The Impact of Technology Finance on Corporate Green Innovation

Abstract

This study examines the impact of integrating technology and finance on corporate green innovation, drawing on a quasi-natural experiment from China's pilot program between 2007 and 2023. Employing a multi-period difference-in-differences (DID) framework, the research provides robust evidence that these tech-finance policies significantly bolster firm-level green innovation. Further analysis reveals that this positive effect is primarily channeled through two mechanisms: increased R&D investment and enhanced environmental information transparency. Conversely, the findings indicate that stricter financial regulation attenuates this beneficial impact. Heterogeneity analysis confirms the policy's effectiveness is more pronounced among privately-held, technology-intensive firms and those located in China's eastern regions.

Keywords: Technology Finance; Green Innovation; Difference-in-Differences (DID)

1. Introduction

Amid intensifying global climate change and resource constraints, green innovation has emerged as a key driver of sustainable corporate development. Unlike conventional technological innovation, green innovation emphasizes the integration of ecological and economic benefits. It helps firms improve environmental performance, achieve carbon reduction targets, and is increasingly recognized as an indicator of corporate social responsibility and long-term value (Rahmani et al., 2024). In the context of China's "dual carbon" strategy, green innovation has become essential for firms to survive and grow within competitive markets and under tightening environmental regulations. It facilitates industrial upgrading, high-quality development, and the transition to a green, low-carbon economic system. However, green innovation entails substantial investment, long timelines, and uncertain returns, often exposing firms to financing constraints and significant financial risks (Bacchiocchi et al., 2024). Addressing these funding challenges is therefore critical for both academics and policymakers.

Technology finance, a paradigm that integrates technological and financial innovation, enhances resource allocation by embedding digital capabilities into financial services. By leveraging tools such as big data analytics and artificial intelligence, it mitigates information asymmetry and broadens firms' access to funding (Khandani et al., 2010). Its adaptability in coordinating diverse resources and tailoring services enables responsive and flexible support for environmentally focused projects. Prior studies highlight the role of technology finance in promoting innovation among small and micro-enterprises (Gomber et al., 2018), financial institutions (Kou & Lu, 2025), and publicly traded firms (Dong & Yu, 2023). Yet, empirical evidence on its specific influence on green innovation and the underlying mechanisms remains limited, highlighting a clear need for further research.

To address this gap, this paper employs a quasi-natural experimental design using panel data from non-financial A-share listed firms in China. It investigates how technology finance advances corporate green innovation, examines the underlying transmission channels, and explores heterogeneity across different enterprise types. The findings enhance the understanding of the economic role of technology-finance integration and provide actionable insights for improving green finance infrastructure and resource allocation policies.

2. Theoretical Analysis and Research Hypothesis

2.1. The Direct Impact of Technology Finance on Corporate Green Innovation

Green innovation, though essential for sustainable development, often encounters serious financing barriers (Li et al., 2024). Projects in areas such as environmental protection, energy-saving equipment, and new energy typically involve high costs, long cycles, and uncertain outcomes, which increase firms' dependence on stable and flexible funding (Bacchiocchi et al., 2024). Yet, traditional financial systems frequently display strong risk aversion due to information asymmetry, outdated credit assessment, and limited awareness of green benefits (Cao et al., 2021), leading to restricted access to funds, high financing costs, and maturity mismatches for green projects.

Fintech provides new solutions to these constraints. By integrating big data, artificial intelligence, and blockchain, fintech platforms can capture non-financial indicators—such as firms' environmental performance, carbon emissions, and technological patents—to develop more accurate credit evaluation models (Lin & Hong, 2022). This helps reduce information asymmetry and improves financing availability. At the same time, fintech broadens capital supply through diverse instruments such as green credit, green bonds, and green industry funds (Tan et al., 2024), while also enhancing capital allocation efficiency via intelligent matching and dynamic risk control (Lin & Xie, 2025. These mechanisms jointly strengthen the financing capacity and risk resilience of firms undertaking green projects.

H1: Fintech promotes corporate green innovation.

2.2. Theoretical Mechanisms through which Technology Finance Influences Corporate Green Innovation

2.2.1. R&D Investment Mechanism

Green innovation depends heavily on sustained R&D investment (Xu et al., 2021), yet such investment often faces financing barriers. The long cycles, high costs, and uncertain returns of green technologies make firms—especially small and medium-sized enterprises—highly sensitive to external funding conditions (Dou et al., 2025). Traditional financing systems, constrained by information asymmetry and collateral requirements, frequently fail to provide sufficient long-term capital, thereby limiting firms' ability to undertake and sustain green R&D.

