

The Dampening Effect of Green Finance Reform Policies on Corporate Green Innovation Bubbles: An Empirical Study of Chinese A-Share Listed Companies

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Abstract

While green finance reform policies channel capital toward green industries, can they effectively curb the green innovation bubbles caused by corporate “greenwashing”? This study examines Chinese A-share listed companies from 2010 to 2024, treating the establishment of green finance reform and innovation pilot zones as a quasi-natural experiment. Using a multi-period difference-in-differences method, the study systematically investigates the impact of green finance policies on corporate green innovation bubbles and their transmission mechanisms. The findings reveal: First, green finance reform policies significantly curb corporate green innovation bubbles. Second, a decomposition of the transmission mechanisms indicates that strategic green innovation is the core channel through which policies exert their “corrective” function; due to the short-term crowding-out effect of policies on substantive innovation, the contribution of the substantive green innovation channel is weak and runs in the opposite direction. Third, the policy effects exhibit heterogeneity: non-state-owned enterprises are more sensitive to policy responses; the moderating role of executives’ financial backgrounds is limited, with differences between groups failing to reach statistical significance. This paper reveals the underlying mechanism by which green finance policies improve innovation quality by curbing strategic innovation, providing empirical evidence for mitigating “greenwashing” risks and optimizing the institutional design of green finance.

Keywords

green finance reform, green innovation bubble, strategic innovation, substantive innovation

1. Introduction

Against the backdrop of the global response to climate change and China’s implementation of the “dual carbon” strategy, driving the green and low-carbon transformation of economic and social development is a key component of achieving high-quality growth. Encouraging enterprises to engage in green innovation has become a core policy option for countries seeking to foster new productive forces and address environmental challenges. To accelerate the development of a green financial system and gain a deeper understanding of its growth trajectory, the Chinese government established green finance reform and innovation pilot zones in three batches in 2017, 2019, and 2022. A large body of academic research indicates that such environmental regulations and market incentive policies can effectively stimulate enterprises’ green innovation activities,

significantly increasing their green patent output and R&D investment [1, 2]. However, driven by policy incentives, a concerning phenomenon is emerging: some enterprises, in order to align with policy directions and secure green finance support, tend to engage in low-quality, symbolic green innovation—that is, they accumulate “green” labels by filing a large number of utility model patents with low technical content, rather than pursuing substantive technological breakthroughs. This behavior has spawned a so-called “green innovation bubble,” manifested by a surge in the quantity of green patents while quality stagnates, and an abnormally high proportion of utility model patents. Once formed, this bubble not only distorts resource allocation—misdirecting limited financial resources toward “greenwashing” enterprises—but also squeezes the survival space of companies genuinely engaged in green R&D, creating a vicious cycle where “bad money drives out good.” Ultimately, this undermines corporate core competitiveness, weakens regional innovation ecosystems, and may even trigger a crisis of confidence in green industries within capital markets. Therefore, exploring whether green finance policies can effectively curb this bubble and guide enterprises toward “true green” practices holds urgent practical significance.

Research and development of green and low-carbon technologies is generally characterized by long cycles, high investment, and significant uncertainty. To some extent, this encourages companies to meet external requirements through token R&D efforts and low-quality patent applications, thereby creating a “green innovation bubble” [3]. Such “innovation bubbles” not only distort resource allocation and dilute the effectiveness of policies, but may also cause long-term damage to enterprises’ core competitiveness and the healthy development of regional innovation ecosystems. Can green finance reform policies effectively curb this bubble? What is the mechanism behind their effectiveness? Do policy outcomes vary across enterprises with different characteristics? These questions urgently require empirical testing. However, most existing studies focus on the “quantitative” effects of green innovation, while relatively little attention has been paid to examining the “quality” and “motivation” of innovation. Scholars have primarily verified the policies’ role in promoting corporate green innovation efficiency and their contribution to fostering new-quality productive forces through a focus on technological innovation [1, 4], but this overlooks the role of policy in managing financial risks, particularly bubbles at the corporate level. In the realm of innovation strategy, While Li and Zheng [5] pioneering research has provided an important perspective for understanding corporate compliance behavior, few studies have directly applied the “strategic innovation” analytical framework to the evaluation of green finance policies or examined its relationship with the “bubble” phenomenon in green innovation.

In light of this, this paper treats the establishment of Green Finance Reform and Innovation Pilot Zones as a quasi-natural experiment. Using data on A-share listed companies from 2010 to 2024 and employing a multi-period difference-in-differences method, we investigate whether this policy can curb green innovation bubbles among firms. Here, the green innovation bubble is defined as the proportion of green utility model patent applications out of the total number of green patent applications; a higher value of this indicator suggests that firms are more inclined to engage in low-quality, strategic green innovation. The study finds the following: First, the Green Finance Reform and Innovation Pilot Zone policy significantly curbs corporate “green innovation bubbles,” reducing the proportion of bubble levels among firms in the treatment group by approximately 3.9%. This conclusion remains valid after a series of robustness tests. Second, this paper further examines the policy’s mechanism of action and finds that it primarily reduces bubbles by curbing firms’ strategic green innovation; this pathway accounts for 69.5% of the total effect; Third, heterogeneity analysis reveals that the policy’s dampening effect is more pronounced in non-state-owned enterprises and firms with executives possessing a financial background. This is because, in these firms, the policy exerts a stronger inhibitory effect on strategic innovation. Additionally, the study finds that the policy generates a short-term crowding-out effect on substantive green innovation, which to some extent weakens the policy’s net effect and offers insights for future policy optimization.

The marginal contributions of this paper are primarily reflected in the following four aspects: First, in terms of research perspective, unlike previous studies that focused on the “quantity” of green innovation while paying less attention to its “quality” and “motivation,” this paper introduces the concept of “green innovation bubbles” into the field of green innovation policy impact assessment. Building on this, the paper further distinguishes between the differential impacts of strategic green innovation and substantive green innovation on green financial bubbles, finding that strategic innovation significantly exacerbates bubbles, whereas substantive innovation suppresses them. This finding not only enriches and deepens our understanding of the micro-level effects of green innovation incentive policies from a new perspective of innovation quality and intrinsic value,

but also reveals the potential harm of “greenwashing” from the perspective of economic consequences, highlighting the necessity of policy intervention and providing supplementary evidence regarding the effectiveness of green finance policies from the perspective of capital markets. Second, regarding the mechanism of action, this paper breaks away from the traditional framework of financing constraints and the intensity of environmental regulations to systematically reveal the transmission channels through which policies influence green innovation bubbles. It confirms for the first time that “strategic green innovation” is the core micro-mechanism of policy transmission, accounting for 69.5% of the total effect; Third, regarding policy implications, this study reveals the “inclusive” nature of green finance reform policies in risk governance. That is, their effectiveness does not depend on local government fiscal investment or the intensity of environmental enforcement, but rather can penetrate regional institutional barriers through channels such as credit allocation and market constraints to directly influence firm-level behavior. At the same time, the short-term crowding-out effect of the policy on substantive innovation suggests that adjustment costs must be considered when guiding corporate transformation, providing empirical support for optimizing policy design and establishing a unified national green finance system.

