

The Impact of Green Finance on Corporate Green Innovation: Operating Cash Flow as a Mediating Channel

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Abstract

Against the institutional backdrop of the ongoing implementation of China's "Dual Carbon" strategy and green finance policies, this paper examines the impact of green finance on corporate green innovation from the perspective of cash flow mediation. Based on panel data of Chinese A-share listed companies from 2015 to 2024, this study uses the green finance index as the core explanatory variable and corporate green innovation as the dependent variable. A two-way fixed effects model is constructed to test the underlying mechanism, heterogeneous effects and transmission mechanism of green finance. The baseline regression results show that green finance significantly promotes corporate green innovation, indicating that the development of green finance can provide important support for enterprises to carry out green technology research and green transformation. This conclusion remains valid after several robustness tests, including replacing the dependent variable and using the lagged core explanatory variable, which confirms the reliability of the empirical results. The heterogeneity analysis further shows that the effect of green finance is more significant in state-owned enterprises, highly profitable enterprises and heavily polluting enterprises. This suggests that enterprises with stronger resource advantages, better profitability or greater environmental pressure are more likely to benefit from green finance policies. The mediation test shows that cash flow is an important channel through which green finance promotes corporate green innovation. Green finance can improve firms' operating cash flow, ease financial constraints in research and development activities, and indirectly encourage enterprises to increase green innovation investment. The results indicate that cash flow plays a partial mediating role, meaning that green finance affects green innovation through both direct and indirect channels. Overall, this paper enriches the empirical evidence on the micro-level effects of green finance and provides a reference for improving green finance policies and promoting enterprise green transformation under the "dual carbon" strategy.

Keywords

green finance, corporate green innovation, cash flow, two-way fixed effects, transmission channels

1. Introduction

Against the backdrop of mounting pressure from global climate change, promoting sustainable development has become a major issue of widespread concern for the international community. In September

2020, in his speech at the General Debate of the 75th Session of the United Nations General Assembly, President Xi Jinping announced that China aims to peak carbon dioxide emissions before 2030 and achieve carbon neutrality before 2060 [1]. Following the introduction of the "dual carbon" goals, my country's economic transition toward a green and low-carbon model has gained a clearer strategic direction, thereby highlighting the increasingly prominent role of green finance in economic development. Green finance links environmental governance with economic growth and channels more capital into low-carbon and eco-friendly sectors; it has thus become a key force in driving the green transition and achieving carbon peak and carbon neutrality goals. In terms of the policy advancement process, the development of my country's green finance system has undergone a period of sustained progress. In 2016, the People's Bank of China, together with seven other government departments, issued the *Guidelines for Establishing the Green Financial System*; this marked the first time my country formulated a relatively systematic, top-level design for the development of a green financial system at the national level. Since then, the 19th National Congress of the Communist Party of China proposed to develop green finance and build a beautiful China. The 20th National Congress of the Communist Party of China further emphasized the need to improve the financial policy and standard system to support green development. Since the beginning of 2024, the People's Bank of China, the National Financial Regulatory Administration, the China Securities Regulatory Commission, and other departments have successively issued a series of policy documents—such as the *Guiding Opinions on Further Strengthening Financial Support for Green and Low-Carbon Development*, the *Opinions on Leveraging Green Finance to Serve the Construction of a Beautiful China*, the *Implementation Plan for High-Quality Development of Green Finance in the Banking and Insurance Sectors*, the *Implementation Opinions on Capital Markets Effectively Addressing the "Five Major Tasks" in Finance*, and the *Overall Statistical System for the "Five Major Tasks" in Finance* [2]. These documents have made more arrangements for the work of green finance and brought more specific policy support to the high-quality development of green and low-carbon. After years of promotion, China's green financial policy framework has gradually formed a relatively complete system, and the scale of the green financial market continues to expand. By the end of the third quarter of 2025, the scale of China's broad green financial market has reached 48.55 trillion yuan, and the whole year is expected to be close to 50 trillion yuan [3]; Under such circumstances, enterprises have become key actors in green technological innovation and the transition toward greener production modes. Their green innovation ability will directly affect the realization effect of carbon peaking and carbon neutrality goals, and also affect the promotion of high-quality economic development; Therefore, examining the impact of green finance on corporate green innovation can, on the one hand, enrich the research on the effect of green finance policies and the reasons that drive green innovation of enterprises. On the other hand, it can also provide some practical references for improving the green financial policy system and guiding enterprises to do green transformation.

With the deepening of the concept of green finance and green development, scholars at home and abroad have made a lot of discussions on the economic and environmental effects of green finance, and the relevant research results are also relatively rich. Generally speaking, the existing literature can be understood from both macro and micro levels.

