in this paper has passed the significance test at the 1% significance level.

The coefficient of the independent variable treated×time is positive and significant at the 1% significance level, indicating that after the implementation of the green finance policy, the number of green utility model patents of listed enterprises has increased by 0.118432%, that is, the introduction of the green finance policy is conducive to the development of corporate green technology innovation. This is because green finance policies provide more financial support for enterprises, and incentive measures such as low-interest loans will encourage enterprises to invest in green technology innovation. Such financial incentives not only reduce the innovation costs of enterprises, but also improve the enthusiasm of corporate innovation investment; secondly, the introduction of green finance policies has prompted financial institutions to pay more attention to the environmental protection and sustainable development of enterprises, and financial institutions will be more inclined to support enterprises that meet environmental protection standards, which reduces the financing difficulty of green technology innovation projects; furthermore, green finance policies will change the structure of market demand, thus driving the market demand for green technology. Currently, to adapt to the market environment, enterprises are willing to increase R&D and innovation investment in green technology; finally, green finance policies are often accompanied by the formulation of environmental protection laws and regulations, which provide a clear development direction and requirements for enterprises. While abiding by relevant policies and regulations, enterprises are more motivated to seek green technology innovation.

4.5. Robustness Test

The purpose of model robustness test is to reduce the possibility of model incorrectness. Therefore, the robustness test is to verify whether the model establishment and variable selection are reasonable and whether the regression of the full text is credible. There are many methods for robustness test.

According to its own situation, this paper selects the placebo test, variable replacement method and sample size adjustment method for the test.

(1) Placebo Test

The placebo test is an important method in econometrics, used to evaluate whether the difference between the treatment group and the control group is really caused by the policy, rather than by other factors. In econometrics, the DID method is usually used to estimate the policy effect. The core assumption of the DID method is that without policy intervention, the change trends of the two control groups are the same, but the change trends of the two control groups will be affected by other factors, such as seasonal changes and the implementation of other policies. Therefore, this paper will conduct a placebo test, and the specific results are shown in Figure 2 below:

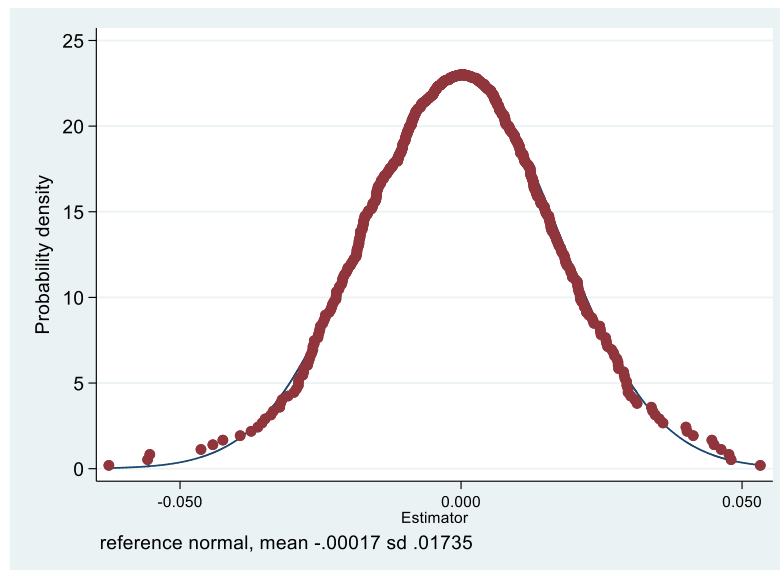


Figure 2. False Estimated Coefficients of the Placebo Test

It can be seen from Figure 2 above that the estimated coefficients of the false difference-in-differences term are concentrated around 0, indicating that there is no major omission in the model and its main conclusions are still robust.

(2) Variable Replacement Method

This paper will replace the dependent variable for regression to test whether the model is significant, selecting the number of green patent applications filed by enterprises in the current year (Intotal) to replace Inuma for regression, and the results are shown in Table 5 below.

It can be seen from the regression in Table 5 that in the regression with the dependent variable replaced, the goodness of fit R-squared of the model is 0.3, a good fit, and the F statistic value is 188.1, with a corresponding P value of 0, which shows that the model has passed the significance test. The regression results of the sample size replacement are consistent with the previous regression results, that is, the coefficient of the independent variable treated $\times$ time is 0.103492, significant at the 1% level, which means that replacing the dependent variable does not change the sign and significance of the independent variable coefficient. That is; after replacing the dependent variable, the introduction of the green finance policy will still promote the level of corporate green technology innovation, so the modeling in this paper is reliable and robust.

(3) Sample Size Adjustment Method

This paper selects the method of changing the sample size for the test, that is, selecting the data from 2008 to 2018 for regression to see if the results are robust, and the results are shown in Table 5 below.

It can be seen from the regression in Table 5 that in the regression of the sample interval from 2008 to 2018, the goodness of fit R-squared of the model is 0.173, a good fit, and the F statistic value is 83.93, with a corresponding P value of 0, which shows that the model has passed the significance test. The regression results of the sample size adjustment are consistent with the previous regression

results, that is, the coefficient of the independent variable $\text{treated} \times \text{time}$ is 0.088458, significant at the 1% level, which means that reducing the sample size does not change the sign and significance of the independent variable coefficient. That is; after reducing the sample size, the introduction of the green finance policy will still promote the level of corporate green technology innovation, so the modeling in this paper is reliable and robust.