Technology finance offers more flexible and targeted funding solutions. By improving risk identification, technology matching, and resource allocation, it enhances firms' access to capital and strengthens their risk-bearing capacity in pursuing complex green projects. Beyond increasing funding availability, technology finance also improves capital efficiency. Evaluation mechanisms based on patent quality, research outcomes, and transfer potential help channel resources toward projects with higher technological and environmental value (Hao et al., 2024). At the same time, technology finance platforms provide supportive services such as project assessment, incubation, and technology matchmaking (Li et al., 2023), further raising the effectiveness of R&D investment. Through these mechanisms, technology finance not only secures more continuous and adequate funding but also optimizes its structure and efficiency, thereby reinforcing the input foundation of green innovation.

H2: Technology finance promotes corporate green innovation by increasing firms' R&D investment.

2.2.2. Environmental Information Disclosure Mechanism

Environmental information disclosure is an essential channel for firms to communicate ecological efforts and sustainability performance, thereby guiding the allocation of green financial resources. High-quality disclosure enhances firms' environmental credibility, reduces risks of moral hazard and adverse selection (Zhou et al., 2024), and improves the efficiency of financing green projects. Yet in practice, disclosure quality is often limited by high costs, inconsistent standards, and weak verification mechanisms, which restrict the effectiveness of green finance in supporting innovation.

Technology finance helps overcome these shortcomings by integrating digital tools such as big data, IoT, and cloud platforms. These technologies enable the real-time collection and processing of environmental metrics—including carbon emissions, resource use, and pollution control—thus shifting disclosure from formal compliance toward more accurate and transparent reporting (Hu et al., 2024). At the same time, technology finance platforms develop green rating metrics and sustainability indices (Wu, 2024), which improve investors' and creditors' ability to evaluate firms' environmental behavior. Enhanced disclosure not only strengthens external monitoring and regulatory oversight but also incentivizes firms to adopt cleaner technologies and maintain stable investment in eco-innovation.

H3: Technology finance promotes corporate green innovation by enhancing the quality of environmental information disclosure.

2.2.3. The Moderating Role of Financial Regulation

Technology finance plays an important role in resource allocation and risk mitigation for green innovation, yet its effectiveness is shaped by the broader institutional environment, particularly financial regulation. Moderate regulation helps stabilize markets, control systemic risks, and standardize green finance practices. However, overly stringent policies—such as excessive entry barriers, capital requirements, and data restrictions—may suppress financial innovation, weaken resource allocation, and limit the flow of capital to green projects (Arner et al., 2022).

Strict regulation increases compliance costs and reduces fintech institutions' willingness to engage in high-risk, long-cycle innovation projects, pushing them instead toward safer, short-term activities (Wu et al., 2024). At the same time, rigid data protection rules and multi-layered approval processes can constrain the ability of technology finance platforms to collect and analyze environmental information, undermining accurate credit evaluation and customized product design. Fragmented regulatory frameworks may also create inconsistent green finance standards, weakening the matching of capital with green project demand. As a result, the positive role of technology finance in fostering corporate green innovation may be weakened or even reversed under excessive regulatory pressure.

H4: Excessively stringent financial regulation may negatively moderate the effect of technology finance on corporate green innovation.

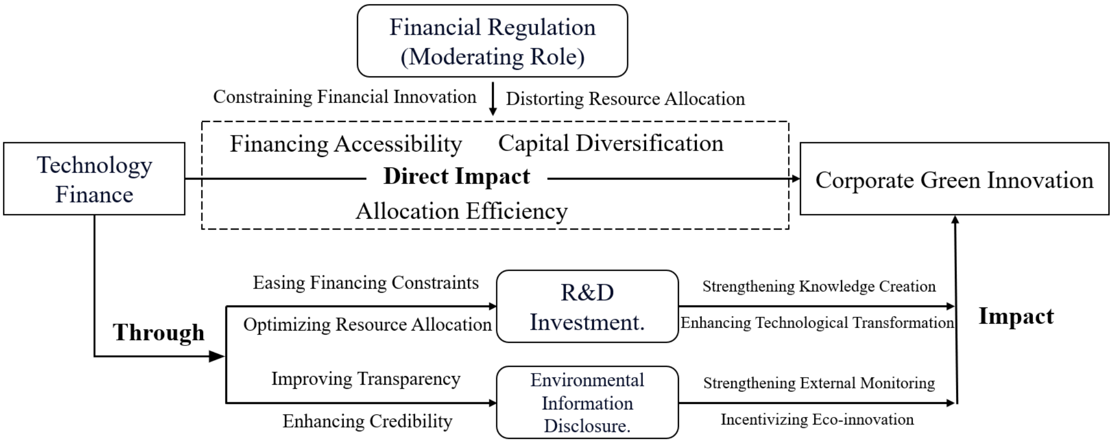

Figure 1 Conceptual Framework of Theoretical Mechanisms

3. Research Design

3.1. Data Sources

This study employs panel data on Chinese A-share firms from 2007 to 2023, excluding financial, ST/*ST/PT firms and records with substantial missing values, yielding over 30,000 firm-year observations from CSMAR, CNRDS, and policy sources. Continuous variables are winsorized and log-transformed. The 2007 start captures pre-policy baselines preceding the 2011 and 2017 technology finance pilots (see Section 3.2.2), while also accounting for the rapid development of China's tech-finance sector after 2006 (Meng & Zang, 2018). These pilots integrate finance with technological innovation, enabling quasi-natural experimental analysis of their causal impact on green innovation while mitigating endogeneity concerns.