At the macro level, most of the existing studies revolve around two aspects, one focuses on the relationship between green finance and economic transformation, and the other discusses the impact of green finance on regional green development. In terms of economic transformation, Guo Xiyu (2022) found that the panel data of China's provincial administrative regions to analyze, and the results showed that the development of green finance has a significant role in promoting the transformation of low-carbon economy in the region [4]. Similarly, Meng Xiaoqian and Wu Chuanqing (2025) reported that green finance is regarded by them as promoting the green transformation of the economy, and this impact will also show a certain positive spatial spillover effect [5]. Yan Jiajia and Jie Qiongnan started from the policy of the green financial reform and innovation pilot zone and found that the policy could further promote the transformation of urban low-carbon economy by promoting the upgrading of industrial structure [6]. Su J. (2026) focuses on the transformation of industrial structure, and makes a more systematic analysis of the core mechanism, promotion mode and current shortcomings of green finance [7]. It can be seen from these studies that green finance is not only a tool to provide funds, but also has an impact on the process of low-carbon economic transformation with the help of capital allocation and industrial adjustment. Regarding the impact of green finance on regional green development, Tu Qiang, Zuo Limei and Zhang Xuying (2025) selected China's provincial panel data from 2012 to 2022, set up the green financial reform innovation pilot zone as a quasi-natural experiment, and used the double difference model for testing. Through research, their findings indicate that the pilot zone for green

financial reform and innovation can promote regional green development by stimulating green technology innovation, optimizing capital allocation and promoting industrial structure upgrading [8]. Chen Mei (2023) argued that the process of mutual integration and mutual promotion from the relationship between green finance and high-quality development of the regional economy [9]. Song C (2026) also shows that green finance can guide capital to flow into the environmental protection industry, support the research and development and application of green technology, further optimize the regional industrial structure, improve the efficiency of resource utilization, and reduce environmental pollution [10].

From the micro level, studies have focused more on enterprises, mainly discussing the impact of green finance on corporate financing, ESG performance and emission reduction behavior. In terms of enterprise financing, Tao Z (2023) found that the green finance pilot zone policy has expanded the financing scale of green enterprises on the one hand, and compressed the financing scale of polluting enterprises on the other hand [11]. Chen Yin'e and Zhao Ying (2023) further demonstrated that green finance can help small and micro enterprises ease capital constraints by improving the profitability, operating capacity and expansion of enterprises [12]; Li Ziyang (2023) further found that the policy of the green financial reform and innovation pilot zone, and also found that green finance has a significant alleviation effect on the financing constraints of enterprises in the pilot zone [13]. Regarding ESG performance, Sun Y and Wang D (2025) empirically showed that with the triple difference method based on the data of listed companies in China from 2012 to 2020. The results showed that the green financial reform innovation pilot zone policy can significantly improve the ESG performance of those seriously polluting enterprises [14]. Zhu H and Li X (2025) took A-share listed companies from 2014 to 2022 as a sample and found that the Green Finance Pilot Policy (GFPP) has a significant effect on the ESG performance of enterprises [15]. Liu Lin and Zhang Yuqing (2025) further demonstrated that ESG performance can promote green innovation of enterprises by easing financing constraints and improving information transparency, and green finance plays a positive regulatory role in this process [16]. Sun Wenyan and Xu Fangyuan (2026) analyzed the data of "specialized and innovative" enterprises and found that the more outstanding the ESG performance of such enterprises, the easier it is to get green financial support, and this mechanism is mainly manifested in both analysts' attention and green innovation [17]. Meng Jin and Zheng Rui (2025) also found that the development of green finance can significantly improve the ESG performance of energy enterprises [18]. In terms of emission reduction, Qin Yutong (2024) found that the synergy of green financial policies and the market can reverse the significant positive spatial spillover effect generated by the development of a single market, so that the carbon emission intensity of industrial enterprises in surrounding areas can be reduced [19]; Kang Cuiyu (2024) further explained that the development of green finance in China has a pronounced inhibitory effect on the intensity of carbon emissions, but this impact is not simply linear, but a "inverted V"-shaped change characteristic [20].

Generally speaking, the existing research on green finance is relatively rich, which provides a good theoretical basis and empirical reference for this article. However, judging from the existing literature, there are still some shortcomings. First, some literature pays more attention to the relationship between green finance and green development. There is still room for further deepening on how green finance directly affects the green innovation of enterprises, especially in the identification of cause and effect. Second, there have been studies that the discussion of the heterogeneity of enterprises is not systematic enough, and there are large differences between enterprises themselves. Enterprises with different property rights, profitability levels and industry attributes are not exactly the same in terms of financing constraints, policy sensitivity and innovation motivation. Therefore, the effect of green finance on different enterprises may also be different. Third, with the release of the *Overall Plan for the Reform of the Ecological Civilization System* in 2015 and the introduction of the carbon peaking and carbon neutrality ("Dual Carbon") goals in 2020, China's green finance system entered a stage of accelerated development. However, the sample periods used in some existing studies do not adequately cover this period, making it difficult to capture the most recent effects of green finance on corporate green innovation.