Table 5. Robustness Test Results

	Variable Replacement	Sample Size Adjustment
VARIABLES	Intotal	Inuma
treated*time	0.103492*** (3.10)	0.088458*** (2.81)
tq	-0.015254 (-0.94)	-0.027166* (-1.75)
roa	-0.300156 (-1.14)	-0.081414 (-0.32)
lev	-0.230685 (-1.61)	-0.166549 (-1.18)
mtb	-0.112472 (-0.73)	-0.149540 (-0.99)
ta	0.410732*** (16.89)	0.275793*** (11.11)
age	0.386797*** (2.97)	0.260498* (1.80)
ppe	0.267008** (2.41)	0.379144*** (3.41)
rd	5.414676*** (8.43)	2.888929*** (4.57)
cash	-0.045632*** (-2.64)	-0.005190 (-0.31)
Constant	-9.354118*** (-16.16)	-6.248938*** (-10.21)
Observations	10,489	8,877
id fe	Yes	Yes
year fe	Yes	Yes
Number of id	807	807
R-squared	0.300	0.173
F test	0	0
r2 a	0.240	0.0876
F	188.1	83.93

t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

4.6. Mediation Effect Test

Because of the above regression, the mediating variable corporate liquidity debt financing is introduced. On this basis, this study intends to use an empirical research method to verify the impact mechanism of green finance policies on corporate green technology innovation. This paper uses the stepwise regression method for the test, and the results are shown in Table 6 below:

Table 6. Mediation Effect Test

	Equation (1)	Equation (2)	Equation (3)
Variable	lnuma	fr	lnuma
treated*time	0.118432*** (3.96)	0.014170*** (6.04)	0.114098*** (3.81)
fr			0.305802** (2.36)
tq	-0.013739 (-0.94)	0.000539 (0.47)	-0.013904 (-0.95)
roa	-0.141221 (-0.60)	0.076584*** (4.13)	-0.164641 (-0.70)
lev	-0.128414 (-1.00)	0.697095*** (69.33)	-0.341587** (-2.18)
mtb	-0.071531 (-0.51)	-0.000819 (-0.08)	-0.071281 (-0.51)
ta	0.288386*** (13.23)	-0.027510*** (-16.10)	0.296799*** (13.44)
age	0.149434 (1.28)	0.025582*** (2.79)	0.141611 (1.21)
ppe	0.436919*** (4.40)	-0.070465*** (-9.05)	0.458467*** (4.60)
rd	3.049651*** (5.30)	-0.018307 (-0.41)	3.055249*** (5.31)
cash	-0.014754 (-0.95)	-0.024261*** (-19.99)	-0.007335 (-0.46)
Constant	-6.405541*** (-12.34)	0.629716*** (15.47)	-6.598109*** (-12.56)
Observations	10,489	10,489	10,489
id fe	Yes	Yes	Yes
year fe	Yes	Yes	Yes
Number of id	807	807	807
R-squared	0.225	0.602	0.225
F test	0	0	0
r2 a	0.159	0.568	0.159
F	127.5	663.8	122.3

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

As can be seen from Table 6, the regression results of Model 2 are significant. The coefficient of the independent variable treated×time is positive and significant at the 1% level, indicating that the implementation of green finance policies increases the proportion of corporate liquidity debt financing. Because of the full regression, Model 3 incorporates the mediating variable. From the stepwise regression method, it can be observed that in Model 3 (note: the original text mentions "Model 4" which may be a typo, corrected to be consistent with the table label) with the mediating variable added, the coefficient corresponding to the variable treated×time is 0.114098, which is significant at the 1% significance level, and the coefficient of the mediating variable is 0.305802, which is significant at the 5% significance level. Therefore, according to the judgment criteria of the stepwise regression method, it can be concluded that corporate liquidity debt financing serves as a mediating variable and exerts a partial mediating effect on the dependent variable. In other words, the impact of green finance policies on corporate green technology innovation is partially transmitted through the mediating variable of corporate liquidity debt financing, and partially exerted directly by the green finance policies themselves.

5. Conclusions and Recommendations

5.1. Conclusions

Based on the sample data of A-share listed companies from 2008 to 2018, this paper empirically analyzes the impact of green finance policies on corporate green technology innovation. The main conclusions are as follows: ① by adopting the difference-in-differences (DID) model, this paper compares the impact of green finance policies on the technological innovation behaviors of small and medium-sized enterprises (SMEs) under different annual and individual scenarios, and reveals the internal mechanism through which green finance policies promote the improvement of SMEs' technological innovation capabilities. ② Green finance policies can affect the technological innovation capabilities of micro, small, and medium-sized enterprises by influencing their liquidity debt financing. ③ to promote the sustainable development of the economy and address

environmental challenges, governments and financial institutions should continue to strengthen the formulation and implementation of green finance policies. Meanwhile, enterprises should actively respond to policy orientations and increase investment in green technology innovation.

5.2. Recommendations

At present, China's green finance system is mainly dominated by green credit. Its formulation and implementation are in line with China's overall development trend, and its implementation effect is the best reflection of the strength and efficiency of China's green financing. The research finds that reducing enterprises' capital investment and their willingness for green technology innovation can significantly improve enterprises' overall green innovation capabilities, but has no obvious effect on enhancing their overall innovation capabilities. This indicates that China's green credit system still has certain deviations, and the supervision over its implementation is insufficient. Governments, enterprises, and banks can use digital technology to establish an information sharing platform, realize information interconnection and exchange, improve the transparency of policy information, and reduce the possibility of enterprises' "rent-seeking" behavior, thereby promoting enterprises' green financing and further facilitating their green innovation. In addition, universities and research institutions should be encouraged to strengthen research in the field of green finance, cultivate professional talents, and provide intellectual support and innovative solutions for enterprises' green transformation. Through these measures, a healthier and more sustainable green finance ecosystem can be constructed, which will further stimulate enterprises' green innovation vitality and promote the green development of the economy.

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