3.2. Variable Description

3.2.1. Dependent Variable: Corporate Green Innovation (GRI)

Green innovation (GRI) is measured as the share of green patents in a firm's total patent portfolio, classified per CNIPA–WIPO criteria in areas such as clean energy, environmental conservation, and resource efficiency. This ratio captures both the scale and environmental orientation of innovation, controlling for firm-specific differences in total patenting and reflecting actual green R&D efforts (Rivera León et al., 2023). It provides a precise indicator to evaluate the effects of technology-finance policies on environmentally focused innovation.

3.2.2. Independent Variable

The key independent variable is technology finance, operationalized via a DID-based policy dummy. Firms in cities implementing China's "Pilot Program for Promoting the Integration of Technology and Finance" form the treatment group, with others as controls. Pre-policy periods are coded 0, post-policy 1, and the interaction term captures the reform's spatiotemporal impact, enabling causal assessment of technology finance on firm-level green innovation while mitigating endogeneity.

3.2.3. Mechanism and Moderating Variables

3.2.3.1. Mechanism Variable: Environmental Information Disclosure (EID)

To further explore the path through which technology finance promotes green innovation by enhancing corporate environmental information disclosure, this study draws on the research of Zhong (2024) and constructs an Environmental Information Disclosure Index (EID) as the mediating variable.

3.2.3.2. Mechanism Variable: R&D Investment (R&D)

Building on the methodology of Ravšelj and Aristovnik (2020), this paper defines the R&D investment mechanism variable (R&D) as the proportion of a firm's research and development spending relative to its operating income, based on figures reported in corporate financial statements.

3.2.3.3. Moderating Variable: Financial Regulation

Building on Fu et al. (2025), this study measures regional financial regulation (FR) as the ratio of financial regulatory expenditure to the financial sector's value-added in each region. To investigate its moderating effect, an interaction term between this variable and the DID indicator (DID_FR) is included in the analysis.

3.2.4. Control Variables

Drawing on prior literature (Sun et al., 2025), this study classifies control variables into firm-specific characteristics and managerial attributes. Firm-level controls include industry classification (HighTech, 1 for high-tech firms, 0 otherwise), firm size (Size, natural logarithm of total assets plus one), financial leverage (Lev, total liabilities divided by total assets), book-to-market ratio (BM, book value of equity over market capitalization), and ownership type (Type, 1 for state-owned enterprises, 0 otherwise). Managerial-level controls comprise the financial background of senior executives (FinBack, 1 if any top manager has financial sector experience, 0 otherwise) and CEO duality (Duality, 1 if CEO and general manager roles are combined, 0 if separated). These variables capture structural, financial, and governance dimensions that may influence firms' innovation decisions, ensuring a more rigorous assessment of the factors shaping corporate R&D and green innovation outcomes.

Descriptions of all variables, along with summary statistics, are reported in Table 2.

Table 2. Baseline Regression Analysis

VARIABLES	mean	sd	min	max	count
Corporate Green Innovation (GRI)	0.085	0.185	0.000	1.000	34,359
DID	0.547	0.498	0.000	1.000	34,359
R&D Investment (R&D)	5.532	6.052	0.000	54.820	34,359
Environmental Information Disclosure (EID)	6.434	6.785	0.000	36.000	34,359
Financial Regulation (FR)	0.196	0.607	-1.643	31.348	34,359
Ownership Type (Type)	0.389	0.488	0.000	1.000	34,359
High-Tech Industry (HighTech)	0.592	0.491	0.000	1.000	34,359
Management Financial Background (FinBack)	0.607	0.488	0.000	1.000	34,359
Firm Size (Size)	22.166	1.340	14.942	28.697	34,359
Leverage Ratio (Lev)	0.419	0.208	0.007	0.998	34,359
Book-to-Market Ratio (BM)	0.623	0.246	0.064	1.258	34,359
CEO Duality (Duality)	0.683	0.402	0.000	1.000	34,359

3.3. Model Construction

3.3.1. Baseline Regression Model

As a starting point, this study constructs Model 1 to quantitatively identify the primary influence of technology finance on corporate green innovation performance.

