

Green Finance Empowering Corporate Green Innovation Based on the Dual Mechanisms of Resource Allocation and Market Signaling

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Abstract. This study empirically examines the impact of green finance on corporate green innovation, its regional heterogeneity, and underlying mechanisms using a sample of A-share listed companies in Shanghai and Shenzhen stock exchanges from 2010 to 2023. The findings reveal three key insights: First, green finance significantly promotes corporate green innovation, a conclusion that remains robust in both one-period lag tests and alternative sample interval robustness checks. Second, the effect exhibits distinct regional heterogeneity - the western region demonstrates the strongest and most significant positive impact, while the eastern region shows a positive but statistically insignificant effect, and the central region displays no significant impact. Third, the study identifies two primary mechanisms through which green finance influences green innovation: alleviating financing constraints by providing specialized financing instruments, policy endorsements, and synergistic effects that enhance capital accessibility for green innovation projects; and transmitting market signals through improved information disclosure, third-party evaluations, and increased market attention that channels resources toward green innovation initiatives. These findings provide micro-level evidence for understanding the green finance-innovation nexus and offer theoretical foundations for optimizing green finance policy design.

Keywords: Green finance, Corporate green innovation, Financing constraints, Market signaling

1. Introduction

The adoption of the Paris Agreement's global temperature control targets has transformed climate change mitigation from scientific consensus into collective action. Within this context, green finance has emerged as a pivotal mechanism for directing capital flows toward environmentally sustainable sectors. At the international level, coordinated efforts are evident through the G20 Green Finance Study Group's standardization initiatives and the European Union's landmark Sustainable Finance Taxonomy [1], while China has concurrently developed a multi-tiered green financial market system. Market innovations continue to proliferate, with green bonds, ESG investing, and transition finance instruments shifting financial paradigms from risk mitigation to value creation, thereby addressing the sustainable development funding gap.

Parallel to these financial innovations, corporate green innovation strategies are undergoing fundamental transformation. The strategic focus has evolved from passive regulatory compliance to active competitive advantage building [2], with innovation scope expanding from end-of-pipe treatment technologies to comprehensive low-carbon process innovations and green product design. The driving forces behind this shift now extend beyond policy pressure to include consumer preferences and supply chain requirements. However, this strategic advancement faces significant structural constraints within the financial system: the long development cycles of green technologies conflict with traditional finance's short-term return expectations, creating temporal mismatches; the inherent uncertainty of innovative projects exacerbates financial institutions' risk aversion; and fragmented green certification standards substantially increase corporate compliance costs. The World Bank has particularly highlighted the "green premium" financing challenges faced by emerging market enterprises.

The impact of green finance on corporate green innovation has garnered significant scholarly attention. Existing research has developed a multifaceted framework analyzing policy effects, transmission mechanisms, and heterogeneous responses.

Studies indicate that green finance policies, such as pilot reforms and the “Bond Connect” program, stimulate corporate green innovation by alleviating financing constraints, optimizing resource allocation, and promoting industrial upgrading [3]. Digital green finance further enhances innovation through technological empowerment and improved capital accessibility, particularly among SMEs and less-polluting firms [4].

Green innovation is driven by synergistic internal and external factors. Key internal drivers include ESG performance, digital transformation, and corporate environmental awareness. Enhanced ESG performance facilitates innovation by improving transparency and financing conditions [5], while digital transformation strengthens innovation capacity through increased operational transparency and risk tolerance [6]. Divergent ESG ratings may also motivate innovation, though financing constraints can weaken this effect [7].

Externally, institutional pressures, regulatory policies, and media attention significantly moderate green finance effects. Regulatory pressure reinforces the influence of green finance on ESG performance [8], and environmental target-based policies strongly promote green innovation, especially in state-owned and high-pollution firms [9]. Media coverage amplifies these effects, with positive reports having greater impact [10]. Integrating emission trading with green finance further supports green transition [11], whereas financial misallocation diminishes it—a drawback mitigated by digital transformation [12].