The remainder of this paper is organized as follows: Section 2 introduces the policy background; Section 3 presents a literature review and theoretical analysis; Section 4 outlines the empirical research design; Section 5 reports the empirical results and analysis; Section 6 provides further analysis; and Section 7 summarizes the conclusions and offers corresponding policy recommendations.

2. Policy Background

As noted in the introduction, while green finance directs capital toward green industries, it also faces potential risks such as “greenwashing” and “green innovation bubbles.” How to design effective incentive and constraint mechanisms that both leverage finance’s role in driving the green transition and guard against market distortions caused by corporate strategic innovation has become a critical challenge for policymakers. To thoroughly explore a green finance development path suited to China’s national conditions, the country has adopted a reform strategy of “piloting first, then gradual rollout,” using regional trials to provide empirical evidence for institutional design.

To thoroughly explore a green finance development path suited to China’s national conditions and establish effective incentive and constraint mechanisms, China has adopted a reform strategy of “piloting first, then gradually expanding.” The issuance of the “Guiding Opinions on Building a Green Finance System” marked the establishment of a policy guidance framework in the field of green finance. In 2017, China established green finance reform and innovation pilot zones in regions such as Zhejiang, Jiangxi, Guizhou, Guangdong, and Xinjiang. In 2019 and 2022, the state respectively included the Lanzhou New Area in Gansu and Chongqing Municipality in the pilot scope, forming a policy implementation pathway of “piloting first, gradual rollout.” The selection of these pilot zones was not arbitrary but followed clear principles aimed at generating replicable and scalable experiences: First, the principle of geographical representativeness, ensuring that the pilots cover regions with varying levels of economic development, including the eastern, central, western, and northeastern regions; Second, the principle of resource endowment diversity, which fully considers the unique characteristics of each region in terms of ecological resources and industrial foundations; third, the principle of resource endowment diversity, which encourages localities to explore differentiated green transition models based on their own strengths. For example, Zhejiang Province focuses on utilizing financial instruments to promote the green upgrading of traditional manufacturing and the innovation of financial products; Guangdong Province, leveraging its developed financial markets, focuses on exploring the integration of carbon finance with the new energy industry; Guizhou Province is committed to promoting the convergence of big data, green industries, and green finance; and Gansu Province (Lanzhou New Area) emphasizes the application of green finance in ecological conservation within the Yellow River Basin and in inclusive finance. The diverse practices in these pilot regions provide a rich institutional context for this paper to examine the micro-level effects of green finance policies at the enterprise level.

It is worth noting that while advancing green finance, pilot regions have also begun to address the risks posed by strategic corporate innovation. Some regions have incorporated measures such as environmental disclosure requirements, green credit review mechanisms, and differentiated interest rate pricing into their policy designs, effectively establishing institutional constraints against “greenwashing.” As a form of

organizational environmental misconduct, greenwashing essentially involves constructing an eco-friendly image through systematic false advertising while evading substantive environmental responsibility and investment. Externally, environmental subsidies, regulatory pressure, regulatory loopholes, and consumer demand for green products collectively create incentives for greenwashing, while information asymmetry provides the space for its implementation. Internally, factors such as low visibility, organizational inertia, the pursuit of environmental reputation, and external financing pressures also drive companies to engage in greenwashing; this tendency is particularly pronounced among highly indebted firms. Research by He et al. [6] indicates that strengthening external oversight can effectively curb corporate greenwashing; for example, central environmental inspections have significantly reduced the extent of greenwashing among polluting enterprises. Therefore, by embedding constraint mechanisms such as information disclosure and credit review within green finance systems, pilot regions are effectively curtailing the scope for greenwashing from an external regulatory perspective. These initiatives provide a rich institutional context for this paper to examine the governance effects of green finance policies on innovation bubbles at the corporate level. By evaluating policies in pilot zones, we can not only verify the effectiveness of the policies themselves but also reveal the unique role of market-based tools in preventing strategic innovation, thereby providing empirical support for the development of a unified national green finance system.

3. Literature Review and Theoretical Hypotheses

3.1 Literature Review

Given that this study examines the factors influencing whether green finance reform and innovation pilot zones can curb green innovation bubbles in enterprises—and considering that green innovation bubbles essentially represent a concentrated manifestation of strategic innovation behavior by enterprises in the green sector—this paper will conduct a literature review focusing on two aspects: strategic innovation and green innovation bubbles.

3.1.1 Strategic Innovation

Identifying the motivations behind corporate innovation is a central issue in the study of the economics of innovation. Li and Zheng's [5] pioneering research systematically distinguishes between substantive innovation and strategic innovation for the first time: substantive innovation refers to “high-quality” innovative activities aimed at driving technological progress within firms and gaining a competitive advantage; strategic innovation, on the other hand, refers to innovation strategies designed to pursue other benefits by prioritizing the “quantity” and “speed” of innovation in order to comply with regulatory requirements and government incentives. This distinction overcomes the limitations of traditional innovation research, which focuses solely on total patent volume, and provides an important analytical tool for understanding the “innovation distortions” that may arise in firms under policy incentives.

Subsequent research has further expanded this framework. When firms face environmental regulations, strategic green innovation may also occur, as Shen et al. [7] have observed, local governments tend to prioritize the quantity of patents over their quality when supporting innovative enterprises. In the area of tax incentives, Yang and Rui [8] found that enterprises certified as high-tech enterprises can obtain more tax breaks and government subsidies. The tax reductions, government subsidies, and talent aggregation effects resulting from industrial policies only promote increased innovation among genuine high-tech enterprises, whereas the incentive effect of industrial policies on innovation is significantly weakened for “pseudo-high-tech enterprises.” In the field of green credit, Liu [9] drawing on China's economic transformation practices, conducted an empirical examination of the impact of green finance policies on firms' strategic green innovation behavior and found that firms exhibit a tendency to engage in strategic green innovation by leveraging green finance policy support.

3.1.2 Green Innovation Bubble

The concept of the “innovation bubble” stems from observations of a divergence between the quantity and quality of innovation. In the field of green innovation, the “green innovation bubble” refers to a phenomenon in which green innovation activities experience rapid quantitative growth driven by multiple factors—including policy incentives, capital flows, and market signals—yet their quality and efficiency fail to improve

at the same pace, resulting in resource misallocation and inflated valuations [10]. A key indicator of this trend is the unusually high proportion of green utility model patents, as these patents do not undergo substantive examination and are therefore more easily used by companies as strategic tools.

This paper defines a “green innovation bubble” as a structural imbalance in which, while the number of green patents held by enterprises increases, the proportion of low-quality patents (utility model patents) rises abnormally. The core metric is the proportion of green utility model patents out of the total number of green patents. The higher this indicator, the more “inflated” the enterprise’s green innovation appears, and the more severe the bubble.