Based on the above considerations, this paper selects China's A-share listed companies from 2015 to 2024 as research samples to empirically test the impact of green finance on the green innovation of enterprises. This paper first builds a benchmark regression model to investigate the relationship between the two, and on this basis, the reliability of the conclusion is verified through robustness test. Then, heterogeneity analysis is carried out to study the differences in the effect of green finance in different enterprises, and finally combined with the mediating effect test to analyze the mechanism of action in the middle. The marginal contribution of this

article is mainly reflected in three aspects: First, expand the sample interval to the new stage after the dual carbon goal is put forward, so as to give updated realistic evidence; Second, a multi-dimensional heterogeneity test was carried out, which supplemented the micro-level evidence for the role of green finance in the green innovation of enterprises; Third, by using cash flow as a mediating variable, the study identifies the transmission pathways through which green finance promotes corporate green innovation, thereby offering an alternative perspective for understanding how green finance facilitates corporate green transformation.

2. Theoretical Foundation and Research Hypotheses

2.1 Relevant Theories

Green finance can be understood as an important financial institutional arrangement to promote economic and social green transformation and corporate green innovation. The G20 Green Finance Research Group proposed in the *G20 Green Finance Synthesis Report* that green finance is “investment and financing activities that can generate environmental benefits to support sustainable development”. The environmental benefits mentioned here mainly include reducing pollution emissions, reducing greenhouse gas emissions, improving resource use efficiency, and mitigating and adapting to climate change [21]. The *Guidelines for Establishing the Green Financial System* jointly issued by the People's Bank of China and other seven ministries and commissions further pointed out that green finance is mainly to support economic activities such as environmental improvement, climate change response and resource conservation and efficient utilization, and to provide financial services such as project investment and financing, project operation and risk management for environmental protection, energy conservation, clean energy, green transportation, green construction and other fields. In other words, as long as the relevant financial services can serve the goal of green development, they can be included in the discussion of green finance. In a broad sense, green finance includes not only financial resources flowing to green economic activities, but also financial support to help high-energy-consuming and high-pollution industries complete the green and low-carbon transformation, as well as financial services for the development of green technology innovation and green emerging industries; In a narrow sense, it refers more to the financial support received by economic activities with zero carbon emissions or close to zero carbon emissions [22].

Green finance primarily provides external financial and policy support, whereas green innovation represents an internal transformation undertaken by firms. When facing environmental pressure, enterprises will integrate environmental protection requirements into product development, production technology, service model and management system. Such activities are generally referred to as green innovation. Rennings (2000) explained this concept earlier. He proposed that green innovation includes new perspectives, new products, new services, new processes or new management systems for dealing with environmental problems [23]. Wu Dejun (2019) pointed out that on the one hand, green innovation reflects the "green" at the level of social responsibility, and on the other hand, it can include the content of economic development from "innovation", which can not only help enterprises deal with environmental problems and improve environmental performance, but also improve the competitiveness of enterprises by reducing production costs and adopting differentiated management [24]. Therefore, compared with general innovation, green innovation attaches more importance to combining economic benefits and environmental benefits, which is an important way for enterprises to achieve green transformation and sustainable development.

2.2 Research Hypotheses

The effect of green finance in promoting green innovation of enterprises is mainly reflected in the following aspects. First, green finance can alleviate the capital pressure faced by enterprises when carrying out green innovation. Green innovation generally requires high costs first, and the recovery cycle is long and the uncertainty is high. It is difficult to sustainably promote by relying on internal funds alone. The development of green finance can promote enterprise innovation by easing financing constraints, and has a relatively pronounced positive impact on the green non-invention patents of enterprises (Wang Yulin and Zhou Yahong, 2023) [25]. Second, green finance can guide enterprises to form a long-term green development orientation. Green finance emphasizes the unity of environmental benefits and economic benefits, and requires enterprises to pay more attention to resource utilization efficiency, pollution emission control and sustainable business ability while obtaining financial resource support. For enterprises that hope to get long-term support from

financial institutions and investors, improving the level of green development and green innovation ability will help to enhance their market recognition. Xie Xuemei and Zhu Qiwei (2021) mentioned that the practice of green innovation by enterprises is closely related to the legitimacy, green image and strategic differentiation of enterprises in society. Green innovation can help enterprises form different advantages from others in market competition [26]. Therefore, green finance can not only relieve the capital pressure of enterprises' green innovation, but also promote enterprises to integrate green innovation into their long-term development strategies. Third, green finance can improve the green innovation momentum of enterprises through information disclosure and external supervision. Green finance usually requires enterprises to disclose relevant information such as environmental management, pollution emissions, and the implementation of green projects, which helps to improve the transparency of enterprise information, and also facilitates financial institutions and investors to see what environmental risks enterprises have and whether their operations are stable. Guo Baitao et al. (2026) found that media attention can significantly strengthen the effect of green finance in promoting green innovation of enterprises [27]. In order to maintain a good green image and obtain more financial resources and market recognition, enterprises will also pay more attention to green technology research and development and green transformation activities. Therefore, under the background of the coexistence of green financial constraints and incentives, enterprises are more motivated to continue to carry out green innovation. Based on this, this paper puts forward the hypothesis:

H1: Green finance can promote green innovation of enterprises.