Notwithstanding these contributions, current scholarship exhibits two critical limitations: predominant focus on isolated financial instruments rather than synergistic effects, and fragmented analysis of transmission mechanisms that fails to integrate financing and signaling pathways. This study aims to address these gaps through two original contributions: First, developing a unified analytical framework incorporating seven green finance instruments to examine combinatorial effects and regional heterogeneity. Second, advancing a dual-pathway theoretical model grounded in resource allocation and signaling theories, thereby enhancing mechanistic explanatory power.

2. Theoretical Framework and Research Hypotheses

Green finance, as an institutional arrangement integrating environmental objectives with financial functions, fundamentally aims to direct financial resources towards environmentally sustainable sectors. Through multiple mechanisms, it directly incentivizes corporate green innovation. From a resource allocation perspective, green finance channels social capital—via instruments such as green credit, green bonds, and green funds—into corporate green R&D projects and environmental technology upgrades. This redirects funding away from traditional high-pollution and high-energy-consumption projects, creating a “positive incentive” for green innovation activities [13]. From a risk compensation perspective, green finance reduces the risk cost associated with corporate green innovation through risk-sharing mechanisms. Given that green innovation is characterized by long R&D cycles, substantial investment, and high uncertainty, green financial instruments mitigate firms’ concerns about innovation failure, through risk-adjusted pricing or loss compensation, thereby enhancing their willingness to undertake green innovation [14]. Furthermore, green finance policies compel enterprises to redirect resources towards green innovation by setting green investment thresholds that restrict funding access for non-green projects.

Based on the above analysis, Hypothesis H1 is proposed: Green finance significantly promotes corporate green innovation.

A core obstacle to corporate green innovation is financing constraints. Sustained and substantial capital investment is required throughout the green innovation process, including R&D, equipment acquisition, and technology commercialization. However, due to the strong positive environmental externalities and weak asset collateralizability of green innovation, traditional financial institutions

often adopt a cautious stance. This results in firms facing high financing costs or difficulties [4]. Green finance alleviates this constraint through targeted mechanisms: Firstly, green financial instruments provide dedicated financing channels for corporate green innovation projects, reducing reliance on traditional collateral and directly increasing capital supply [15]. Secondly, green finance policies reduce information asymmetry through policy endorsement, guiding financial institutions to increase trust in green innovation projects and lower financing interest rates [16]. Thirdly, the synergistic effects of green finance further broaden financing channels by lowering transaction costs, making it easier for firms to secure funds for green innovation [17].

The alleviation of financing constraints provides a solid material foundation for corporate green innovation. Regarding the innovation input stage, improved financing enables firms to allocate more funds to green R&D activities. This allows for increased investment in green patent technologies and environmentally friendly processes, the acquisition of advanced energy-saving and emission-reduction equipment, and the introduction of green production technologies. It also facilitates hiring high-end R&D talent in fields like environmental science and low-carbon technology, forming specialized innovation teams, and even establishing dedicated green technology laboratories or R&D centers, thereby providing human and technical support for green innovation [10][4]. Regarding the innovation output commercialization stage, sufficient financial support helps firms accelerate the transition of green innovations from the laboratory to industrialization. On one hand, funds can be invested in pilot testing to resolve scaling challenges in production. On the other hand, firms can modify existing production lines and build marketing channels for green products to promote market penetration and achieve the large-scale application of green innovations [16]. This cyclical mechanism—"funding supports green R&D, innovation output generates market value, and market returns fuel subsequent R&D"—not only ensures the continuity of corporate green innovation activities but also enhances the endogenous motivation for firms to pursue green innovation through value realization, fostering a sustainable innovation ecosystem [13].

Based on the above analysis, Hypothesis H2 is proposed: Green finance promotes corporate green innovation by alleviating financing constraints.