The formation mechanism of the green innovation bubble can be explained from multiple perspectives. First, the combination of policy incentives and regulatory gaps. Fiscal support is insufficient, and effective regulatory measures are lacking. Some local governments have introduced incentives such as fiscal subsidies and tax breaks to meet environmental assessment targets; however, due to the absence of effective evaluation and oversight, enterprises exploit a large number of low-quality green patents to obtain policy resources, resulting in the widespread phenomenon of “nominal innovation.” Second, the transmission of speculative behavior in capital markets. Irrational speculative activities in the stock market have exacerbated the risk of market bubbles. Against a backdrop of widespread social responsibility awareness, massive capital inflows into the environmental protection sector have caused the valuation of related companies to deviate from their actual innovation capabilities and profit levels. Third, information asymmetry regarding green technologies. Due to the unique nature of green technologies and information asymmetry, investors and regulators find it difficult to accurately assess their true value, leading to the phenomenon of “greenwashing” In addition to micro-level factors, the macro-level institutional environment is also a key factor influencing the formation and development of green innovation bubbles. Beyond micro-level factors, the macro-level institutional environment similarly impacts the formation and development of green innovation bubbles. The national unified market serves as a crucial institutional platform for promoting the flow of factors of production, fostering fair competition, and eliminating trade barriers between regions. It helps improve the efficiency of green technology allocation across China’s regions while reducing information barriers and resource misallocation. Advancing this process can not only facilitate the flow of innovation resources and enhance green innovation but also effectively curb innovation bubbles caused by policy arbitrage and market closure. However, existing research lacks systematic analysis of how China’s unified national market influences the formation of green innovation bubbles, and there is an urgent need for in-depth exploration from an integration perspective.

3.1.3 Research Gaps

In summary, existing research leaves room for further exploration in the following areas: First, few studies have directly linked green finance policies to “green innovation bubbles” (rather than simply the quantity of innovation or strategic innovation itself) to examine the governance effects of policies on the quality structure of innovation. Second, the underlying mechanisms through which policies influence firms’ strategic innovation remain unclear and have not been systematically tested empirically. Third, the differentiated impacts of strategic innovation and substantive innovation on the same economic outcomes (such as firm value and innovation bubbles) have not yet been fully elucidated.

3.2 Theoretical Analysis and Research Hypotheses

Within the important institutional framework of China’s green finance policies, enterprises constitute a vital component of the country’s economic development and serve as a key driving force in promoting economic growth and achieving a green transition. Therefore, examining the significant role of China’s green finance pilot policies in national economic development from the perspective of enterprises holds important theoretical value for the formulation and implementation of relevant policies.

3.2.1 The General Effect Hypothesis

In markets characterized by information asymmetry, companies—as parties possessing private information about their own green technological capabilities—need to convey their “green credentials” to principals such as governments, investors, and financial institutions by sending observable signals (such as green patents). Different types of patents serve as signals with significant variations in cost and credibility: substantive green

innovation (invention patents) involves long R&D cycles, substantial investment, and high technical barriers, making it a high-cost signal with high credibility; strategic green innovation (utility model patents) entails low R&D costs and rapid authorization, making it a low-cost signal with low credibility. In the absence of an effective signal screening mechanism, the market may fall into a “convergence equilibrium”—where all firms send low-cost signals (strategic innovation), leading to “Gresham’s law” and the formation of a green innovation bubble. The root cause of this agency problem lies in the fact that management, acting as corporate agents, may be motivated by self-interest to pursue rapid growth in patent volume to quickly capture policy dividends and boost short-term performance, while neglecting technological substance and environmental benefits.

The introduction of policies for Green Finance Reform and Innovation Pilot Zones has fundamentally altered the rules of this signaling game. As mentioned earlier, green finance policies, by directing financial resources toward enterprises with genuine green technological capabilities, effectively raise the implicit costs of firms sending low-cost signals (strategic green innovation) and enhance the returns on high-cost signals (substantive green innovation). On the one hand, green finance policies typically come with strict criteria for green project certification and environmental disclosure requirements. This makes it difficult for “pseudo-green” enterprises—those relying solely on strategic patent packaging—to pass reviews and obtain financing support such as green loans and green bonds, significantly increasing the cost of their low-cost “disguise.” On the other hand, for firms with substantive green innovations, green finance policies provide positive incentives such as lower financing rates, more accessible financing channels, and government subsidies, thereby amplifying the returns on high-cost signaling. This reshaping of the cost-benefit structure will disrupt the existing “equilibrium of conflation,” prompting firms to shift from strategic innovation focused on short-term patent volume to substantive innovation emphasizing technological quality, thereby curbing the formation of a green innovation bubble. Based on this, this paper proposes the main hypothesis:

H₁: Policies in green finance reform and innovation pilot zones help curb green innovation bubbles among enterprises.

3.2.2 Mechanistic hypothesis

Furthermore, this paper analyzes the mechanisms through which green finance reform pilot zones exert their dampening effect on corporate green innovation bubbles. The policy reduces the marginal cost of substantive innovation through positive incentives, while simultaneously increasing the marginal cost of strategic innovation through negative constraints; the combined effect of these two mechanisms leads firms to reduce strategic innovation activities. On the other hand, strategic innovation is the direct source of green innovation bubbles—when firms engage in low-quality, short-sighted strategic innovation, it directly leads to an increase in the proportion of green utility model patents, resulting in an “inflated” innovation structure. Based on this, the following hypotheses are proposed:

H_{2a}: Policies in green finance reform and innovation pilot zones help curb strategic green innovation by enterprises.

H_{2b}: Strategic green innovation may exacerbate the green innovation bubble among companies.

4. Empirical Strategies and Data

4.1 Sample Data

This study uses Chinese A-share listed companies from 2010 to 2024 as the research sample. Green patent data was obtained from the China Research Data Service Platform (CNRDS), corporate financial and governance data from the Guotai-An Database (CSMAR), and the list of green finance reform pilot zones was manually compiled based on relevant policy documents issued by the People’s Bank of China and other authorities. Following existing research, the initial sample was screened as follows: (1) companies classified as ST, *ST, or SST, as well as those delisted during the study period, were excluded; (2) financial sector listed companies were excluded; (3) companies listed for less than three years were excluded. To eliminate the impact of outliers, all continuous variables were trimmed at the 1st and 99th percentiles. This resulted in a final dataset of 34,278 company-year observations, covering 3,919 listed companies distributed across 271 cities.

4.2 Model Setup

To examine the impact of policies in the green finance reform pilot zone on green innovation bubbles among enterprises, this paper constructs a multi-period difference-in-differences model as follows (main model):

$$GBR_{i,t} = \beta_0 + \alpha_1 DID_{i,t} + \gamma Controls_{i,t} + \delta_i + \lambda_t + \theta_c + \varepsilon_{i,t} \quad (1)$$

Here, i, c, t represent firm, city, and year, respectively; GBR is the dependent variable; DID is the key independent variable; $Controls_{i,t}$ are control variables; δ_i is the firm-level fixed effect, λ_t is the year-level fixed effect, θ_c is the city-level fixed effect; $\varepsilon_{i,t}$ is the random error term. Standard errors are cluster-adjusted at the city level to address within-group correlation issues. If α_1 is significantly negative, it indicates that the policy significantly suppressed the green innovation bubble among firms, and hypothesis H_1 is supported.