In the process of green finance promoting green innovation of enterprises, cash flow may play a mediating role. Green innovation has the characteristics of long investment cycle, high capital occupation, and uncertain short-term returns. Therefore, whether an enterprise has stable cash flow will directly affect the continuity of its green innovation activities. Compared with general business investment, green technology research and development and environmental protection equipment transformation rely more on long-term financial support.

The effect of cash flow in green finance affecting the green innovation of enterprises is mainly reflected in the following aspects. First, the improvement of cash flow can enhance the continuity of green innovation investment of enterprises. Short-term green innovation may only bring stage benefits, while the long-term competitive advantage of enterprises comes more from the accumulation of continuous innovation ability. Therefore, if enterprises want to form a stable green competitive advantage, they need to continue to promote green innovation activities (Tang Long and Chen Xiangguang, 2024) [28]. If the enterprise lacks stable cash flow, green research and development activities are easily interrupted by business fluctuations. The research on enterprise innovation by Wen Jun and Feng Genfu (2018) shows that enterprise innovation activities are closely related to capital conditions, and a good capital base helps enterprises to continue to carry out innovation activities [29]. Yang Guozhong and others' research on the financing constraints of enterprise green technology innovation further pointed out that there is a positive correlation between enterprise green technology innovation investment and internal cash flow, indicating that internal cash flow is an important factor affecting the investment of enterprise green technology innovation [30]. Therefore, stable cash flow can provide more sustainable financial security for enterprises' green research and development, green product development and production process improvement. Second, cash flow can affect the risk-taking ability of enterprises for green innovation. Hall (2002) pointed out that R&D activities are more likely to face financing difficulties than general investment, mainly because R&D investment has the characteristics of uncertain results, high degree of information asymmetry, and difficult mortgage of knowledge assets and intangible assets [31]. Because continuous green innovation activities require a large amount of R&D funds, the risk of early investment, R&D difficulty and output uncertainty are all large, and the R&D cycle is long, but the time to obtain relevant benefits is relatively short [28]. When the cash flow of an enterprise is tight, the management is more likely to choose projects with short return cycles and fast capital recovery, and reduce investment in green research and development. Tang Long and Chen Xiangguang (2024) pointed out that capital chain risks and liquidity risks will weaken the cash flexibility of enterprises, and insufficient cash flexibility will make enterprises' continuous green innovation activities more susceptible to external shocks, and increase the risk of interruption of innovation activities and unrecoverable investment [28]. This shows that stable cash flow and strong cash flexibility can improve the ability of enterprises to continuously carry out green innovation. Therefore, this article puts forward the hypothesis:

H2: Green finance can promote green innovation of enterprises by improving the cash flow of enterprises.

3. Research Design

3.1 Sample Selection and Data Sources

This paper selects Shanghai-Shenzhen A-share listed enterprises in China from 2015 to 2024 as research objects, and processes the samples as follows: Eliminate listed enterprises specially processed in the financial category and ST, *ST and PT categories; eliminate the samples with missing values; All continuous variables are contracted at a level of 1% to avoid the results being affected by extreme or abnormal values, and finally 12,749 observations were obtained. The data used comes from the CSMAR database, the Wind database, the China Research Data Service Platform (CNRDS platform), the Intellectual Property Office of the People's Republic of China, the National Bureau of Statistics and various statistical yearbooks.

3.2 Variable Definitions

3.2.1 Dependent Variable

Corporate Green Innovation. Drawing on the practice of Zhu Chaohui and others (2023), the number of green patent applications is adopted as the proxy variable of the green innovation level of enterprises [32]. Specifically, selecting the number of green patent applications of sample enterprises during the reporting period, standardizing the natural logarithm after adding 1, and constructing the corporate green innovation can effectively alleviate the interference of the long tail distribution to the panel regression model. Green patents can be divided into green inventions, green utility models and green appearance design patents. Because green invention patents can better reflect the innovation quality of enterprises, the number of green invention patent applications (*Innovation_inv*) is used for testing in the robustness inspection part.

3.2.2 Independent Variable

Green Finance (GF). Drawing on the research methods of Zhang Shuhui and Ren Chongtao (2025) [33] and Du Lixia (2024) [34], based on the four indicators of green credit, green securities, green insurance and green investment, the entropy value method is used to obtain the final results to measure the level of green financial development.

3.2.3 Mediating Variable

Cash Flow Ratio (*CashFlow*). It is measured as the ratio of net cash flow from operating activities to total assets.