Information asymmetry constitutes another key factor constraining corporate green innovation. The environmental and economic value generated by corporate green innovation activities is often difficult for external stakeholders to fully recognize, hindering the effective aggregation of resources. Green finance reduces information asymmetry by transmitting market signals, thereby incentivizing green innovation: Firstly, a firm's participation in green finance activities signals its commitment to green transformation, conveying to the market its emphasis on environmental responsibility and sustainable development potential. This attracts attention and support from investors and partners [18]. Secondly, disclosure requirements within the green finance system compel firms to publicize information related to green innovation, enhancing transparency, reducing "greenwashing," and increasing stakeholder trust in their innovation activities [11]. Thirdly, the market-oriented mechanism of green finance, reinforced by third-party assessments, strengthens signal transmission, enabling firms with high levels of green innovation to receive more resource allocation [19].

Positive market signals significantly propel corporate green innovation by both facilitating access to external resources and incentivizing sustained investment through reputation mechanisms. Specifically, such signals convey the firm's proactive stance and development potential in green transformation to the market. This helps attract external entities—such as investors and partners—to provide financial, technical, and other support for green innovation projects. Simultaneously, it enhances governmental recognition of the firm's green practices, increasing the likelihood of policy support [24]. Under the influence of the reputation mechanism, firms aiming to maintain their image as "green innovators" will integrate green innovation into their long-term development strategies. They will proactively increase investment in green technology R&D, accelerate the application of innovation outcomes, and develop endogenous motivation for continuous green innovation, thereby consolidating their competitive advantage in the field of green development [21].

Based on the above analysis, Hypothesis H3 is proposed: Green finance promotes corporate green innovation by transmitting market signals.

3. Research Design

3.1. Variable Specification

3.1.1. Explained Variable

This study measures corporate green innovation (GI) using the ratio of green patent applications to total patent applications filed by a firm in the current period. Patent application counts are preferred over granted patents because patent approvals exhibit a 1- to 2-year lag and lack stability, whereas application data more timely reflects policy impacts on corporate innovation behavior. This metric effectively mitigates interference from unobservable macroeconomic factors and aligns with [22], who similarly employ green patent applications to measure corporate green innovation.

3.1.2. Explanatory Variable

Green finance encompasses the totality of financial services supporting environmental improvement, climate change mitigation, and resource-efficient utilization. It influences corporate green innovation by directing capital toward green industries and incentivizing corporate green transformation. Consistent with existing research recognizing green finance's multidimensional nature [23], this study constructs a Green Finance Development Index (GF) integrating seven core dimensions: green credit, green investment, green insurance, green bonds, government support, green funds, and green equities.

To objectively synthesize information across these seven dimensions, we employ the entropy method [23]. This approach determines indicator weights by calculating information entropy, thereby avoiding subjective weighting bias. A higher GF value indicates more advanced regional green finance development. Given the time-lagged effect of green finance on corporate green innovation, we apply a one-period lag to the GF index to more accurately capture its actual impact.

3.1.3. Control Variables

To isolate the influence of other factors on corporate green innovation, we include control variables across three dimensions: corporate characteristics, corporate governance, and external environment. Corporate characteristics include: Firm size (Size), Profitability (ROA), Capital structure (LEV), Growth potential (TobinQ). Corporate governance includes: Ownership concentration (TOP1), Board size (BOARD). External environment includes: Regional economic development level (LNPGDP)

3.1.4. Mechanism Variables

The study examines two primary mechanisms through which green finance affects green innovation:

- (1) Alleviation of financing constraints (measured by the FC index, where higher values indicate stronger constraints)
- (2) Reduction of information asymmetry through signaling corporate green transformation (measured by analyst coverage)

Detailed variable definitions are presented in Table.1.

Table 1. Variable definition and description

Variable Name	Symbol	Definition
Green Innovation	GI	Green patent applications / Total patent applications in current period
Green Finance Index	GF	Measured via entropy-weighted composite index (see Section 3.1.2)
Firm Size	Size	ln (total assets)
Profitability	ROA	Net profit / Total assets
Capital Structure	LEV	Total liabilities / Total assets
Growth Potential	TobinQ	Tobin's Q ratio
Ownership Concentration	TOP1	Shareholding percentage of largest shareholder
Board Size	BOARD	ln (number of directors)
Regional Economic Level	LNPGDP	ln (regional GDP per capita)
Financing Constraints	FC	FC index (higher values indicate stronger constraints)
Analyst Attention	AA	ln (number of analysts+1)
Regional Dummies	East	Whether it belongs to the eastern region: 1 yes, 0 no
	Mid	Whether it belongs to the central region: 1 yes, 0 no
	West	Whether it belongs to the Western region: 1 yes, 0 no

