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# The impact of green finance on corporate environmental investment: a quasi-natural experiment based on the Green Finance Reform and Innovation Pilot Zones

***Huabo Hu***

Communication University of China, Chuangda Company, Jinhua, China

harbourhu422@163.com

**Abstract.** Green finance is a pivotal market-oriented instrument for coordinating economic growth with ecological sustainability. Against the backdrop of China's Green Finance Reform and Innovation Pilot Zone (GFRIPZ) policy, this paper utilizes this policy implemented in 2017 as a quasi-natural experiment to investigate its impact on corporate environmental investment. Based on data from Shanghai and Shenzhen A-share listed companies from 2011 to 2024, this study conducts an empirical test using the Difference-in-Differences (DID) model. The results indicate that the pilot policy significantly promotes corporate environmental investment. Mechanism analysis demonstrates that the policy drives investment through two main channels: first, by increasing government environmental subsidies to provide fiscal incentives; and second, by strengthening regional environmental regulation intensity to exert external pressure. Furthermore, heterogeneity analysis reveals that the promoting effect of the pilot policy on environmental investment is more pronounced for non-state-owned enterprises and non-heavily polluting firms. This paper provides empirical evidence for assessing the micro-level effectiveness of green finance policies and offers theoretical support for optimizing resource allocation and driving a comprehensive green economic transformation.

**Keywords:** green finance, corporate environmental investment, Difference-in-Differences, government subsidies, environmental regulation

## 1. Introduction

As the vital source of steady economic growth, finance acts as a crucial factor influencing ecological development [1]. As early as 1992, the United Nations Environment Programme (UNEP) emphasized the importance of the financial sector in promoting ecological development in the *Statement by Banks on the Environment and Sustainable Development*. This sparked global attention regarding the 'green' nature of the financial industry, leading to the formation of the green finance concept. As a vital market-oriented environmental governance tool, green finance guides capital flows toward green and low-carbon sectors [2]. It not only optimizes resource allocation [3, 4] but also provides critical financial support and institutional incentives for corporate green transformation [5, 6]. How to rely on market-based mechanisms to guide enterprises in strengthening environmental governance remains a critical issue for achieving economic green

transformation and sustainable development [7, 8]. Theoretically, green finance policies represent economic behaviors related to green development that are supported by the national government and implemented by the financial sector. Environmental governance should always serve as the fundamental direction for the implementation of green finance policies [9]. The Green Finance Reform and Innovation Pilot Zone policy implemented in China since 2017 provides a typical quasi-natural experimental setting to analyze how green finance policies guide market demand and regulate the behavior of market entities. The original intention of this policy is to allocate financial resources from the supply side: on one hand, it supports enterprises in undergoing green transformation, encouraging breakthroughs in resource utilization, environmental protection technology, and sustainable development; on the other hand, it exerts pressure on polluting enterprises by restricting their access to finance or increasing their financing costs, thereby forcing them to increase environmental protection investment and achieve green transformation.

Extensive research has analyzed the macroeconomic and environmental consequences of green finance reform policies. Using a Difference-in-Differences (DID) model, Huang and Zhang [10] and Wang et al. [11] empirically found that the Green Finance Reform and Innovation Pilot Zone policy significantly reduced environmental pollution and promoted regional green development. Ran and Zhang [12] and Hu et al. [13] argued that this policy significantly promotes carbon emission reduction, drives the transition to a low-carbon economy, and exhibits spatial spillover effects. Regarding transmission mechanisms, some scholars posit that green finance improves environmental performance by optimizing industrial structure, promoting technological progress, and enhancing energy efficiency. Furthermore, concerning the impact of green finance on corporate innovation, research has focused on both the quantity and quality of innovation output. Liu & Wang [14] and Zhang & Li [15] both concluded that green finance reform significantly increased the number of corporate green patent applications and improved innovation quality. On the other hand, some studies have explored the pathways through which green finance influences innovation. First, regarding the alleviation of financing constraints, Yan et al. [16] and Liu & Xiong [17] pointed out that the policy promotes corporate R&D investment and innovation by reducing debt financing costs and easing financing constraints. Second, regarding external supervision and signaling, Shi et al. [18] found that green finance policies reduce financing costs through a reputation insurance effect rather than the innovation compensation effect of the Porter Hypothesis, while Zeng et al. [19] emphasized the role of the signaling mechanism in alleviating financing constraints. Additionally, Yan et al. [16] found that the pilot zone policy significantly reduced inefficient investment and over-investment, thereby enhancing overall corporate investment efficiency. Meanwhile, numerous scholars, such as Lei & Yu [20] and Gao et al. [21] have focused on the enhancement of corporate ESG performance by green finance, arguing that the policy improves corporate sustainability performance by introducing institutional investors and alleviating external pressures. However, Huang et al. [22] cautioned that the policy might also induce "greenwashing" behaviors by exacerbating managerial myopia, leading to strategic rather than substantive environmental improvements.