3.2.4 Control Variables

Following existing studies, this study includes the following control variables: leverage (*Lev*), profitability (*ROA*), growth opportunities (*TobinQ*), CEO duality (*Dual*), the proportion of independent directors (*Indep*), ownership concentration (*Top1*), and firm size (*Size*). In addition, industry (*Industry*) and year (*Year*) fixed effects are controlled for.

The specific variable definitions in this article are shown in Table 1.

Table 1: Variable Definitions

Variable Type	Variable	Symbol	Measurement
Dependent Variable	Corporate Green Innovation	<i>Innovation</i>	Natural logarithm of the total number of green patent applications plus one
Independent Variable	Green Finance Development	<i>GF</i>	Green finance index
Mediating Variable	Cash Flow Ratio	<i>CashFlow</i>	Net cash flow from operating activities divided by total assets
Control Variable	Leverage	<i>Lev</i>	Measured by the debt-to-asset ratio
	Profitability	<i>ROA</i>	Measured by return on assets
	Growth Opportunities	<i>TobinQ</i>	Measured by Tobin's Q (market value/total assets)
	CEO Duality	<i>Dual</i>	Equals 1 if the chairman of the board and the CEO are the same person, and 0 otherwise
	Proportion of Independent Directors	<i>Indep</i>	Ratio of the number of independent directors to the total number of directors
	Ownership Concentration	<i>Top1</i>	Shareholding ratio of the largest shareholder
	Firm Size	<i>Size</i>	Natural logarithm of total assets at year-end

3.3 Model Specification

This study employs a two-way fixed-effects model to test the research hypotheses and establishes the following regression model, drawing on the approach of Wen and Ye (2014) [35]. Construct a model (1) to examine the impact of green finance on corporate green innovation, focusing primarily on β_1 ; if the coefficient is significantly positive, it indicates that green finance promotes corporate green innovation. Model construction (2): Examine the relationship between green finance and corporate cash flow, focusing primarily on α_1 ; if the coefficient is significantly positive, it indicates that green finance can improve the corporate cash flow position. Model construction (3): Test whether a mediating effect of cash flow exists between green finance and corporate green innovation.

$$Innovation_{i,t} = \beta_0 + \beta_1 GF_{i,t} + \beta_2 Controls_{i,t} + Year + Industry + \varepsilon_{i,t} \quad (1)$$

$$CashFlow_{i,t} = \alpha_0 + \alpha_1 GF_{i,t} + \alpha_2 Controls_{i,t} + Year + Industry + \varepsilon_{i,t} \quad (2)$$

$$Innovation_{i,t} = \gamma_0 + \gamma_1 GF_{i,t} + \gamma_2 CashFlow_{i,t} + \gamma_3 Controls_{i,t} + Year + Industry + \varepsilon_{i,t} \quad (3)$$

Here, *Innovation* is the dependent variable, representing the company's level of green innovation, while *GF* is the independent variable, representing the level of green finance development in the province where the company is located. *CashFlow* is the mediating variable, *i* and *t* denote the firm and the year respectively, and *Control* represents control variables; *Year* and *Industry* represent the time effect and the industry effect, respectively; $\varepsilon_{i,t}$ is the random error term.

4. Empirical Results and Analysis

4.1 Descriptive Statistics

The descriptive statistical results of the main variables in this article are shown in Table 2. The sample consists of 12,749 firm-year observations. And the sample scale was large. The average value of green innovation of the dependent variable enterprise is 1.085, and the standard deviation is 1.302, indicating that the overall level of green innovation of sample enterprises is not high and the individual differences are significant. The descriptive statistics indicate that the overall development of green finance is relatively high, and the standard deviation also reflects the pronounced differentiation of the green financial environment in which different enterprises are located. Each control variable is in a reasonable range, and there are no extreme abnormal values, which lays a good foundation for subsequent empirical analysis.

Table 2: Descriptive Statistics

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Innovation	12749	1.0852	1.3020	0.0000	5.2311
GF	12749	0.6685	0.2083	0.0913	0.9281
Lev	12749	0.4087	0.2016	0.0603	0.8821
ROA	12749	0.0345	0.0633	-0.2272	0.1840
TobinQ	12749	2.0678	1.3180	0.8227	7.9566
Dual	12397	0.3245	0.4682	0.0000	1.0000
Indep	12749	0.3810	0.0533	0.3333	0.5714
Top1	12749	0.3390	0.1494	0.0848	0.7272
Size	12749	22.3208	1.3667	19.9963	26.3951

4.2 Baseline Regression Analysis

In order to test the overall impact of green finance on the green innovation of enterprises, this paper gradually introduces the two-way fixed effect of control variables, time and industry for benchmark regression. The results of benchmark regression are shown in Table 3. Column (1) The control variable is not added, and the green finance GF is significantly positive at the 1% statistical level; Column (2) After adding the enterprise-level control variables, the coefficient of GF is still significantly positive at the 1% level; Column (3) further control the fixed effect of the year and industry to exclude the interference of macroeconomic shock and industry heterogeneity. The results show that the coefficient of GF is 0.14, which is significantly positive, indicating that green finance can significantly promote the improvement of the green innovation level of

enterprises. The research hypothesis of this article is verified by H1. Under the background of the dual carbon goals strategy and the continuous improvement of the green financial system, green finance has given full play to the functions of capital guidance and resource allocation, effectively guiding social capital to flow into the fields of enterprises' green research and development, technology transformation, and stimulating the green innovation vitality of enterprises.