3.2. Model design

In order to test the impact of green finance on enterprise green innovation, the following model is constructed

$$GI_{it} = \beta_a + \beta_b GF_{jt} + \gamma X + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

GI is the level of green innovation of enterprises; GF is the Green Finance Index; β_a , β_b are the estimation parameters, X is the control variables at the city level and enterprise level, and μ and λ represent the fixed effect of enterprises and time respectively. ε is a random perturbation term. Subscripts i, j, and t represent the enterprise, city, and year respectively.

3.3. Data Sources

This study uses A-share listed companies in the Shanghai and Shenzhen stock exchanges from 2010 to 2023 as the initial sample. To ensure data quality, it excludes ST firms, financial enterprises, and observations with missing or anomalous data. Data are sourced from the China Stock Market & Accounting Research (CSMAR) database, including provincial per capita GDP, green finance indices, sample firms' balance sheets, income statements, annual basic information tables, the China Listed Companies' Ownership Concentration files, and relative valuation indicators. The final sample comprises 10,926 company-year observations.

4. Empirical Results Analysis

4.1. Descriptive Statistics

Table 2 presents the descriptive statistics for the variables in this study. The mean value of Green Finance (GF) is 0.387, with a standard deviation of 0.097. This indicates variation in green finance development levels across the sample. The range between the minimum value (0.102) and the maximum value (0.609) further reflects differences in green finance participation or development

among the sampled entities. Green Innovation (GI) has a mean of 0.471 and a standard deviation of 0.349. Its values range from 0 to 1, demonstrating the distribution characteristics of corporate green innovation activities within the sample. This suggests that while some firms exhibit lower levels of green innovation, others have attained higher levels. The descriptive statistics for all other control variables fall within reasonable ranges.

Table 2. Descriptive statistical results

Variable	Obs	Mean	Std. Dev.	Min	Max
GI	10926	0.471	0.349	0	1
GF	10926	0.387	0.097	0.102	0.609
Size	10926	22.955	1.433	20.422	27.075
ROA	10926	0.032	0.06	-0.267	0.179
LEV	10926	0.498	0.182	0.089	0.895
TobinQ	10926	1.912	1.053	0.85	6.495
TOP1	10926	34.711	15.726	8.774	75.722
BOARD	10926	2.158	0.197	1.609	2.708
LNPGDP	10926	11.229	0.464	10.108	12.156

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

4.2. Benchmark Regression Results Analysis

Table 3 presents the benchmark regression results in columns (1) and (2). Column (1) reports the results without control variables, showing a positive coefficient for Green Finance (GF) on Green Innovation (GI). Column (2) displays the results after incorporating individual and time fixed effects, along with other control variables. The coefficient of GF on GI remains positive and is statistically significant at the 1% level.

This indicates that green finance development significantly promotes corporate green innovation, providing initial evidence that green finance effectively supports firms' green innovation activities. Thus, Hypothesis H1 is supported.

From an economic perspective, the expansion of the green finance market and the diversification of its products and services—such as increased green credit quotas and active green bond markets—broaden enterprises' access to green innovation funding and reduce financing costs. This, in turn, incentivizes firms to allocate more resources to green innovation activities, thereby enhancing their green innovation levels.

Table 3. Benchmark regression results

	GI	
	(1)	(2)
GF	0.842***	0.887***
	(3.42)	(3.65)
Control	Yes	No
Company--fe	Yes	Yes
Year--fe	Yes	Yes
N	10916	10916
R ²	0.371	0.370

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

4.3. Robustness Tests

To ensure the reliability and validity of the findings, this study conducts robustness tests using lagged variables and altered sample sizes.