$$GRI_{i,t} = \beta_0 + \beta_1 DID_{i,t} + \beta_2 control_{i,t} + \gamma_1 Year_t + \delta_j Industry_j + \alpha_i + \varepsilon_{i,t} \tag{1}$$

To test whether technology finance promotes green innovation by enhancing corporate environmental information disclosure, Model 2 is developed.

$$EID_{i,t} = \beta_0 + \beta_1 DID_{i,t} + \beta_2 control_{i,t} + \gamma_1 Year_t + \delta_j Industry_j + \alpha_i + \varepsilon_{i,t} \tag{2}$$

To investigate whether technology finance facilitates green innovation through boosting corporate R&D investment, Model 3 is established.

$$R\&D_{i,t} = \beta_0 + \beta_1 DID_{i,t} + \beta_2 control_{i,t} + \gamma_1 Year_t + \delta_j Industry_j + \alpha_i + \varepsilon_{i,t} \tag{3}$$

To assess the moderating role of financial regulation, Model 4 is specified.

$$GRI_{i,t} = \beta_0 + \beta_1 DID \times FR_{i,t} + \beta_2 control_{i,t} + \gamma_1 Year_t + \delta_j Industry_j + \alpha_i + \varepsilon_{i,t} \tag{4}$$

In the empirical models, the dependent variable GI represents firms' green innovation intensity, whereas the key independent variable DID captures whether the firm operates within regions affected by the "Pilot Program for Promoting the Integration of Technology and Finance." The mechanism variables R&D and EID refer to research and development investment and environmental disclosure practices, respectively. Control includes a set of covariates introduced to account for firm-specific characteristics. $Year_t$ and $Industry_j$ are incorporated to control for unobservable influences across years and industries. The term α_i denotes firm fixed effects, capturing time-invariant unobserved heterogeneity at the firm level, and $\varepsilon_{i,t}$ captures the idiosyncratic disturbance term. Subscripts i and t refer to the firm and time dimensions, respectively.

4. Empirical Results Analysis

4.1. Baseline Results Analysis

Table 3 reports the estimated effects of technology finance on firms' green innovation performance. Column (1) shows the baseline regression without control variables, while the following columns progressively include them. Across all specifications, the DID coefficients remain significantly positive at the 1% level. Furthermore, the coefficient magnitude increases as controls are added, reinforcing the robustness of the findings and supporting Hypothesis H1. In terms of economic significance, the DID coefficients imply that the implementation of technology finance policies leads to an increase of roughly 9%–13% in firms' green innovation output relative to the sample mean. It suggests that technology finance not only passes statistical tests but also delivers tangible incentives for enterprises to expand their portfolios of green patents and environmentally friendly technologies.

These results imply that technology finance significantly contributes to the advancement of green innovation within firms. This effect likely arises from the transformation of traditional risk assessment systems enabled by digital technologies. By leveraging big data to extract non-financial signals—such as environmental performance and carbon emission data—financial institutions can refine credit evaluations, thereby reducing informational gaps in the green innovation context. Consequently, they are more inclined to support projects characterized by high capital intensity and long investment horizons. In addition, tech-finance platforms equipped with intelligent services have developed various green financial tools, such as sustainability-linked loans and green bonds, easing traditional collateral constraints. These flexible financing channels reduce capital bottlenecks, optimize resource allocation, and stimulate enterprises to increase their efforts in green patenting and environmentally friendly technology adoption—leading to a notable rise in firm-level green innovation.

Table 3. Baseline Regression Analysis

VARIABLES	(1) GRI	(2) GRI	(3) GRI	(4) GRI	(5) GRI	(6) GRI	(8) GRI	(9) GRI
DID	0.009***	0.010***	0.011***	0.011***	0.011***	0.012***	0.013***	0.013***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Type		0.011***	0.011***	0.011***	0.005*	0.001	0.001	0.001
		(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
HighTech			0.017***	0.017***	0.016***	0.017***	0.018***	0.019***
			(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
FinBack				-0.004*	-0.005**	-0.005**	-0.005*	-0.005*
				(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Size					0.007***	0.003***	0.002	0.002
					(0.001)	(0.001)	(0.001)	(0.001)
Lev						0.054***	0.057***	0.050***
						(0.007)	(0.008)	(0.007)
BM							0.028***	0.026***
							(0.006)	(0.006)
Duality								0.005
								(0.001)

Constant	0.080***	0.074***	0.060***	0.062***	-0.083***	-0.022*	0.011*	-0.021***
	(0.002)	(0.002)	(0.004)	(0.004)	(0.022)	(0.024)	(0.024)	(0.024)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.128	0.131	0.128	0.128	0.130	0.130	0.134	0.135
Observations	34,359	34,359	34,359	34,359	34,359	34,359	34,359	34,359

Note: Standard errors appear in parentheses.