4.3 Variable Definitions

4.3.1 Dependent Variable

Green Innovation Bubble (GBR). Drawing on existing research, this paper defines the green innovation bubble as the proportion of green utility model patent applications out of the total number of green patent applications. A higher value for this indicator suggests that a larger proportion of patents in corporate green innovation are of lower quality, and that the bubble is more severe. Green patents are identified based on the green list of the International Patent Classification published by the World Intellectual Property Organization (WIPO).

4.3.2 Key Explanatory Variable

Policy dummy variable (DID). This paper employs a multi-period difference-in-differences (DID) model to evaluate the policy effects. If a firm's city is designated as a green finance reform pilot zone in year t or thereafter, the DID takes a value of 1 in year t and subsequent years; otherwise, it is 0. China established green finance reform and innovation pilot zones in three batches in 2017, 2019, and 2022. This paper generates the DID variable based on the pilot year corresponding to the firm's city.

4.3.3 Mechanism Variable

Strategic Green Innovation (TGU): Drawing on the research by Li Wenjing and Zheng Manni (2016), this paper uses the number of green utility model patent applications as a proxy for strategic green innovation. This variable refers to the number of green utility model patents for which a company filed applications independently in a given year.

Substantial Green Innovation (TGI): Use the number of green invention patent applications as a proxy for substantive green innovation. This variable represents the number of green invention patents for which the company filed applications independently during the year.

4.3.4 Control Variable

Drawing on existing research, this study selects the following characteristic variables that may influence corporate green innovation as control variables: $Firm_Size$, $Debt_To_Asset$, ROA , $Current_Ratio$, $Top1_holder$, $Tobins_Q$, $Inst_holding$, L_rd_ratio . In addition, this paper controls for firm-level, city-level, and year-level fixed effects. The specific variable definitions are as follows: Table 1.

Table 1: Variable Declaration

Variable type	Variable name	Variable Definition
Dependent variable	GBR	Percentage of green utility model patents
Key explanatory variable	DID	If the city where the company is located is a pilot city in the current year and subsequent years, the value is 1; otherwise, it is 0.
Mechanism variable	TGU	Total number of green utility model patents
	TGI	Total number of green invention patents
Control variable	$Firm_Size$	The natural logarithm of total assets at year-end
	$Debt_To_Asset$	Total Liabilities at Year-End / Total Assets at Year-End
	ROA	Net income / Total assets

Variable type	Variable name	Variable Definition
	<i>Current Ratio</i>	Current assets / Current liabilities
	<i>Top1_holder</i>	Number of shares held by the largest shareholder / Total number of shares
	<i>Tobins Q</i>	Market value / Replacement cost
	<i>Inst holding</i>	Number of shares held by institutional investors / Total number of shares
	<i>L rd ratio</i>	R&D expenses / revenue for the prior period
Heterogeneous variable	<i>SOE</i>	Return 1 if it is a state-owned enterprise; otherwise, return 0
	<i>FinBack</i>	If members of the board of directors, supervisors, and senior management have a financial background, assign a value of 1; otherwise, assign a value of 0

4.3.5 Descriptive Statistics

Table 2 presents the descriptive statistics for the main variables.

Table 2: Descriptive Statistics

Variable name	Mean	Standard deviation	Minimum	Maximum	N
<i>DID</i>	0.031	0.174	0	1	34278
<i>GBR</i>	0.118	0.282	0	1	34278
<i>TGU</i>	0.547	1.755	0	17	34278
<i>TGI</i>	0.757	2.475	0	30	34278
<i>Firm Size</i>	22.150	1.183	19.867	26.314	34278
<i>Debt To Asset</i>	0.410	0.196	0.057	0.914	34278
<i>ROA</i>	0.410	0.055	-0.242	0.184	34278
<i>Current Ratio</i>	2.486	2.165	0.319	15.364	34278
<i>Top1_holder</i>	0.331	0.140	0.084	0.727	34278
<i>Tobins Q</i>	1.978	1.080	0.834	7.998	34278
<i>Inst holding</i>	0.412	0.241	0.005	0.907	34278
<i>L rd ratio</i>	0.048	0.047	0.0002	0.314	34278

Note: Continuous variables have been truncated at the 1% and 99% levels.

5. Empirical Findings and Analysis

5.1 Evaluation of the Parallel Trends Hypothesis

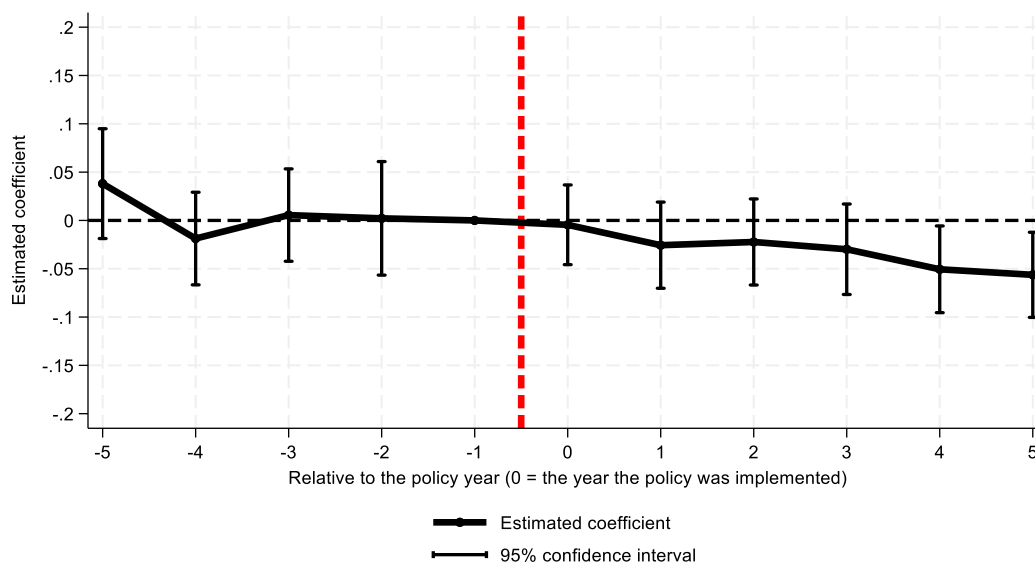
Before applying the multiple-time-point double-difference model, it is necessary to verify whether the treatment and control groups satisfy the parallel trends assumption prior to policy implementation; that is, before the implementation of policies in the Green Finance Reform and Innovation Pilot Zones, there should be no systematic differences in the degree of green innovation bubbles between enterprises within the pilot zones and those outside them. Following the approach in the existing literature, this study employs the event study method to test for parallel trends and constructs the following model:

$$GBR_{i,t} = \alpha + \sum_{k=-5}^5 \beta_k \times D_{it}^k + \gamma Controls_{it} + \delta_i + \lambda_t + \theta_c + \varepsilon_{it} \quad (2)$$