4.3.1. One-Period Lagged Core Variables

Considering the potential time-lagged effect of green finance on green innovation, we re-estimate the model by lagging the core explanatory variable (Green Finance Index) by one period. As shown in column (1) of Table 4, the coefficient of the one-period lagged Green Finance Index (GF) on Green Innovation (GI) is positive and statistically significant at the 5% level. This result aligns with the significantly positive impact of the contemporaneous GF observed in the benchmark regression, suggesting a persistent promoting effect of green finance on green innovation. Consequently, the support for Hypothesis H1 remains robust.

4.3.2. Altered Sample Size

To mitigate potential bias from sample selection, we adjust the sample period by excluding years 2021-2023 and re-estimate the model using data from 2010-2020. Results in column (2) of Table 4 indicate that the coefficient of GF on GI remains positive and significant at the 1% level. This consistency with the benchmark regression confirms that the promoting effect of green finance on green innovation persists even when narrowing the sample scope to focus on firms with observable green innovation activities.

Table 4. Robustness test results

	(1)	(2)
	One-Period Lagged Core Variables	Altered Sample Size
	GI	GI
GF		0.943***
gf	0.722**	(3.34)
Control	(2.46)	
	Yes	Yes
Company--fe	Yes	Yes
Year--fe	Yes	Yes
N	6505	8981
R ²	0.534	0.479

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

4.4. Heterogeneity Analysis

Given China's regional economic disparities and significant variations in green finance market maturity, corporate green innovation foundations, and policy support, we conduct subgroup regressions based on firm location (Eastern, Central, Western China) to examine regional heterogeneity. Table 5 presents the heterogeneity analysis results.

The results reveal pronounced regional heterogeneity in the impact of green finance on green innovation. In Western China, the coefficient of GF on GI is 1.603, positive and significant at the 1% level, indicating the strongest promoting effect in this region. Potential explanations include: although green finance development started relatively late in the West, substantial recent policy support has enhanced the effectiveness of green finance instruments in alleviating financing constraints for green innovation; concurrently, heightened ecological pressures and urgent corporate green transformation needs in the West make financial guidance more readily translate into tangible innovation incentives.

The pattern differs in Eastern China. The coefficient of GF on GI (0.573) is statistically insignificant even at the 10% level. Despite possessing the most mature green finance market and stronger corporate green innovation foundations, the marginal improvement space for green innovation may be relatively limited in this region. Alternatively, saturation of green finance resources in certain sectors could contribute to the lack of statistically significant promotion.

For Central China, the coefficient of GF on GI is negative (-1.220) and statistically insignificant. This outcome may relate to the "middle trap" phenomenon in the region's green finance development: its market maturity lags behind the East, resulting in constrained capital supply and product diversity, while simultaneously, weaker endogenous motivation and technological capabilities among firms hinder their ability to effectively absorb and transform green finance resources. Consequently, the anticipated promoting effect of green finance has yet to materialize.

Table 5. Results of heterogeneity analysis

	(1)	(2)	(3)
	eastern	Central	Western
GF	0.573	-1.220	1.603***
	(1.23)	(-1.47)	(2.81)
Control	Yes	Yes	Yes
Company--fe	Yes	Yes	Yes
Year--fe	Yes	Yes	Yes
N	7570	1893	1444
R ²	0.389	0.357	0.310

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

4.5. Mechanism Tests

To investigate the mechanisms through which green finance influences corporate green innovation, we extend the benchmark model (1) by constructing model (2) following Jiang Ting's operational guidelines for mediation effect analysis [24]. This framework categorizes mechanism variables into two pathways: alleviating financing constraints and transmitting market signals.

$$M = \beta_a + \beta_b GF_{jt} + \gamma X + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

Model (2) examines the relationship between the core explanatory variable GF and mechanism variable M, where M represents the two aforementioned pathways.

To empirically validate the dual pathways—financing constraint alleviation (FC) and market signal transmission (proxied by analyst attention, AA)—we estimate model (2) within Jiang Ting's mediation framework.