Statistical significance is denoted by *, **, and ***, corresponding to the 10%, 5%, and 1% significance levels, respectively.

This notation is consistently applied throughout all following regression tables to facilitate interpretation.

4.2. Robustness Tests

4.2.1. Replacement of the Explanatory Variable

A critical assumption for the validity of the difference-in-differences (DID) approach is that the treatment and control groups must follow parallel trends prior to the policy intervention. In this study, this implies that before the implementation of the technology finance pilot program, firms in both pilot (treatment) and non-pilot (control) cities exhibited similar trajectories in green innovation. Figure 2 visually confirms this assumption; the estimated policy effects for all pre-treatment periods hover around zero and are statistically insignificant, indicating no pre-existing differential trends. This result validates that the parallel trends assumption is met, supporting the suitability of the multi-period DID model for this analysis.

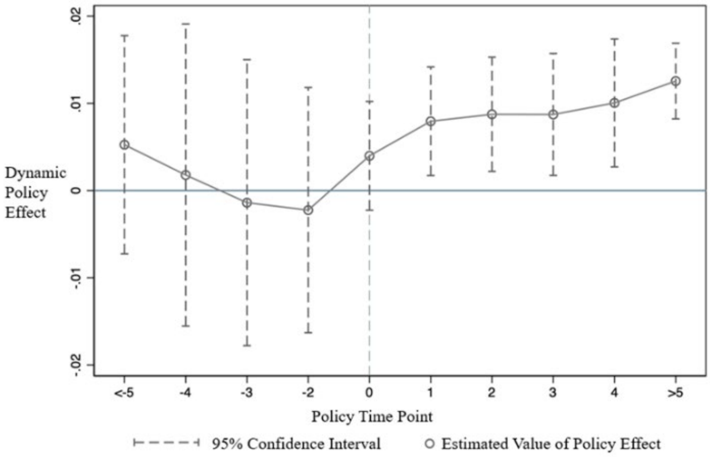

Figure 2 Parallel Trend Test

4.2.2. Placebo Test

To ascertain whether the enhancement in corporate green innovation is attributable to the Sci-Tech Finance Pilot Policy rather than confounding factors, this study performs a placebo test involving 500 random sampling iterations. A random group is selected as the pseudo-treatment group (firms in cities with the Sci-Tech Finance Pilot Policy), and the remaining samples are designated as firms in cities without the Sci-Tech Finance Pilot Policy, thereby constructing a placebo dummy variable. The placebo results are shown in the figure. As can be seen from Figure 3, the estimated coefficients of the test are basically clustered around 0, and are not significant in most cases, with a large gap from the actual coefficient. This indicates that there is no spurious treatment effect in the empirical process of this study, and the conclusions of this study are relatively robust.

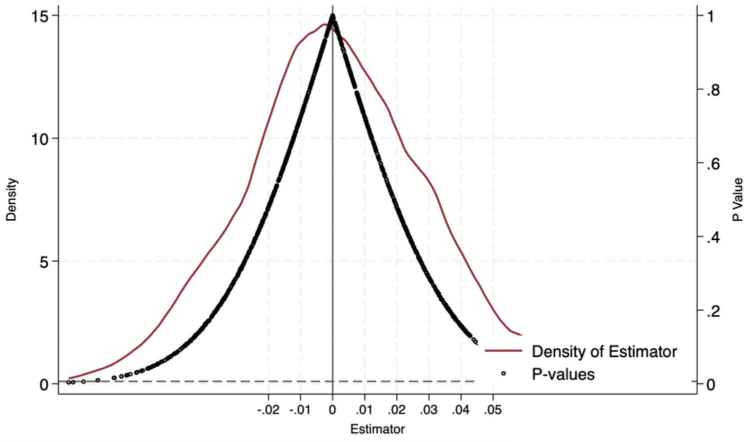

Figure 3 Placebo test chart

4.2.3. Instrumental Variable Approach

Although the technology finance pilot policy is implemented at the regional level, while green innovation primarily manifests at the firm level, indicating that the two do not reside on the same analytical plane, the issue of endogeneity arising from reverse causality is not prominent in this study. However, there may still exist certain unobservable regional economic characteristics or institutional environments that simultaneously influence both the technology finance pilot policy and corporate green innovation, thereby introducing potential endogeneity bias into the estimation results.

To address this issue, a robustness check is conducted using an instrumental variable two-stage least squares (IV-2SLS) approach (He et al., 2025). The “Broadband China” initiative is selected as the instrument to identify the net impact of technology finance pilots on firms’ green innovation. As a state-promoted digital infrastructure policy, “Broadband China” primarily seeks to improve regional internet penetration and accelerate digital economic growth—creating a conducive technological and institutional setting for the development of technology finance (Niu et al., 2022). This strong policy linkage ensures it satisfies the relevance condition. Importantly, as the policy does not target green innovation directly, nor does it influence it through other channels, the exogeneity condition is also likely to be met. The estimation results from this approach are displayed in the corresponding table.