Here, D_{it}^k denotes Firm idummy variable for the k th year before and after policy implementation in the city where firm i is located, with the period immediately preceding policy implementation ($k = -1$) serving as the baseline. Specifically, using the period immediately preceding policy implementation as the baseline, we examine the differences in green innovation bubbles between firms in the treatment group and the control group across periods before and after policy implementation. As shown in Figure 1, the estimated coefficients for all periods prior to policy implementation are not significantly different from 0, indicating that the degree of green innovation bubbles among enterprises in the pilot zone before policy implementation did not differ significantly from that of enterprises outside the pilot zone, passing the parallel trends test. Furthermore, the policy effect exhibits a lag of approximately three years, becoming significantly negative starting from the fourth year after policy implementation, with the effect's intensity gradually increasing over time. This dynamic characteristic aligns with signaling theory: the policy operates by strengthening signal discrimination criteria and altering the relative costs of signaling, requiring firms time to perceive policy signals and adjust their innovation strategies. As the policy continues to be implemented, the signal discrimination mechanism is

continuously strengthened, and the cost of disguising strategic innovation continues to rise; consequently, the policy effect exhibits a cumulative strengthening pattern. The policy’s corrective function is sustainable in the long term; coefficients in subsequent periods after policy implementation gradually turn negative and become significant, indicating that the policy significantly suppressed the green innovation bubble among firms in the pilot zone, which is consistent with the main conclusion of this paper. Figure 1 reports the results of the parallel trends test.

Figure 1: Evaluation of the Parallel Trends Hypothesis



Note: Period -1 serves as the base period. Insignificant pre-policy coefficients support the parallel trends assumption.

5.2 Regression to the Mean

To test the impact of policies in green finance reform pilot zones on green innovation bubbles in firms (hypothesis H_1), his study conducts estimations by progressively incorporating fixed effects and control variables. Table 3 presents the regression results. Column (1) presents a mixed OLS regression containing only the core explanatory variables and the DID; Column (2) controls for city and year fixed effects on top of this; Column (3) includes control variables but does not control for firm fixed effects; Column (4) controls for firm, city, and year fixed effects as well as control variables, and serves as the benchmark model for this study. Table 3 reports the benchmark regression results.

The results show that the coefficient of the DID in Column (1) is -0.027, which is significant at the 1% level, suggesting that the policy has a dampening effect on the green innovation bubble. In Column (2), after incorporating city and year fixed effects, the absolute value of the DID coefficient increases to -0.038 and remains highly significant, indicating that the policy effect becomes more pronounced after controlling for city- and year-specific macroeconomic factors. In Column (3), which includes control variables but does not account for firm-level fixed effects, the DID coefficient is -0.031 and is significantly negative; however, the adjusted R^2 is only 0.098, indicating limited explanatory power of the model. In Column (4), firm-level fixed effects are further controlled for. The DID coefficient is -0.039, significant at the 1% level, and the adjusted R^2 increases substantially to 0.316, indicating that firm-level heterogeneity is a key factor explaining differences in green innovation bubbles. Therefore, this paper adopts Column (4) as the baseline model.

From an economic perspective, the mean value of the green innovation bubble is 0.118. The DID coefficient of -0.039 in the baseline model implies that, following policy implementation, the proportion of the green innovation bubble among firms in the treatment group decreased significantly by approximately 3.9 percentage points compared to the control group—equivalent to 35.1% of the mean. This indicates that the policy effect possesses both statistical and economic significance. In summary, **H_1 has been proven.**

Table 3: Regression to the Mean: The Impact of Policy on the Green Innovation Bubble

Variable name	(1)	(2)	(3)	(4)
	<i>GBR</i>	<i>GBR</i>	<i>GBR</i>	<i>GBR</i>
<i>DID</i>	-0.027***	-0.038***	-0.031***	-0.039***
	(0.007)	(0.014)	(0.008)	(0.014)
<i>Firm Size</i>			0.009**	0.009*
			(0.004)	(0.005)
<i>Debt To Asset</i>			0.059***	-0.012
			(0.019)	(0.019)
<i>ROA</i>			0.241***	0.024
			(0.042)	(0.038)
<i>Current Ratio</i>			-0.002	-0.002
			(0.001)	(0.001)
<i>Top1 holder</i>			0.050***	0.044
			(0.019)	(0.031)
<i>Tobins Q</i>			-0.007***	-0.001
			(0.003)	(0.002)
<i>Inst holding</i>			-0.052***	-0.019
			(0.013)	(0.022)
City fixed effects		Yes		Yes
Year fixed effects		Yes		Yes
Firm fixed effects		Yes		Yes
N	34124	34124	34124	34016
R ²	0.000	0.019	0.008	0.316

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. The figures in parentheses represent robust standard errors aggregated to the city level. The same applies below.

5.3 Stability Test

5.3.1 Change Cluster Level

In the baseline regression, standard errors were clustered at the industry-city-industry level. To further test the sensitivity of the findings to the choice of clustering level, this study re-estimated the model with standard errors clustered at the city-industry level. This level accounts for potential within-group correlations among firms within the same industry in the same city (such as local industrial policies and regional agglomeration effects). The results in Column (1) of Table 4 show that the DID coefficient is -0.039, which is significant at the 5% level (standard error = 0.018). This is highly consistent with the results of the baseline regression, indicating that the core conclusions are not affected by the choice of clustering level.

5.3.2 Exclude Samples Collected During the Pandemic

The COVID-19 pandemic from 2020 to 2022 may have had a significant impact on corporate innovation activities. To eliminate the confounding effects of this exceptional event, this study excluded the 2020–2022 samples and reran the regression analysis. The results in Column (2) of Table 4 show that the coefficient of the DID is -0.044, which is significant at the 1% level (standard error = 0.010). This is highly consistent with the results of the baseline regression, indicating that the core conclusions are not affected by the choice of clustering hierarchy.

5.3.3 Control for Other Policy Factors

During the study period, other concurrent policies may have influenced firms' green innovation. Building on the baseline model, this paper sequentially incorporates the low-carbon city pilot policy and the innovative city pilot policy as additional control variables. The results are reported in columns (3), (4), and (5) of Table 4. After controlling for these policies, the DID coefficient remains significantly negative at the 1% level, with a stable magnitude of -0.040. Meanwhile, the coefficients of the two policy variables themselves are not significant, indicating that the core conclusion of this paper is not affected by interference from other policies and exhibits a high degree of robustness. The policy variable for the Ecological Civilization Pilot Demonstration Zone was automatically omitted by the model due to multicollinearity with fixed effects. This reflects, to some extent, that the effects of this policy have been absorbed by unobservable factors at the city

level. Nevertheless, the coefficient of the core explanatory variable, DID, remains significant and stable across all models, indicating that the conclusions of this study are not subject to interference from other policies. Table reports the results of a series of robustness tests.