4.5.1. Financing Constraint Alleviation Pathway

Column (1) of Table 6 shows a statistically significant negative coefficient, indicating that green finance development substantially alleviates corporate financing constraints. This aligns with the theoretical premise that specialized financing channels, policy endorsements, and synergistic effects of green finance instruments lower capital acquisition barriers for green innovation activities, thereby providing empirical support for Hypothesis H2.

4.5.2. Market Signal Transmission Pathway

Column (2) of Table 6 reveals a statistically significant positive coefficient, demonstrating that green finance development increases analyst coverage (AA). This confirms the signaling pathway: participation in green finance activities, reinforced by disclosure requirements and third-party

evaluations, sends credible signals to the market. These signals attract resource allocation toward green innovation projects and enhance external support, yielding robust evidence for Hypothesis H3.

Collectively, these results establish that green finance promotes corporate green innovation through dual complementary mechanisms:

Financing constraint alleviation provides essential capital stability for R&D investment, talent acquisition, and technology commercialization.

Market signal transmission reduces information asymmetry, redirects external resources toward green innovation, and strengthens firms' endogenous motivation.

This "resource facilitation–market signaling" framework constitutes the core mechanism driving green innovation.

Table 6. Results of mechanism of action

	(1)	(2)
	FC	AA
GF	-0.164*	18.443***
	(-1.68)	(2.74)
Control	Yes	Yes
Company—fe	Yes	Yes
Year--fe	Yes	Yes
N	8401	8401
R ²	0.877	0.677

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

5. Conclusions and Policy Implications

5.1. Conclusions

Using a sample of A-share listed firms in Shanghai and Shenzhen (2010–2023), this study systematically examines the impact, regional heterogeneity, and mechanisms of green finance on corporate green innovation. Key findings are:

First, green finance exerts a significant positive effect on green innovation. Benchmark regressions show a significantly positive coefficient for GF on GI after controlling for firm characteristics, governance, external factors, and fixed effects. Robustness tests—including one-period lagged GF and a restricted sample (2010–2020)—confirm the result's persistence and stability.

Second, pronounced regional heterogeneity exists. The strongest promoting effect occurs in Western China, attributable to strong policy support and urgent corporate transformation needs. In Eastern China, the positive coefficient lacks statistical significance, likely due to diminishing marginal returns from green innovation or resource saturation. Central China shows an insignificant negative coefficient, reflecting a "middle trap" of underdeveloped green finance markets and weak corporate absorptive capacity.

Third, green finance operates through dual mechanisms:

Alleviating financing constraints (validating H2): Specialized financing, policy endorsements, and instrument synergy lower capital barriers.

Transmitting market signals (validating H3): Enhanced disclosure and third-party evaluations increase analyst attention (AA), reducing information asymmetry and attracting resources.

This "resource facilitation–market signaling" duality forms the core transmission mechanism.

5.2. Policy Recommendations

Based on these findings, we propose:

First, Enhance Synergy in Green Finance Instruments. Address limitations of standalone tools by promoting integrated use of green credit, bonds, and funds. Strengthen complementary effects through policy incentives—e.g., subsidize green credit interest for bond-issuing firms to create "bond + credit" financing loops. Expand green insurance coverage to mitigate innovation risks.

Second, Strengthen Market Signaling Mechanisms. Mandate standardized disclosures on green innovation fund utilization and environmental impact to curb greenwashing. Introduce third-party green innovation ratings linked to financing eligibility, directing resources toward high-performing innovators.

Third, Implement Regionally Differentiated Policies. For Western China: Increase policy tilt via green finance reform pilot zones, targeted relending, and risk compensation funds to ease financing bottlenecks. For Eastern China: Focus on "quality-efficiency enhancement" by promoting transition finance and carbon finance for high-value green R&D. For Central China: Upgrade financial infrastructure using fiscal incentives to attract institutions. Conduct green innovation capacity-building programs to improve resource absorption.

Last, Optimize Financing Constraint Mitigation. Address firm-level heterogeneity by establishing a "Certified Green Innovation Project List" for streamlined credit approval and reduced collateral requirements. Foster fintech-green finance integration to enable big-data-driven risk assessment and efficient capital allocation.

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