In the first-stage regression, the “Broadband China” variable exhibits a strong positive association with regional technology finance, with a coefficient of 0.356 significant at the 1% level, demonstrating the instrument’s validity. In the second stage, the technology finance pilot (DID) variable retains a positive and statistically significant coefficient of 0.044 at the 1% level. This confirms that, even after addressing potential endogeneity, the technology finance policy continues to significantly enhance firms’ green innovation efforts. These findings support the main regression outcomes and offer additional empirical evidence for the study’s hypotheses.

Table 4. Instrumental Variable Approach

	(1)	(2)

	First Stage DID	Second Stage GRI
Broadband	0.356***	
	(0.007)	
DID		0.044***
		(0.009)
Control	Yes	Yes
Year FE	Yes	Yes
Industry FE	Yes	Yes
Firm FE	Yes	Yes
Constant	-0.252***	0.104***
	(0.028)	(0.022)
R-squared	0.059	0.133
Observations	31504	31504

4.2.4. PSM-DID

To mitigate potential endogeneity arising from non-random selection into the treatment group, this study employs a Propensity Score Matching and Difference-in-Differences (PSM-DID) approach as a further robustness check. Firms were designated into treatment (located in pilot cities) and control groups. We then performed a 1:1 nearest-neighbor matching procedure with replacement, using a set of firm-specific covariates: ownership type (Type), high-tech status (HighTech), management's financial background (FinBack), firm size (Size), leverage (Lev), book-to-market ratio (BM), and CEO-chairman duality (Duality).

The matching process successfully balanced the covariates between the two groups, as evidenced by a substantial reduction in standardized differences, indicating a high-quality match. The baseline model was subsequently re-estimated using this matched sample. As reported in Table 5, Column (2), the DID coefficient remains positive and significant at the 1% level post-matching (0.011), consistent with the pre-matching estimate (0.013). This result demonstrates that even after accounting for potential selection bias, the tech-finance policy's positive impact on corporate green innovation holds. These findings reinforce our main conclusions, confirming that technology finance is a key driver of corporate green

Table 5. PSM-DID regression results

	(1) Before Matching GRI	(2) After Matching GRI
DID	0.013***	0.011***
	(0.003)	(0.003)
Control	Yes	Yes
Year FE	Yes	Yes
Industry FE	Yes	Yes
Firm FE	Yes	Yes
R-squared	0.182	0.267
Observations	34359	30568

4.2.5. Endogeneity test

One potential concern in the empirical design is that the implementation of technology finance pilot policies is not entirely random. Pilot selection may have been influenced by pre-existing macroeconomic conditions—such as the level of regional technology investment, financial development, or industrial structure—which could simultaneously affect corporate green innovation. To mitigate this source of endogeneity, we incorporate interaction terms between these regional macro factors and time trends into the baseline DID specification, following the approach of Heshmati & Kumbhakar (2011). This strategy allows us to partial out the influence of differential time-varying trends across regions that may bias the estimated policy effects.

$$\mathrm{GRI}_{i,t} = \alpha + \beta(\mathrm{DID}_{i,t}) + \gamma(\mathrm{Macro}_r \times \mathrm{Trend}_t) + \delta \mathrm{Controls}_{i,t} + \mu_i + \lambda_t + \eta_j + \varepsilon_{i,t} \quad (5)$$

Where Macror represents regional macroeconomic indicators, including (i) R&D expenditure intensity (R&DExp), (ii) financial development level (FinDev), and (iii) the share of secondary industry in GDP (IndStruct). These variables are interacted with a linear time trend ($Trend_t$) to capture heterogeneous regional dynamics that may correlate with both pilot designation and green innovation.

The results are presented in Table 6. Across all model specifications, the DID coefficients remain significantly positive at the 1% level, consistent with our baseline findings. This suggests that the observed policy effects are unlikely to be driven solely by unobserved macro-level differences between pilot and non-pilot regions. Importantly, the significance levels of the interaction terms are lower than that of DID. Only some of them are significant at the 10% level, and FinDev×Trend is not statistically significant, implying that while regional macro factors influence the trajectory of green innovation, they do not fully explain the estimated impact of technology finance pilots.