Table 3: Baseline Regression Results

	(1)	(2)	(3)
	Innovation	Innovation	Innovation
GF	0.178***	0.359***	0.140***
	(3.372)	(7.740)	(3.159)
Lev		0.320***	0.163***
		(5.136)	(2.846)
ROA		-0.419***	-0.458***
		(-2.587)	(-3.062)
TobinQ		0.009	0.009
		(1.199)	(1.221)
Dual		0.040*	0.006
		(1.848)	(0.313)
Indep		0.336*	-0.120
		(1.682)	(-0.701)
Top1		-0.231***	0.242***
		(-3.173)	(3.654)
Size		0.452***	0.548***
		(40.714)	(54.009)
cons	0.966***	-9.449***	-11.338***
	(26.644)	(-36.619)	(-48.676)
N	12749	12397	12393
R ²	0.001	0.240	0.457
adj. R ²	0.001	0.240	0.453

t statistics in parentheses

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

4.3 Robustness Tests

In order to exclude interference such as variable measurement deviation and endogenous problems, and to ensure the reliability of the baseline regression conclusion, this paper conducts a robustness test from multiple dimensions, and the results are shown in Table 4. First, replace the dependent variable, and use the logarithm of the enterprise's green invention patent application as an alternative indicator for green innovation. The regression results show that the coefficient of the core explanatory variable green finance is 0.21, which is significantly positive, indicating that the conclusion is not affected by the measurement method of the dependent variable. Green finance can not only increase the number of green innovations, but also promote the upgrading of the quality of innovation. Second, in order to alleviate the potential endogenous problem of reverse causality, this paper returns the lag of the core explanatory variable to the first phase, and the coefficient is still significantly positive, indicating that the effect of green finance in promoting green innovation of enterprises is stable. Third, only control the year fixed effect for regression, and regress after excluding the industry fixed effect. The GF coefficient is 0.277, which is still significantly positive at the 1% level. It shows that after changing the fixed effect setting of the model, there is no substantial change in the symbol and significance of the core explanatory variable, which further verifies the robustness of the benchmark regression conclusion.

Table 4: Robustness Test Results

	(1)	(2)	(3)
	Innovation inv	Innovation	Innovation
GF	0.210*** (5.204)		0.277*** (5.864)
Lev	-0.071 (-1.373)	0.125* (1.937)	0.351*** (5.623)
ROA	-0.604*** (-4.497)	-0.600*** (-3.530)	-0.356** (-2.171)
TobinQ	0.029*** (4.191)	-0.007 (-0.720)	0.016** (1.984)
Dual	0.011 (0.608)	0.024 (1.072)	0.029 (1.332)
Indep	0.045 (0.281)	-0.215 (-1.104)	0.315 (1.579)
Top1	0.297*** (4.877)	0.226*** (2.963)	-0.189*** (-2.589)
Size	0.490*** (46.934)	0.571*** (50.072)	0.448*** (39.882)
L1_GF		0.141*** (2.710)	
_cons	-10.448*** (-43.166)	-11.767*** (-44.992)	-9.333*** (-35.646)
N	12393	9765	12397
R ²	0.406	0.474	0.245
adj. R ²	0.402	0.469	0.244

t statistics in parentheses

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

4.4 Heterogeneity Analysis

From the perspectives of ownership, industry pollution intensity, and profitability, this section examines the heterogeneous effects of green finance on corporate green innovation. The results are shown in Table 5. First, in terms of the nature of property rights, green finance plays a more significant role in promoting green innovation of state-owned enterprises, while the impact on private enterprises is relatively weak. This may be because state-owned enterprises have a natural advantage in policy response and financing, and can use green finance to promote innovation more efficiently. Second, judging from the pollution attributes of the industry, green finance has a significant role in promoting the green innovation of enterprises in heavy pollution and non-heavy pollution industries. Second, the estimated coefficient is larger for heavily polluting industries, and the significance level of non-heavy pollution industries is higher. This may be because enterprises in heavy pollution industries usually face stricter environmental supervision and higher pollution control costs, which leads to a stronger marginal promotion effect of green finance on green innovation. Enterprises in non-heavy pollution industries may be relatively less affected by business fluctuations and environmental protection policies. The investment in green innovation of enterprises is more stable, and the internal differences in the sample are lower, so that the estimated results are more stable. Third, in terms of profitability, the effect of green finance in promoting green innovation of high-ROA enterprises is more pronounced. One possible explanation is that profitable enterprises usually have a more stable capital base and stronger risk-taking capacity, and can transform green financial support into green R&D input and innovation output. In contrast,

low-ROA enterprises may face greater operating pressure and capital constraints. Even with green financial support, they are more likely to be prioritized to maintain daily operations or relieve short-term financial pressure, and it is difficult to translate into green innovation activities.