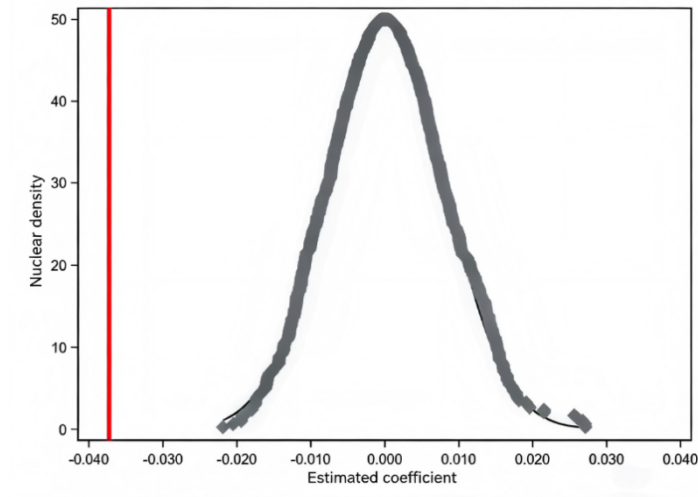
Table 4: Stability Test Results

Variable name	(1)	(2)	(3)	(4)	(5)
	City-Industry Clustering	Exclude COVID-19	Filter by Low-Carbon City Pilot Policies	Filter by Innovative Pilot Policies	Filter by All
<i>DID</i>	-0.039**	-0.044***	-0.040***	-0.040***	-0.040***
	(0.018)	(0.010)	(0.014)	(0.014)	(0.014)
<i>Lowcarbon</i>			-0.010		-0.010
			(0.009)		(0.009)
<i>Innovcity</i>				-0.003	-0.008
				(0.017)	(0.014)
Control variables	Yes	Yes	Yes	Yes	Yes
City fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
N	34016	24960	34016	34016	34016
R ²	0.322	0.299	0.316	0.316	0.316

5.3.4 Placebo Test

To rule out the interference of random factors on policy effects, this study also conducts a placebo test by randomly selecting samples from the experimental group. Following the approach of Lu et al. [11], and while keeping the policy implementation period constant, this study randomly samples firms from the sample based on the number of treatment groups in the baseline regression, designating them as a “pseudo” treatment group (i.e., firms within a virtual green finance reform and innovation pilot zone). Specifically, we randomly generated 1,000 combinations of treatment and control groups and varying years, re-estimating the model after each random sampling to obtain 1,000 “pseudo” estimated coefficients. As shown in Figure 2, the 1,000 estimated coefficients obtained from the random sampling are concentrated around the origin. The red vertical line in the figure represents the true estimated coefficient (-0.039) obtained from the baseline regression in this study, which is clearly located at the left tail of the overall distribution. Therefore, the results of the baseline regression in this study are unlikely to be due to chance, which indirectly supports the robustness of these results. Figure 2 reports the results of the placebo test.

Figure 2: Placebo Test Results



6. Further Analysis

6.1 Mechanism Analysis

Drawing on Shi Lei et al.’s [12] “action pathway decomposition” framework, this paper examines how green finance reform policies influence corporate green innovation bubbles through two possible pathways: the strategic green innovation pathway and the substantive green innovation pathway. This section first tests the significance of each pathway separately, and then quantifies the contribution share of each pathway.

6.1.1 Mechanism Test: Strategic Green Innovation

Based on the theoretical framework discussed earlier, policies in green finance reform and innovation pilot zones may curb the green innovation bubble by suppressing firms’ strategic green innovation and encouraging substantive green innovation (with the former being the primary mechanism). Therefore, this paper replaces the dependent variable in the main model with the mechanism variable; the specific results are shown in columns (1) and (2) of Table 5.

Table 5: Regression Results of the Mechanism Test

Variable name	(1)	(2)
	<i>TGU</i>	<i>TGI</i>
<i>DID</i>	-0.319***	-0.129*
	(0.048)	(0.069)
Control variables		
City fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Firm fixed effects	Yes	Yes
N	34066	34016
R ²	0.467	0.317

The results in Column (1) show that the DID coefficient for strategic green innovation is -0.319, which is significant at the 1% level, indicating that the policy significantly suppresses firms’ strategic green innovation; **H_{2a} is thus supported.**

The results in Column (2) show that the DID coefficient for substantive green innovation is -0.129, which is significant at the 10% level, indicating that the policy has a crowding-out effect on substantive green innovation in the short term. Further regression analysis reveals that substantive green innovation itself has a significant negative impact on the green innovation bubble (coefficient: -0.0046, $p < 0.01$). However, due to the crowding-out effect of the policy, the net contribution of this channel is very small (approximately 0.0006, accounting for only 1.5%) and is not statistically significant. This result is provided as supplementary information and is not included in the hypothesis testing.

6.1.2 Causal Path Analysis of Policy Mechanisms

To further examine the specific mechanisms through which digital industrial cluster policies operate, this paper draws on the average treatment effect decomposition approach proposed by Zhou and Yamamoto [13]. Within the Rubin framework, we analyze how policies in green finance reform and innovation pilot zones reduce corporate green innovation bubbles through the mechanisms of strategic green innovation and substantive green innovation.

Let the total policy effect be α_l (from the main model). First, we test the effect of the policy on strategic green innovation, yielding coefficient β_1 ; second, we test the effect of strategic green innovation on the green innovation bubble (controlling for the policy variable), yielding coefficient γ_1 . Similarly, we test the effect of the policy on substantive green innovation, yielding coefficient δ_1 , and test the effect of substantive green innovation on the green innovation bubble, yielding coefficient θ_1 . The formulas for calculating the contributions of each path and the direct effect are as follows:

Contribution of the strategic innovation path: $\beta_1 \times \gamma_1$

Contribution of the substantive innovation path: $\delta_1 \times \theta_1$

Direct effect: $\alpha_l - (\beta_1 \times \gamma_1 + \delta_1 \times \theta_1)$

The proportion of each path's contribution is calculated as follows:

Proportion of strategic innovation path = $\frac{\beta_1 \times \gamma_1}{\alpha_l} \times 100\%$

Proportion of the substantive innovation path = $\frac{\delta_1 \times \theta_1}{\alpha_l} \times 100\%$

Proportion of the direct effect = $\frac{\alpha_l - (\beta_1 \times \gamma_1 + \delta_1 \times \theta_1)}{\alpha_l} \times 100\%$

If $\beta_1 \times \gamma_1$ has the same sign as α_l and accounts for a high proportion, this indicates that strategic innovation is a key pathway through which policy exerts its influence, thereby confirming Hypothesis H_{2b}.

The calculated contribution ratios for each path are presented in Table 6.