Table 6 Endogeneity test results

VARIABLES	(1) GRI	(2) GRI	(3) GRI
DID	0.011***	0.010***	0.012***
	(0.003)	(0.003)	(0.003)
R&DExp × Trend	0.004*		
	(0.002)		
FinDev × Trend		-0.002	
		(0.001)	
IndStruct × Trend			0.003*
			(0.002)
Controls	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Observations	34,359	34,359	34,359
R-squared	0.134	0.136	0.137

4.2.6. Additional Robustness Checks

This study further implements a series of robustness checks. First, a sub-period analysis is conducted. To address potential distortions caused by widespread production halts during the COVID-19 outbreak, data from 2020 onward are excluded. As indicated by the estimates in columns (1) and (2) of Table 7, the main findings remain statistically robust. During China's 12th Five-Year Plan period (2011–2015), multiple green development policies were introduced, such as the Green Credit Policy (2007/2012), the Energy Conservation and Emission Reduction Policy (2007), and the Carbon Emission Trading Pilot Policy (2013). These policies may interfere with the research results of this study. Therefore, this study excludes these key years (2011–2015) and conducts regression analysis again. The results, shown in Columns (3) and (4), remain robust. Second, recognizing the variation in how green innovation is quantified across firms, the previously used indicator—the proportion of green patents—may underrepresent green innovation output in large enterprises, where general patent volume is high. To address this, an alternative proxy is introduced: The alternative measure used is the natural logarithm of one plus the number of green patents independently filed by firms each year (GRI_All). Results shown in columns (5) and (6) of Table 7 remain statistically significant and align with previous outcomes. These additional tests demonstrate that the empirical findings are robust to changes in sample periods and measurement approaches, further confirming the reliability of the study's main conclusions.

Table 7. Additional Robustness Checks

VARIABLES	(1) GRI	(2) GRI	(3) GRI	(4) GRI	(5) GRI_All	(6) GRI_All
DID	0.011***	0.016***	0.018***	0.022***	0.060***	0.067***
	(0.003)	(0.004)	(0.005)	(0.005)	(0.007)	(0.008)
Control	NO	Yes	NO	Yes	NO	Yes
Constant	0.074***	0.046***	0.066***	0.045***	0.194***	-0.133***
	(0.002)	(0.013)	(0.002)	(0.009)	(0.005)	(0.027)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.108	0.110	0.118	0.132	0.065	0.087
Observations	25,773	23,751	22822	21361	33,698	33,058

4.3. Mechanism Analysis

Building on the theoretical framework, this section investigates whether technology finance fosters corporate green innovation through two primary channels: improving environmental information disclosure and boosting R&D investment, with financial regulation possibly exerting a moderating influence. To verify these mechanisms and effects, Models (2), (3), and (4) are estimated.

4.3.1. R&D Investment Mechanism Test

As presented in column (1) of Table 8, the coefficient is both positive and statistically significant at the 5% level, suggesting that technology finance enhances firms' R&D spending. Innovation activities inherently involve high uncertainty and limited financing options. By improving access to capital and optimizing both funding structure and utilization, technology finance strengthens the financial support for research and development. The crucial role of R&D in promoting environmentally oriented innovation is well-documented in previous literature (Xu et al., 2021; Rauf et al., 2024; Shi & Yang, 2022), thereby confirming Hypothesis H2.

4.3.2. Environmental Information Disclosure Mechanism Test

Column (2) of Table 8 shows that the coefficient measuring the impact of technology finance on firms' environmental information disclosure is positive and statistically significant at the 1% level, indicating a substantial enhancement in disclosure quality. Prior studies have highlighted environmental disclosure as a key channel for signaling to green financial markets, whereby greater transparency and standardization enhance firms' financing efficiency and support sustainability transitions (Lu & Li, 2023; Ma, 2025; Bai & Lyu, 2023). Nevertheless, disclosure in practice often suffers from low reliability and high costs. By applying technologies like big data analytics, technology finance upgrades both the technical and institutional bases for disclosure, offering a more transparent and evaluable context for green innovation to flourish. These outcomes lend empirical support to Hypothesis H3.

4.3.3. Moderating Effect of Financial Regulation

Column (3) of Table 8 presents the estimation results for the interaction between the DID variable and financial regulation intensity. The negative and significant coefficient on DID_FR suggests that tighter regulatory measures diminish the beneficial effects of technology finance on green innovation outcomes. The success of technology finance relies on a stable and innovation-supportive regulatory environment. Excessive or poorly coordinated oversight can raise compliance costs, limit flexibility in data handling and product development, and ultimately reduce incentives for green innovation. This finding supports Hypothesis H4.

