A Research of Green Finance on Green Innovation

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Abstract. Enterprise green innovation is an important way to achieve the goal of "double carbon" in China and promote high-quality economic growth. This paper constructs a fixed-effect econometric model based on the annual reporting data of A-share listed companies from 2011 to 2021, and studies the influence of green finance on enterprises' green innovation behavior from all aspects. The main results of the analysis are as follows: (1) Green finance has a significant positive impact on the green innovation of enterprises, and it still holds after many robustness tests. (2) Its role in green innovation is mainly through two channels, namely, alleviating the financing friction faced by enterprises and improving the standard of information disclosure. (3) Heterogeneity analysis shows that green finance plays a stronger role in promoting state-owned enterprises and large enterprises, but has no statistical significance in promoting non-state-owned entities and small and medium-sized enterprises. It not only provides reliable empirical support for the theoretical path of linking green finance with green innovation, but also brings practical policy impact to government agencies to improve the policy coordination framework and enterprises to rationally allocate innovation resources.

Keywords: green finance, green innovation, financing constraints, information transparency

1. Introduction

On July 14th, 2025, China officially released the Catalog of Green Financial Support Projects. The main purpose of the plan is to use green financial tools to improve the ecological environment and promote the transformation of the economy to a green and low-carbon operation mode. At present, the global climate challenge is becoming more and more serious. Green finance is an important lever in this situation. It can guide capital from industries with high pollution and high energy consumption to green industries and advanced technologies, and provide financial support for green technological innovation [1].

Enterprises have turned their attention from pure profit to green transformation. Green innovation is an important driving force. It is an innovation of products, processes or management practices, which is beneficial to environmental sustainability [2]. It combines ecological advantages with economic advantages, and improves the competitiveness and long-term viability of enterprises while restraining pollution [3]. Enterprises are the micro-foundation of the green economy, which is very important to achieve the goal of "double carbon" and promote high-quality development [4].

Therefore, it is of great practical significance to study how to effectively promote the green innovation of enterprises.

Although the green innovation of enterprises is influenced by many driving factors, the existing academic research has not systematically studied how green finance affects green innovation. The main function of green finance is to guide social capital to flow into green and low-carbon industries and promote new economic growth points [5]; Green innovation can promote the green transformation and energy efficiency improvement of traditional industries and enhance the core competitiveness of enterprises [6]. In this case, a detailed investigation into the transmission channels of green finance affecting green innovation can not only enrich the theoretical research framework in related fields, but also provide empirical guidance for enterprises' green transformation practice and the improvement of green financial policies.

This paper selects China A-share listed companies from 2011 to 2021 as samples, empirically analyzes the impact of green finance on green innovation and explores its impact mechanism, hoping that this work can provide theoretical reference and enlightenment for perfecting and improving green financial policies.

The contributions of this paper are primarily manifested in the four aspects outlined below.

First of all, the research scope of this paper is cross-domain integration. Although there have been many studies on the driving factors of green innovation and the economic impact of green finance, there are few systematic studies on bringing them into a unified analytical framework. At present, most studies emphasize how macro-level factors promote green innovation [7-9]. However, in this context, insufficient attention has been paid to green finance. This paper mainly explores how green finance specifically affects the green innovation of enterprises, and then gives purposeful theoretical support to support enterprises to carry out green transformation.

Secondly, this paper overcomes the limitation of relying only on a single intermediary factor from the research point of view. Previous studies mostly used a single intermediary variable to study the relationship between green finance and enterprise green innovation. In the current research, financing friction and information disclosure standards are included in the analysis model. This method reveals the internal mechanism of green finance affecting green innovation of enterprises by exploring the double intermediary compound path at the micro-enterprise level.

2. Literature review

2.1. Research on the economic effects of green finance

Prior academic works have explored the economic impacts of green finance from both macro and micro angles. From a macro perspective, green finance contributes to high-quality economic growth and environmental enhancement. In terms of economic advancement, it refines resource distribution, strengthens information exchange, and drives industrial upgrading [10]. Green finance pilot areas have been found to restrict enterprises' pollution-related investments, upgrade industrial frameworks, and elevate green total factor productivity—with this effect being particularly notable in western China and regions with non-resource-dependent industries [11]. Certain studies note that green finance fosters regional green innovation by advancing human capital development and optimizing the business climate [12]. In terms of environmental gains, green finance policies aid in cutting industrial carbon emissions and their intensity [13], with spillover impacts on nearby areas. From an energy standpoint, green finance boosts local energy efficiency and supports the relocation of pollution-intensive industries [14].