Table 5: Heterogeneity Analysis Results

	(1)	(2)	(3)	(4)	(5)	(6)
	SOEs	Private Enterprises	Heavily Polluting	Non-Heavily Polluting	High ROA	Low ROA
	Innovation	Innovation	Innovation	Innovation	Innovation	Innovation
GF	0.356*** (4.410)	0.033 (0.595)	0.200** (2.126)	0.138*** (2.760)	0.297*** (4.777)	-0.064 (-1.021)
Lev	-0.396*** (-3.543)	0.469*** (6.913)	-0.192 (-1.615)	0.288*** (4.406)	-0.091 (-1.192)	0.563*** (6.227)
ROA	-0.254 (-0.663)	-0.076 (-0.460)	-0.167 (-0.504)	-0.478*** (-2.865)	-0.162 (-0.727)	-1.045*** (-2.797)
TobinQ	0.008 (0.406)	0.006 (0.728)	0.109*** (6.353)	-0.005 (-0.596)	0.087*** (6.577)	-0.010 (-0.956)
Dual	-0.047 (-0.837)	0.051** (2.461)	-0.163*** (-4.008)	0.041* (1.916)	0.028 (0.985)	-0.006 (-0.239)
Indep	0.262 (0.836)	-0.357* (-1.776)	-0.177 (-0.470)	-0.152 (-0.797)	0.156 (0.640)	-0.486** (-2.038)
Top1	0.357*** (2.909)	-0.142* (-1.825)	0.752*** (5.427)	0.109 (1.457)	0.192* (1.943)	0.281*** (3.121)
Size	0.650*** (35.125)	0.442*** (33.448)	0.671*** (34.818)	0.512*** (43.305)	0.614*** (40.597)	0.511*** (36.508)
cons	-13.851*** (-33.532)	-8.842*** (-29.069)	-14.409*** (-32.090)	-10.504*** (-39.096)	-13.050*** (-37.567)	-10.293*** (-32.039)
N	3787	8603	2400	9978	6149	6239
R ²	0.593	0.368	0.547	0.443	0.490	0.444
adj. R ²	0.585	0.362	0.541	0.438	0.482	0.436

t statistics in parentheses

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

4.5 Mediation Effect Analysis

Table 6 reports the results of the mediation analysis examining the effect of operating cash flow. Column (1) shows that the regression coefficient of green finance is 0.140, which is significant at the statistical level of 1%, indicating that green finance can significantly promote green innovation of enterprises. Column (2) uses operating cash flow as the dependent variable. The regression coefficient of green finance is 0.005, which is significantly positive at the statistical level of 5%, indicating that the development of green finance helps to improve the operating cash flow of enterprises. Column (3) After adding green finance and operating cash flow at the same time, the coefficient of green finance is 0.143, which is still significantly positive at the level of 1%; The coefficient of operating cash flow is -0.517, and it is significantly negative at the level of 1%, indicating that the indirect effect through operating cash flow is negative to the direct direction of green finance. After joining the operating cash flow, the green finance coefficient rose from 0.140 to 0.143, which further shows that the operating cash flow may play a negative role in the process of green finance promoting green innovation of enterprises, rather than a positive mediation effect. The positive direct effect of green finance on the green innovation of enterprises is partially offset by the negative indirect path of cash flow. The possible reasons are: First, green innovation is characterized by large investment and long recovery cycle. Enterprises increasing green research and development, paying salaries of research and development personnel and

carrying out green equipment transformation will consume operating cash flow, so enterprises with high green innovation in the current period may show low operating cash flow. Second, enterprises with abundant cash flow may not use new funds for green innovation, but may also give priority to expanding traditional business, repaying debts, paying dividends or making short-term investments. Therefore, the improvement of cash flow does not necessarily translate into green R&D investment.