As environmental issues become increasingly severe, corporate environmental investment has become a critical link connecting environmental protection with economic development. Existing literature on corporate environmental investment presents a multi-dimensional perspective, mainly focusing on the institutional and market factors influencing such investment, as well as the resulting environmental and economic consequences. Huang and Lei [23] refined the types of regulations and found an inverted U-shaped relationship between command-and-control regulation and corporate green investment, whereas regulations based on market mechanisms and public participation were positively correlated with green investment. Zhang et al. [24] based on the establishment of environmental courts, found that environmental judicial reform

significantly promoted corporate environmental investment by improving law enforcement levels and reducing local protectionism.

It is noteworthy that policy uncertainty acts as an "inhibitor" to investment; uncertainty in either policy content or implementation significantly suppresses corporate willingness for green investment [25]. The "soft constraint" mechanism constituted by public demands and internal governance also cannot be ignored. Public demands can prompt local governments to strengthen the enforcement of environmental regulations, thereby indirectly driving enterprises to increase green investment [26]. From an internal corporate perspective, Li et al. [27] found that good ESG performance generates positive incentives for corporate environmental investment by alleviating financing constraints and strengthening internal supervision. Gu et al. [28] highlighted that the pressure associated with CEO turnover in heavily polluting enterprises prompts successors to alleviate external pressure by increasing green investment.

The efficiency of financial resource allocation directly affects firms' investment capacity; however, due to information asymmetry, whether financial support translates into substantive green transformation remains to be further explored. For instance, Tian et al. [29] argued that while green credit increased the quantity of investment, it reduced the green investment efficiency of heavily polluting enterprises.

Regarding the consequences of corporate environmental investment, existing research generally supports the existence of "dual dividends" in environmental and financial performance. At the environmental level, Ren et al. [30] confirmed that green investment significantly reduces local environmental pollution by improving energy conservation and emission reduction efficiency as well as technological innovation capabilities. Research by Shen et al. [31] also supports the negative correlation between green investment and carbon dioxide emissions. At the economic level, Chen and Ma [32] argued that green investment is significantly positively correlated with the financial performance of energy companies.

Overall, although extensive literature has discussed the macroeconomic and environmental consequences of green finance policies, there is still a lack of in-depth empirical analysis on the impact mechanisms at the corporate level, particularly regarding environmental investment. Based on this, taking the establishment of China's Green Finance Reform and Innovation Pilot Zones as the research background, this paper uses Shanghai and Shenzhen A-share listed companies from 2011 to 2024 as the research sample and employs a Difference-in-Differences (DID) model to empirically test the impact of the pilot policy on corporate environmental investment. The study finds that the pilot policy significantly promotes corporate environmental investment. Further research reveals that the pilot policy promotes corporate environmental investment through two pathways: increasing government environmental subsidies and strengthening environmental regulation intensity.

The marginal contributions of this paper are reflected in the following two aspects. First, from the perspective of corporate micro-investment behavior, this study directly tests the causal effect of the Green Finance Reform and Innovation Pilot Zones on corporate environmental investment. It fills the gap in existing literature where insufficient attention has been paid to environmental investment—a key variable—in policy evaluations, thereby expanding the research boundary of the economic consequences of green finance policies. While existing literature mostly focuses on the impact of pilot policies on green innovation and pollution emissions, it has not systematically examined their direct role in corporate environmental investment decisions; thus, this paper provides new empirical evidence for understanding how green finance guides corporate resource allocation. Second, starting from the dual mechanisms of fiscal incentives and environmental regulation, this paper reveals that the pilot policy affects corporate environmental investment through two pathways: government environmental subsidies and environmental regulation intensity.

Furthermore, it examines the heterogeneous effects based on enterprise ownership and industry pollution attributes, providing theoretical support for policy optimization.

The structure of the remainder of the paper is as follows: Section 2 introduces the institutional background and theoretically analyzes the impact of the green finance pilot zones on corporate environmental investment; Section 3 presents the research design of the empirical part; Section 4 displays the empirical results of hypothesis testing; and Section 5 provides the conclusions and policy recommendations.

## 2. Policy background and hypothesis development

### 2.1. Policy background

China has long recognized the pivotal role of the financial system in supporting the construction of an ecological civilization. Although various policy documents concerning the environmental and financial sectors were promulgated at an earlier stage, green finance truly entered a systematic and standardized development track only with the issuance of the *Green Credit Guidelines* by the former China Banking Regulatory Commission (CBRC) in 2012. For the first time, this document clarified regulatory requirements for financial institutions regarding environmental risk identification, loan structure adjustment, and the allocation of green credit, thereby laying the foundation for the formation of China's green credit policy system.