Table 8. Mechanism Analysis

VARIABLES	(1) R&D	(2) EID	(3) GRI
DID	5.419**	0.876***	0.0161***
	(2.543)	(0.185)	(0.00466)
DID_FR			-0.0200***
			(0.00758)
Control	Yes	Yes	Yes
Constant	7.988	4.391***	0.0568***
	(9.660)	(0.603)	(0.0154)
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
R-squared	0.106	0.296	0.103
Observations	34359	34359	34359

4.4. Heterogeneity Analysis

4.4.1. Regional Heterogeneity

The estimates reported in columns (1) and (2) of Table 9 suggest that the effect of technology finance on green innovation is more evident in eastern provinces, whereas the results for non-eastern regions are not statistically significant. One plausible explanation is that eastern regions benefit from relatively developed financial systems, higher concentrations of skilled labor, and stronger policy support, which together may facilitate the conversion of financial tools into innovative outcomes. At the same time, structural challenges in central and western regions—such as weaker financial infrastructure and institutional constraints—could limit the effectiveness of technology finance.

Table 9. Heterogeneity Analysis (Regional)

	(1)	(2)
VARIABLES	GRI	
	Non-Eastern Region	Eastern Region
DID	-0.000415	0.0103***
	(0.00908)	(0.00343)
Control	Yes	Yes
Year FE	Yes	Yes
Industry FE	Yes	Yes
Firm FE	Yes	Yes
R-squared	0.522	0.141
Observations	8,973	20,952

4.4.2. Ownership Heterogeneity

Table 10 reports significant positive effects of technology finance on green innovation for both ownership types. For non-SOEs, the coefficient is 0.0114 and highly significant at the 1% level. For SOEs, the coefficient is slightly larger at 0.0174 but only significant at the 5% level, suggesting a less stable response. This contrast implies that while SOEs may benefit more in magnitude, non-SOEs demonstrate stronger reliability in absorbing financial support, reflecting differences in incentive mechanisms and institutional constraints.

Table 10. Heterogeneity Analysis (Ownership)

VARIABLES	(1) GRI Non-State-Owned Enterprises	(2) State-Owned Enterprises
DID	0.0114***	0.0174**
	(0.00319)	(0.00868)
Control	Yes	Yes
Year FE	Yes	Yes
Industry FE	Yes	Yes
Firm FE	Yes	Yes
R-squared	0.137	0.524
Observations	19,412	9,501

4.4.3. Firm Characteristic Heterogeneity

As reflected in columns (1) and (2) of Table 11, the green innovation benefits from technology finance are significantly greater for technology-intensive firms than for their less tech-oriented peers. This highlights the pivotal role of internal innovation capability and technical preparedness in leveraging financial instruments. Firms with a high degree of technological specialization are often better equipped with skilled personnel and structured R&D processes, allowing them to deploy financial resources more effectively in advancing green technologies. Additionally, such enterprises are more capable of recognizing emerging green tech opportunities and translating them into market-driven solutions.

Table 11. Heterogeneity Analysis (Firm Characteristics)

VARIABLES	(1) GRI Non-Technology-Intensive	(2) Technology-Intensive
DID	0.0121	0.0112***
	(0.00924)	(0.00344)
Control	Yes	Yes
Year FE	Yes	Yes
Industry FE	Yes	Yes
Firm FE	Yes	Yes
R-squared	0.511	0.187
Observations	13,714	18,103

5. Conclusion and Policy Implications

5.1. Research Conclusions

Drawing on panel data of China's non-financial A-share listed firms from 2007 to 2023, this study employs a DID approach to examine the effect of technology finance on corporate green innovation. The empirical results demonstrate that technology finance significantly promotes green innovation by reducing financing constraints through improved risk assessment and diversified funding channels. The effect primarily operates through two mechanisms: enhancing firms' R&D investment and improving the credibility and scope of environmental information disclosure, both of which strengthen incentives for sustainable innovation. However, the benefits of technology finance are weakened under overly stringent financial regulation, suggesting that regulatory rigidity may constrain innovation vitality and limit the efficiency of capital allocation. Moreover, heterogeneity analysis reveals that the effect is stronger in eastern regions, privately owned enterprises, and technology-intensive firms, highlighting the importance of regional economic environments, ownership structures, and technological capabilities in shaping policy outcomes.

Based on these findings, several policy implications emerge. First, differentiated regional strategies are needed to balance the uneven development of technology finance. Eastern regions should deepen the integration of financial innovation with green industries and pilot advanced tools such as carbon finance, while non-eastern regions should prioritize strengthening financial infrastructure, establishing guidance funds, and expanding access to green financing. Second, the standardization of environmental information disclosure is crucial. Unified reporting rules, coupled with digital technologies such as blockchain, can improve data reliability and encourage firms to adopt transparent sustainability practices, which in turn should be rewarded through preferential financing. Finally, regulatory frameworks must remain flexible and coordinated. Policymakers should pursue tiered supervision, streamline administrative processes, and strengthen inter-agency coordination to foster both financial stability and innovation. By achieving this balance, technology finance can more effectively serve as a catalyst for corporate green innovation and sustainable development.

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