Table 6: Mediation Analysis Results: The Cash Flow Mechanism

	(1)	(2)	(3)
	Innovation	CashFlow	Innovation
GF	0.140*** (3.159)	0.005** (1.972)	0.143*** (3.215)
Lev	0.163*** (2.846)	-0.007* (-1.851)	0.160*** (2.781)
ROA	-0.458*** (-3.062)	0.425*** (33.562)	-0.238 (-1.465)
TobinQ	0.009 (1.221)	0.004*** (8.042)	0.011 (1.499)
Dual	0.006 (0.313)	-0.002* (-1.825)	0.005 (0.256)
Indep	-0.120 (-0.701)	-0.003 (-0.275)	-0.121 (-0.710)
Top1	0.242*** (3.654)	0.015*** (4.010)	0.250*** (3.770)
Size	0.548*** (54.009)	0.005*** (8.922)	0.550*** (54.091)
CashFlow			-0.517*** (-3.449)
cons	-11.338*** (-48.676)	-0.088*** (-7.233)	-11.384*** (-48.810)
N	12393	12393	12393
R ²	0.457	0.281	0.458
adj. R ²	0.453	0.276	0.454

t statistics in parentheses

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

5. Conclusions and Future Prospects

5.1 Conclusions

This study uses A-share listed companies from 2015 to 2024 as a research sample to empirically examines the impact of green finance on the green innovation of enterprises, and further examines the mediating role of cash flow and the heterogeneous impact under the characteristics of different enterprises. The study mainly draws the following conclusions.

First, green finance can significantly promote the green innovation of enterprises. The baseline regression results indicate that the benchmark regression, the improvement of the level of green finance has a significant positive effect on the green innovation of enterprises. After further robustness testing through the method of variable replacement, using the one-period lagged explanatory variable and only controlling the fixed effect of the year, the core conclusion is still valid, indicating that the research results have strong robustness.

Second, the test results of the mediating effect show that green finance can improve the cash flow of enterprises and relieve the capital pressure of enterprises in the process of green innovation, thus further promoting green innovation of enterprises.

Third, there is pronounced heterogeneity in the effect of green finance in promoting green innovation of enterprises. Judging from the nature of property rights, the effect of green finance in promoting green innovation of state-owned enterprises is more significant, while the impact on non-state-owned enterprises is relatively weak. In terms of pollution attributes, green finance has a promoting effect on both heavily polluting enterprises and non-heavy polluting enterprises, but its role in heavily polluting enterprises is more prominent, which shows that green finance can accelerate the green transformation of high-pollution industries. In terms of profitability, the effect of green finance in promoting green innovation for highly profitable enterprises is more pronounced, while the impact on low-profitable enterprises is relatively weak, indicating that the enterprise's own business status may affect their ability to use green financial resources to carry out innovative activities.

5.2 Policy Recommendations

First, further improve the green financial support system and improve the accurate support ability of green finance for the green innovation of enterprises. The government and financial institutions are encouraged to continue to improve green credit, green bonds, green funds and other financial instruments to guide more funds to the fields of green technology research and development and green production transformation. At the same time, the identification of green projects and the disclosure of environmental information could also be strengthened to reduce the cost of financial institutions to identify green innovation projects and improve the efficiency of green financial resource allocation.

Second, pay attention to the support of enterprise cash flow and ease the constraints of green innovation financing. Due to the long-term and uncertainty of green innovation, enterprises are prone to financial pressure in the process of research and development. Therefore, the cash flow of enterprises could be improved through loan discounts, green special funds, tax incentives, etc., and the ability of enterprises to continuously carry out green research and development should be enhanced. Financial institutions should also design more flexible financing terms and repayment arrangements according to the characteristics of the long cycle of green innovation projects.

Third, implement differentiated green financial policies for different types of enterprises. For non-state-owned enterprises, we should further lower the threshold of green financing, improve their financing availability, and avoid excessive concentration of green financial resources in state-owned enterprises. For heavily polluted enterprises, green financial constraints and incentives should be strengthened to guide them to accelerate technological transformation and green transformation. For enterprises with weak profitability, more policy support could be provided under the premise of risk control to prevent them from giving up green innovation due to lack of funds.

5.3 Research Limitations and Future Research Directions

There are still some shortcomings in this article, and the follow-up research can be further expanded from the following aspects. First, this paper mainly adopts the two-way fixed-effects model for empirical analysis. Although some endogeneity problems have been alleviated through robustness testing, there is still room for further improvement in causal identification. Follow-up research can more accurately identify the causal effect of green finance on green innovation of enterprises by introducing the pilot zone policy of green finance reform and using the DID model to carry out quasi-natural experiments. Second, the research samples in this article are mainly A-share listed companies. The sample range is relatively limited and fails to fully cover small, medium and micro enterprises and non-listed companies. Follow-up research can further extend the sample scope and include more types of enterprises in the scope of analysis, so as to improve the micro-effect research system of green finance. Third, this article mainly examines the mechanism of green finance affecting the green innovation of enterprises from the perspective of cash flow. There is still room for expansion in the mechanism analysis. Follow-up research can expand the intermediary and adjustment path, such as further examining mediating or moderating variables such as financing constraints, research and development

investment, government subsidies, environmental regulations, etc., so as to further examine the multi-dimensional role mechanism of green finance in promoting green innovation in enterprises.

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Conflicts of Interest

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