Subsequently, the institutional framework of green finance was further reinforced by national top-level design. In 2015, the CPC Central Committee and the State Council issued the *Overall Plan for the Reform of Ecological Civilization System*, formally proposing the general concept of building a green finance system. This document defined the positioning and policy direction of finance within ecological civilization construction, marking the elevation of green finance from fragmented policy measures to a national strategy. Under this framework, the People's Bank of China (PBOC), in conjunction with multiple ministries, jointly issued the *Guidelines for Establishing the Green Financial System* in 2016. This document set forth systematic regulations covering institutional supply, standard systems, information disclosure, incentive and constraint mechanisms, and risk management. It represented the first institutionalized and systematic scheme for China's green finance system, establishing a top-down green finance policy framework and ushering in a stage of comprehensive implementation.

Following the preliminary completion of the top-level institutional design, the central government began to explore feasible pathways and practical models for green finance at the local level. In 2017, to further promote the development of the green finance system nationwide, the State Council executive meeting approved the resolution to establish the first batch of Green Finance Reform and Innovation Pilot Zones in five provinces (regions): Zhejiang, Jiangxi, Guizhou, Guangdong, and the Xinjiang Uygur Autonomous Region. This officially signaled that China's green finance system had begun to form a "bottom-up" model of innovative exploration and development. The establishment of these initial pilot zones aimed to generate replicable and scalable green finance development schemes nationwide, thereby driving the continuous improvement and long-term development of China's green finance system and laying a financial service foundation for the future construction of China's green economic system.

In fact, the selection of the first batch of pilot zones comprehensively considered the unique characteristics and developmental advantages of different regions; they were broadly categorized based on economic development levels and ecological infrastructure. Specifically, Zhejiang and Guangdong Provinces are located on the eastern coast, possessing strong economic foundations and relatively complete ecological governance systems. They are considered optimal regions for leading green finance institutional innovation. Consequently, they assume the role of "pioneering demonstrations", utilizing financial guidance to promote industrial

greening and economic structural optimization. Jiangxi and Guizhou Provinces are located in the central and western regions. Although their economic development levels are relatively limited, they are rich in ecological resource reserves and possess the capacity for ecological asset conversion. The construction of pilot zones in these areas aims to explore how to rely on green finance to facilitate the value realization and sustainable utilization of ecological resources. As a western border region, the Xinjiang Uygur Autonomous Region faces the reality of relatively weak economic and ecological foundations. However, it benefits from substantial policy support and ample space for institutional innovation. The establishment of this pilot zone aims to formulate a green finance development path adapted to the characteristics of border regions and to provide a reference model for other western regions.

## 2.2. Hypothesis development

Theoretically, the Green Finance Reform and Innovation Pilot Zone (GFRIPZ) policy alters the cost-benefit structure of enterprises through its intrinsic incentive and constraint mechanisms, thereby influencing their decision-making behavior. The core objective of the GFRIPZ policy is to construct a green finance system, guiding capital flows toward green domains through various financial instruments such as credit and bonds, while simultaneously imposing hard constraints on high-pollution industries. Existing research has fully confirmed the macro-environmental benefits of green finance reform, including significantly reducing environmental pollution and promoting regional green development [10, 11]. The realization of such macro-performance inevitably relies on green transformation at the corporate micro-level, among which environmental investment serves as a key substantive input for enterprises to conduct pollution prevention and enhance resource efficiency. Under the implementation of the pilot zone policy, financing costs for green enterprises are reduced and investment opportunities increase; conversely, high-pollution enterprises face external pressure and must increase environmental inputs to maintain compliance and market reputation. Therefore, this paper proposes Hypothesis 1.

H1: The Green Finance Reform and Innovation Pilot Zones have a positive promoting effect on corporate environmental investment.

As a typical investment with positive externalities, the returns on corporate environmental investment are difficult for firms to fully internalize, leading to a tendency toward underinvestment. To correct this market failure, government fiscal intervention becomes a necessary instrument. The implementation of the green finance reform policy represents not only a transformation of the financial sector but also a profound adjustment in local governments' environmental governance goals and fiscal spending orientation. Following the establishment of the pilot zones, to align with central policies and ensure the achievement of regional environmental targets, local governments tend to increase the supply of government environmental subsidies, utilizing them as a supporting incentive tool to leverage corporate environmental investment. An increase in government environmental subsidies is equivalent to directly reducing the cost of corporate environmental inputs and enhancing the rate of return on environmental investment. Such direct fiscal incentives can effectively alleviate firms' concerns arising from the long cycles and high uncertainty of returns associated with environmental investment, thereby stimulating their investment enthusiasm. Therefore, this paper proposes Hypothesis 2.

H2: The Green Finance Reform and Innovation Pilot Zones will indirectly promote the increase of corporate environmental investment by increasing government environmental subsidies.