In micro-enterprises, green finance reduces the financing cost of enterprises, promotes their green transformation and innovation, and reduces environmental violations. Green financial policy can reduce the credit spread of green bonds but increase the spread of brown bonds [15]. They urge polluting enterprises to improve environmental information disclosure [16]-this effect is more obvious in state-owned enterprises and areas with strong intellectual property protection systems [17]. In addition, these policies curb corporate environmental violations through green transformation, financing friction and stricter supervision of financial institutions [18].

2.2. Research on the influencing factors of green innovation

Current academic works on the determinants of green innovation mainly center on two aspects: the external policy context and internal corporate attributes.

Corporate green innovation is strongly shaped by the external policy environment, with environmental regulatory measures, environmental inspections, and low-carbon pilot schemes acting as core driving forces. Studies indicate that environmental supervision and green innovation have an inverted U-shaped association: moderate oversight boosts innovation momentum, whereas overly stringent requirements hinder innovative practices [19]. For specific policies, environmental inspections advance the concentration of green innovation resources and elevate the industry's overall innovation capacity by standardizing market operations and filtering innovation participants [20]; low-carbon pilot policies enable enterprises to pursue green innovation by guiding R&D spending and refining executive compensation incentives (such as those tied to environmental performance) [21].

Internally, firm characteristics such as digital transformation, executive awareness, and managerial capabilities are also key drivers of green innovation. Digital transformation enhances information sharing and knowledge integration, significantly boosting green innovation performance [22]. Executives' environmental awareness strongly promotes green innovation [23], and greater managerial proactiveness further facilitates its advancement [24].

3. Research hypothesis

Because of high cost, long payback period and high risk. Enterprises' green innovation faces financing difficulties. Green finance provides long-term stable funds in various ways [25]. It sends money to green enterprises and projects, helps traditional and emerging industries to upgrade their ecology, improve productivity and create an economic foundation for green innovation. Improve resource allocation, risk management and market pricing, promote the development of high-carbon industries in the direction of advanced intelligence, and enhance the greenness of strategic industries [26]. Use market mechanism and innovation to attract social investment to high-end environmental protection industries, and give key impetus to green innovation of enterprises [27].

H_1: Green finance has greatly enhanced the green innovation of enterprises.

There are great financing obstacles in green innovation projects, which stem from technical complexity and positive spillover effects, both of which will make it difficult for financial institutions to accurately assess risks. This will lead to an increase in financing costs and fewer ways for enterprises to obtain funds, thus slowing down the speed of R&D investment and delaying the process of green innovation. Green finance provides stable and diversified funds for R&D and technological progress, which lightens these constraints. Support reduces the financial pressure of enterprises [17], broadens the financing channels, urges enterprises to increase investment in

research and development, improves operational efficiency, and finally promotes the development of green innovation.

H_2: Green finance promotes green innovation of enterprises by alleviating financing constraints.

Environmental information disclosure is the link between capital market and technological innovation. However, due to the lack of sufficient verification and standardization, more and more corporate green behavior data have aroused people's concerns about digital green cleaning and reputation deficit. This detracts from the value of green innovation efforts. Green financial policy relies on institutional innovation to achieve higher disclosure standards to meet this challenge [28]. Such policies provide basic standards and promote a market-led certification system, including third-party evaluation. Disclosure of technical development plans and carbon footprint can reduce investors' perceptual bias, and standardized environmental, social and governance reports establish traceable environmental responsibilities, improve transparency and meet shareholders' priorities [29]. Therefore, improving disclosure can narrow the information gap, improve the liquidity of the stock market, reduce financing costs and promote green innovation activities [30].

H_3: Green finance promotes green innovation of enterprises by improving the quality of information disclosure.

4. Model construction and variable selection

4.1. Data sources and description

This research takes A-share listed enterprises in China (covering 2011–2021) as the research sample, with sample screening conducted through the following steps: First, listed financial firms and enterprises designated as ST, *ST, or PT are excluded; second, observation samples with incomplete data are removed. A final dataset of 31,570 observations is constructed.

Data were collected from authoritative statistical sources, including provincial and municipal statistical yearbooks, environmental status bulletins, and various national publications. Additional data were obtained from official websites of institutions including the People's Bank of China (PBOC), company annual reports, and corporate websites. Other firm-level data were sourced from the CNRDS database, CSMAR database, Wind database, and the China National Intellectual Property Administration.

4.2. Variable description

4.2.1. Independent variable: green finance GF_i

Considering the development features and data accessibility of China's multi-tiered green financial system, this paper adopts the entropy weight method to build a composite green finance index covering seven dimensions [31]. The specific component indicators and their measurement approaches are outlined below: (1) For the green credit dimension, the credit allocation ratio of environmental protection projects is used as the proxy variable; the green investment dimension is quantified by the share of pollution control investment in GDP; the green insurance dimension is measured by the proportion of pollution liability insurance revenue in total insurance premiums; the green bond dimension is represented by the ratio of green bond issuances to total bond issuances; the green support dimension is reflected by the share of fiscal environmental expenditure in total budgetary spending; the green fund dimension is calculated as the ratio of green fund market value

to the overall market value of all public funds; the green equity dimension is gauged by the proportion of carbon and emission trading volume in the total equity market scale.