Table 6: Path Analysis: Core Path Contributions to Strategic Green Innovation

Pathways of Green Finance Reform Pilot Policies	Coefficient Value	Percentage (%)
Overall Average Effect	-0.039***	100.00%
Green Finance Reform Pilot Policies → Strategic Innovation ↔ Green Innovation Bubble	-0.027***	69.5%
Green Finance Reform Pilot Policies → Substantive Innovation ↔ Substantive Innovation	0.0006	-1.5%
Substantive Innovation → Green Innovation Bubble	-0.012	32.0%

Note: The average total effect is derived from the baseline regression. The contribution of the strategic innovation pathway is calculated as the product of the strategic innovation coefficient (-0.319) in column (1) of Table 5 and the strategic innovation coefficient (0.085) in column (1) of Table 6. The contribution of the substantive innovation path is the product of the coefficient for substantive innovation in column (2) of Table 5 (-0.129) and the coefficient for substantive innovation in column (2) of Table 6 (-0.005). The direct effect is the total effect minus the sum of the contributions from the two paths. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively (the significance of the strategic innovation path is calculated using the Delta method, $z = -6.57, p < 0.001$). Among these, the contribution of the substantive innovation path is positive and opposite in direction to the total effect; the percentage shown in the table is the absolute value, and its actual effect is to weaken the total effect.

As shown in Table 6, the contribution of the strategic green innovation path is -0.027, accounting for 69.5% of the total effect, and is highly significant. This indicates that strategic green innovation exacerbates green innovation bubbles in firms, confirming Hypothesis H_{2b}. The contribution of the substantive green innovation path is 0.0006, accounting for -1.5% (in the opposite direction), and is not statistically significant. This result suggests that, in the short term, the policy exerts a certain crowding-out effect on substantive green innovation, offsetting the bubble-suppressing role it would otherwise play. However, the contribution of this pathway is negligible and does not affect the dominant effect exerted by the policy through the strategic innovation pathway. The direct effect accounts for 32.0%, indicating that the policy likely operates through other

unobserved channels (such as market expectations or reputational effects) or signals that the two pathways fail to fully capture.

In summary, green finance reform policies primarily reduce green innovation bubbles by curbing firms' strategic green innovation, while the slight negative effect of the substantive innovation channel reflects adjustment costs during the policy transition period and does not affect the core conclusion.

6.2 Heterogeneity Analysis

There may be differences in the ability of firms with different characteristics to receive and respond to policy signals, which determines the heterogeneity of policy outcomes.

(1) Dimension of Ownership Structure

State-owned enterprises and non-state-owned enterprises exhibit significant differences in terms of resource acquisition, market sensitivity, and incentive-constraint mechanisms. According to Fang [14], state-owned enterprises, relying on their inherent ties to the government, possess inherent advantages in areas such as access to financing and policy support, and are relatively less sensitive to financial market signals. When policy adjustments alter the rules of the signaling game, state-owned enterprises may feel less urgency to adjust their innovation strategies due to "soft budget constraints" and their advantages in resource endowments. In contrast, non-state-owned enterprises face long-term financing constraints and are more sensitive to financial market signals; they must respond swiftly to policy changes to maintain their financing channels and competitive market positions. Therefore, the inhibitory effect of policies on strategic innovation should be more pronounced in non-state-owned enterprises, thereby exerting a stronger dampening effect on green innovation bubbles. Based on this, the following hypotheses are proposed:

H₃: Green finance reform policies may have a stronger dampening effect on green innovation bubbles in non-state-owned enterprises than in state-owned enterprises.

6.2.1 Heterogeneity in Ownership Structure

Heterogeneity in Ownership Structure. Table 7 presents the results of the group-specific tests.

Table 7: Heterogeneity Analysis: Nature of Property Rights

Variable name	TGU	GBR		
	(1) Non-state-owned enterprise	(2) State-owned enterprise	(3) Non-state-owned enterprise	(4) State-owned enterprise
<i>DID</i>	-0.231***	-0.366***	-0.0401***	0.00842
	(-4.22)	(-4.35)	(-9.52)	(0.41)
<i>TGU</i>			0.0892***	0.0833***
			(15.15)	(18.47)
Control variables	Yes	Yes	Yes	Yes
City fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
N	14590	18858	14590	18858
R ²	0.471	0.472	0.467	0.457

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively; the values in parentheses are *t*-statistics adjusted for clustering at the city level. The test for differences in coefficients across groups was based on 500 bootstrap repetitions. In the strategic innovation equation, the difference in DID coefficients across groups was not significant ($p = 0.192$); in the green innovation bubble equation, the difference in DID coefficients across groups was significant ($p = 0.046$).

In terms of strategic innovation, the DID coefficients for non-SOEs and SOEs were -0.231 and -0.366, respectively, both significant at the 1% level. However, a test of the difference in coefficients between the two groups showed no significant difference ($p=0.192$), indicating that there is no significant difference in the inhibitory effect of policy on strategic innovation between the two types of enterprises.

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groups showed no significant difference ($p=0.192$), indicating that there is no significant difference in the inhibitory effect of policy on strategic innovation between the two types of enterprises H3.

In terms of strategic innovation, the DID coefficients for non-SOEs and SOEs were -0.231 and -0.366, respectively, both significant at the 1% level. However, a test of the difference in coefficients between the two groups showed no significant difference ($p=0.192$), indicating that there is no significant difference in the inhibitory effect of policy on strategic innovation between the two types of enterprises.

6.2.2 Regional Heterogeneity

Regarding the regional heterogeneity of green finance policy effects, existing literature has accumulated a wealth of empirical evidence. In terms of the level of green finance development, China exhibits a distinct spatial pattern characterized by “higher levels in the east and lower levels in the west”; specifically, the level of green finance development is relatively higher in the eastern regions, while it lags behind in the central and western regions [15, 16]. In terms of policy impact, the role of green finance in promoting regional development is more pronounced in the eastern regions; for example, its effect on enhancing macroeconomic resilience is stronger in eastern provinces than in central and western provinces. In terms of transmission mechanisms, the higher level of marketization and greater efficiency in resource allocation in the eastern regions are key factors enabling these policy effects to be more fully realized; the carbon reduction effects of green credit are more evident in areas with high resource allocation efficiency, such as eastern cities [17].

Based on this, this paper further examines the regional heterogeneity of the policy effects of green finance reform pilot zones, hypothesizing that the policy’s dampening effect on green innovation bubbles may be stronger in the eastern regions than in the central and western regions. This paper divides the sample into eastern and central-western regions for group-specific regression analysis and employs a permutation test to examine differences in coefficients between groups. Table 8 reports the results of the group-specific regression analysis.