4.2.2. Dependent variable: green innovation GC_i

The measurement method of enterprise's green innovation level is: based on the total amount of green patent applications submitted by enterprises, it is calculated by adding 1 after natural logarithm conversion [32].

4.2.3. Control variables

Building on insights from prior related research [4,33,34], this study integrates the following control variables into its analysis: Return on assets: Computed as the ratio of a firm's net profit to its total assets; Asset-liability ratio: Measured by the share of total liabilities relative to a firm's total assets; Equity concentration: Captured by the combined shareholding of the top five largest shareholders; Tangible asset ratio: Defined as the proportion of tangible assets within a firm's total assets; Cash-to-current assets ratio: The proportion of cash holdings in a firm's current asset portfolio; Firm age: Calculated by first adding 1 to the number of years the enterprise has been publicly listed, then applying a natural logarithm transformation to the result.

4.2.4. Mechanism variables

This study measures financing constraints using the absolute value of the SA index [35], where a larger value denotes a higher constraint level.

For information transparency, we adopt the Shenzhen Stock Exchange's corporate information disclosure ratings (categorized as Excellent=4, Good=3, Pass=2, Fail=1) [36], with a higher score indicating greater transparency.

4.3. Model construction of green finance on green innovation

This paper adopts the fixed effects model, with the formula as follows:

$$GC_i=\alpha+\beta GF_i+\tau X_i+f_i+\varepsilon_i \tag{1}$$

GC_i represents the level of green innovation of firm i, GF_i denotes the comprehensive green finance index; X_i is the control variables, τ is the coefficient vector of controlled variables; i represents the individual, f_i captures individual fixed effects; ε_i is the idiosyncratic error term.

4.4. Descriptive statistics

The descriptive statistical results for each variable are summarized in Table 1.

Table 1. Descriptive statistics

	Variables	Symbol	Obs	Mean	SD	Min	Max
Independent Variable	Green Finance	GF_i	31021	0.593	0.074	0.422	0.748
Dependent Variable	Green Innovation	GC_i	31021	0.421	0.871	0	7.062
Control Variables	Firm Size	Size	31021	22.14	1.342	14.942	28.636
	Return on Assets	Roa	31021	4.843	73.465	-7503.3	1066.15
	Asset-Liability Ratio	Rol	31021	0.426	1.047	-0.195	178.346
	Equity Concentration	Central	31021	53.9	15.599	0.8109	99.23
	Tangible Asset Ratio	Tar	31021	0.925	0.095	0.062	1
	Firm Age	Age	31021	2.02	0.953	0	3.466
	Cash Asset Ratio	Car	31021	0.168	0.137	-0.004	0.999
Mechanism Variables	Financing Constraint	SA	31021	-3.8	0.268	-5.646	-1.455
	Information Transparency	Inform	23818	3.029	0.634	1	4

5. Empirical results and tests

5.1. Benchmark regression

In Table 2, the coefficient of green finance is positive and significant at the 1% level, supporting Hypothesis H_1 that green finance promotes corporate green innovation. Regarding control variables, firm size, tangible asset ratio, and firm age also show significantly positive effects. Larger size and higher tangible assets provide financial security, while greater age brings accumulated experience and stronger organizational capabilities, all conducive to green innovation.

Table 2. Benchmark regression

	GC_i
GF_i	0.458***
	(0.062)
Control variables	Control
Fixed effect	Control
Obs	31021
R^2	0.7398

Note: *,**, and*** denote statistical significance at the 10%, 5%, and 1% levels respectively; Robust standard errors are reported in parentheses; For simplicity, only the estimated results of the independent variables are reported here.

5.2. Robustness test

This research employs five approaches to conduct robustness checks, with the detailed test findings presented in Table 3.

First, variable winsorization processing: Variables associated with green finance and green innovation are winsorized at the 1% and 99% quantiles, after which they are reintroduced into the regression model for re-estimation. Second, explanatory variable replacement: Drawing on prior studies [4], a new integrated index is built using the dimensions of green credit, green bonds, green insurance, green investment, and carbon finance. Third, the sample elimination test. Excluding the observation data of Beijing, Chongqing, Shanghai and Tianjin, the remaining samples were regressed. Fourthly, the regression of sample partition. Divide the total sample into three regions: east, middle and west, and carry out sub-regional regression tests respectively. Fifth, explain the lag treatment of variables. The green innovation variable is delayed by one observation period, and it is estimated by regression model again.

Table 3. Robustness test results

	GC_i		
	(1)	(2)	(3)
	Winsorizing	Replacing explanatory variable	Removing special cities
GF_i	0.421***	0.395***	0.535***
	(0.06)	(0.099)	(0.072)
Obs	31021	31021	24767
R^2	0.7259	0.7394	0.7276

	GC_i		
	(4)		(5)
	Narrowing the sample interval		Lagging the explained variable by one period
	Eastern region	Central region	Western region	
GF_i	0.411***	0.648***	0.424**	0.429***
	(0.073)	(0.163)	(0.174)	(0.072)
Obs	22726	4719	3578	26792
R^2	0.7509	0.7285	0.6784	0.7420

Notes are the same as Table 2.

5.3. Heterogeneity analysis

5.3.1. Equity heterogeneity

To examine ownership-based heterogeneity, Table 4 presents regression results for state-owned enterprises (SOEs) and non-SOEs. Column (1) shows a significantly positive coefficient for green finance in SOEs, indicating a stronger promoting effect. This is because SOEs' closer government ties facilitate access to green funding, and their greater social responsibility aligns with green policy goals, motivating green innovation. In contrast, non-SOEs face stronger market competition and financing constraints, limiting the effect of green finance.

Table 4. Equity heterogeneity

	GC_i	
	SOEs	non-SOEs
GF_i	0.664***	0.085
	(0.106)	(0.084)
Obs	10722	20224
R^2	0.7815	0.7129

Notes are the same as Table 2.

5.3.2. Scale heterogeneity

Firms are categorized into large-scale enterprises and small-to-medium-sized enterprises (SMEs) based on the median value of firm size, followed by group-wise regression analysis. The significantly positive coefficient in column (1) in Table 5 shows that green finance notably promotes green innovation in large-scale enterprises. This is because larger firms possess more abundant resources and greater risk resilience, creating a better environment for innovation. In contrast, SMEs face higher financing constraints that substantially increase the difficulty of green innovation, despite their strong willingness to innovate.

Table 5. Scale heterogeneity

	GC_i	
	large-scale enterprises	small-to-medium-sized enterprises
GF_i	0.552***	-0.015
	(0.100)	(0.084)
Obs	15902	14714
R^2	0.7875	0.6723

Notes are the same as Table 2.

6. Mechanism testing

This study examines financing constraints and information disclosure quality as mediators. The test results are presented in Table 6.

The significantly negative coefficient for green finance in column (1) indicates that it alleviates financing constraints. This alleviation promotes green innovation by reducing financing costs, enhancing risk-bearing capacity, and improving the ability to utilize policy incentives [37,38]. Thus, the above analysis validates Hypothesis H_2.

The significantly positive coefficient in column (2) indicates that green finance improves corporate information disclosure quality. Higher disclosure quality enhances resource allocation, strengthens incentives and accountability, boosts market reputation, and improves policy response efficiency, thereby increasing both motivation and capability for green innovation [39,40]. Thus, the above analysis validates Hypothesis H_3.

Table 6. Mechanism test

	SA	Inform
GF_i	-0.937***	2.625***
	(0.009)	(0.05)
Obs	31021	23818
R^2	0.9465	0.6257

Notes are the same as Table 2.

7. Conclusions and recommendations

This research reveals that green finance exerts a significant promotional effect on corporate green innovation. It functions by easing financing frictions and elevating the quality of information disclosure, which in turn underscores the key roles of optimizing resource distribution and boosting transparency. Additionally, this effect is more prominent among state-owned enterprises and large-scale firms.

To this end, this paper puts forward the following policy suggestions. First, strengthen policy coordination and promote the construction of a green financial system. Government departments and financial regulators should make joint efforts to expand the scope and depth of national green financial policies in a systematic way. This includes promoting the development of various green financial products. These measures are conducive to the formation of a stable policy environment, and then generate sustained incentives. Second, strengthen the dual channels of financing and information. The government should encourage financial institutions to innovate risk assessment models to finance green projects. At the same time, enterprises should unify standards and strengthen environmental information disclosure. Third-party evaluation can improve the credibility of information and reduce information asymmetry, thus improving the allocation of resources. Third, implement a differentiated strategy to improve the inclusiveness and pertinence of policies. For state-owned and large enterprises with inherent advantages, policies should set higher green innovation goals and play a demonstration role. At the same time, it is necessary to tailor support for

small and medium-sized enterprises and micro-enterprises, reduce the cost of green transformation of small and medium-sized enterprises and micro-enterprises, and make the benefits of green finance benefit more people more fairly.

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