Table 8: Regional heterogeneity: Eastern VS Midwest

Variable name	TGU	GBR		
	(1) East	(2) Mid west	(3) East	(4) Mid west
DID	-0.306***	-0.277***	-0.021***	0.006
	(0.049)	(0.044)	(0.007)	(0.006)
TGU			0.084***	0.090***
			(0.004)	(0.006)
City control effect	Yes	Yes	Yes	Yes
City control effect	Yes	Yes	Yes	Yes
Year control effect	Yes	Yes	Yes	Yes
Firm control effect	Yes	Yes	Yes	Yes
N	24503	9276	24503	9276
R ²	0.473	0.461	0.468	0.463

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively; the values in parentheses are t-statistics adjusted for clustering at the city level. The test for differences in coefficients between groups was based on 500 bootstrap repetitions. The difference in DID coefficients between the two groups in the strategic innovation equation was not significant ($p = 0.444$), and the difference in DID coefficients between the two groups in the green innovation bubble equation was also not significant ($p = 0.218$).

In terms of strategic innovation, the DID coefficients for the eastern and central-western groups were -0.306 and -0.277, respectively, both significant at the 1% level; however, a test of the difference in coefficients between the groups showed no significant difference ($p > 0.1$), indicating that there is no significant difference in the inhibitory effect of the policy on strategic innovation among firms in these two types of regions.

Regarding green innovation bubbles, the DID coefficient for the Eastern group is -0.021, which is significant at the 1% level; whereas the DID coefficient for the Central and Western group is 0.006, which is not significant. The test of differences in coefficients between groups indicates that the difference between the two groups is significant ($p < 0.01$). This suggests that the policy’s dampening effect on green innovation bubbles is significant only in the Eastern region and has not yet manifested in the Central and Western regions. A possible reason lies in the fact that financial markets in the eastern region are more developed and information transmission is more efficient, allowing policy signals to be transmitted more effectively to

corporate behavior; whereas in the central and western regions, the degree of marketization is relatively lower, and the implementation of policy effects may face more obstacles.

To examine regional differences in policy effects, this study divides the sample into two groups—the eastern region and the central and western regions—for regression analysis, and employs a permutation test (500 iterations) to test for differences in coefficients between groups.

Regarding strategic innovation, the DID coefficients for the eastern and central-western groups are -0.306 and -0.277, respectively, both significant at the 1% level; however, the p-value for the between-group difference test is 0.444, indicating no statistically significant difference between the two groups' coefficients. Regarding green innovation bubbles, the DID coefficient for the Eastern group is -0.021 (significant at the 1% level), while that for the Central and Western group is 0.006 (not significant); however, the p-value for the test of differences between groups is 0.218, which is also not significant. Therefore, there is no significant regional difference between the Eastern and Central and Western regions in the policy's dampening effect on green innovation bubbles.

This result indicates that the effects of green finance reform policies are consistent across the eastern and central-western regions; differences in the degree of marketization or the level of financial development among regions do not significantly alter the policy's transmission effects. A possible reason lies in the fact that green finance reform policies, as a form of top-level design, directly impact enterprises through mechanisms such as credit review and information disclosure. Their efficacy can transcend regional barriers, reflecting a certain degree of "universal" characteristics.

7. Conclusions and Policy Recommendations

This study examines Chinese A-share listed companies from 2010 to 2024. Drawing on the quasi-natural experiment created by the establishment of Green Finance Reform and Innovation Pilot Zones, it systematically investigates the impact of green finance policies on corporate green innovation bubbles and their underlying mechanisms. The study finds the following: First, policies in green finance reform pilot zones significantly suppress corporate green innovation bubbles. After policy implementation, the proportion of firms in the treatment group exhibiting bubbles decreased by approximately 3.9 percentage points, equivalent to 35.1% of the mean; this conclusion remains valid after a series of robustness tests. Second, strategic green innovation is the core mechanism through which the policy suppresses bubbles. The policy significantly suppressed firms' strategic green innovation (coefficient = -0.319), whereas strategic innovation significantly exacerbated green innovation bubbles. Path decomposition revealed that the strategic innovation path contributed -0.027, accounting for 69.5% of the policy's total effect, while the direct effect was not significant. Third, policies exert a short-term crowding-out effect on substantive green innovation, but they inherently serve to suppress bubbles. Policies significantly suppressed substantive green innovation (coefficient = -0.129), while substantive innovation significantly suppressed bubbles (coefficient = -0.0046). The contribution of this path was only 0.0006, which was not statistically significant, indicating that the policy crowding-out effect and the innovation-suppressing effect offset each other. Fourth, the policy effects exhibit heterogeneity. In terms of ownership structure, there is no significant difference in the policy's suppression of strategic innovation between the two types of firms, but the suppression of green innovation bubbles is significant only in non-state-owned enterprises (non-SOEs: -0.040; SOEs: 0.008), with a significant difference between groups ($p = 0.034$). In terms of regional heterogeneity, the policy's suppression of strategic innovation was significant in both the eastern and central-western regions, while its suppression of the green innovation bubble was significant only in the eastern region; however, the test for differences between groups was not significant ($p = 0.218$). This indicates that the policy effects exhibit consistency across regions, reflecting the inclusive nature of market-based tools.

This paper identifies strategic green innovation as the primary mechanism through which policies can curb green innovation bubbles; however, whether there are other potential channels (such as corporate green culture and green transmission through supply chains) remains to be explored in future research.

Based on the above conclusions, this paper offers the following policy implications:

First, we should continue to deepen the development of green finance reform pilot zones and strengthen the signal-discrimination function of policies. This paper demonstrates that policies effectively reduce green

innovation bubbles by curbing strategic innovation, indicating that their built-in incentive-compatibility mechanisms—raising signal discrimination standards and altering the relative costs of signaling—play a crucial role. It is recommended that, building on existing pilot programs, the scope of pilot zones be further expanded, successful experiences be promoted, and supporting systems such as environmental information disclosure and green credit review be continuously improved to strengthen the policy’s “correction” function.

Second, establish a differentiated innovation quality assessment system to accurately identify enterprises’ strategic innovation behaviors. Strategic green innovation is a direct source of bubble formation; regulatory authorities should establish a more refined green patent quality assessment system that focuses not only on patent quantity but also on technical content, application scenarios, and environmental benefits. The proportion of green utility model patents could serve as a monitoring indicator, with enterprises showing abnormally high proportions subject to focused scrutiny to reduce the scope for “greenwashing” practices.

Third, address adjustment costs during policy transitions and provide transitional support for substantive innovation. The short-term crowding-out effect of policies on substantive green innovation indicates that enterprises face resource reallocation costs and barriers to technological accumulation during the innovation transition. It is recommended that, during the initial implementation phase of policies, enterprises be provided with a buffer period and transitional support—such as establishing green innovation transition funds and offering technical consulting and talent training services—to help them smoothly shift from strategic innovation to substantive innovation.

Fourth, improve the green credit allocation mechanism to ensure financial resources flow toward genuine green innovation. Although the path of green credit share did not pass the validity test in this study, the core function of green finance remains to direct credit resources toward green sectors. The screening criteria for green credit should be further optimized to prevent credit funds from being used for “greenwashing” projects, ensuring that financial support truly benefits enterprises engaged in high-quality green R&D.

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