The construction of a green finance system is inextricably linked to an effective environmental regulation system. For instance, environmental judicial reform has been proven to significantly promote corporate environmental investment by improving law enforcement levels [24]. The establishment of green finance

reform pilot zones signifies not only financial innovation but also an upgrade in the regional environmental governance system. Clear policy objectives and central assessment requirements will intensify competition in environmental governance among local governments, prompting environmental regulatory agencies in the pilot zones to tighten enforcement standards and increase regulatory frequency. This strengthened regional environmental regulation creates clear external pressure and a "forcing effect" on enterprises. The rise in environmental compliance costs and the increased risk of potential fines and reputational damage compel enterprises to transform passive compliance into active investment, shifting funds from non-environmental projects to environmental projects to evade regulatory risks. Therefore, this paper proposes Hypothesis 3.

H3: The Green Finance Reform and Innovation Pilot Zones will promote the increase of corporate environmental investment by intensifying regional environmental regulation.

## 3. Research design

### 3.1. Model setting

To investigate the impact of the Green Finance Reform and Innovation Pilot Zone on corporate environmental investment, this paper constructs the following Difference-in-Differences (DID) model (see Equation (1)):

$$Invest_{it} = a_0 + a_1 Greenfin_{it} + \beta control_{it} + {}_i + \gamma_t + \varepsilon_{it} \quad (1)$$

Where the subscript $i$ denotes the firm and $t$ denotes the year. $Invest_{it}$ represents the environmental investment of firm $i$ in year $t$. The variable $Greenfin_{it}$ indicates whether the Green Finance Reform and Innovation Pilot Zone policy is implemented for the firm in year $t$. $control_{it}$ represents a series of control variables that may affect corporate environmental investment. $i$ denotes firm fixed effects, $\gamma_t$ denotes time fixed effects, and $\varepsilon_{it}$ represents the random disturbance term. This paper primarily focuses on the coefficient $a_1$ of the core explanatory variable; if this coefficient is positive, it indicates that green finance can increase corporate environmental investment. This paper uses robust standard errors clustered at the firm level.

### 3.2. Sample selection and data sources

In June 2017, China established the first batch of Green Finance Reform and Innovation Pilot Zones across eight locations in five provinces (autonomous regions). Subsequently, a second batch was established in Lanzhou, Gansu Province, in December 2019, followed by a further expansion to include Chongqing in August 2022. Given that the staggered Difference-in-Differences (DID) estimation requires data spanning the pre-event period to evaluate time effects, this study selects A-share companies listed on the Shanghai and Shenzhen Stock Exchanges from 2011 to 2024 as the research sample.

The data were processed according to the following criteria: (1) listed companies in the financial sector were excluded; (2) samples designated as ST, *ST, or PT in the current year were excluded; and (3) samples with missing values for key variables were removed. Ultimately, the final sample comprises 48,080 firm-year observations covering 5,149 listed companies. Furthermore, to mitigate the influence of outliers, all continuous variables were winsorized at the 1% and 99% levels. Data on corporate environmental investment were derived from annual financial reports, while corporate basic information and financial data were sourced from the China Stock Market & Accounting Research (CSMAR) database.

## 3.3. Variable design

### *3.3.1. Independent variable*

The independent variable in this paper is the Green Finance Reform and Innovation Pilot *Zone (Greenfin)*. If the city where a firm is located is designated as a Green Finance Reform and Innovation Pilot Zone in a given year, the variable takes a value of 1 for that year and all subsequent years; otherwise, it takes a value of 0.

### *3.3.2 Dependent variable*

The dependent variable in this study is corporate environmental investment *(Invest)*. The "Construction in Progress" account in the annual financial reports of listed companies discloses expenditures on environmental projects, such as desulfurization, denitrification, and sewage treatment. Following Zhang et al. [24], projects are identified as environmental investments if their details contain keywords such as "environmental protection", "wastewater treatment", "clean", "greening", "energy saving", "emission reduction", "desulfurization", or "dust removal". These investments are aggregated to determine the total capitalized environmental expenditure for the year. To mitigate scale effects, corporate environmental investment is standardized by the firm's year-end net assets. Additionally, to enhance the readability of the empirical results, the standardized value is multiplied by 100. In the subsequent robustness tests, the sum of expensed environmental expenditures (recorded under the "Administrative Expenses" account in annual reports) and capitalized environmental investments is used as an alternative proxy variable for corporate environmental investment.

### *3.3.3. Control variables*

Following existing research [33-35], this paper introduces control variables that may influence corporate environmental investment, specifically including: (1) Firm size *(Size)*, measured by the natural logarithm of total assets; (2) Return on assets *(ROA)*, measured by the ratio of net profit to total assets; (3) Asset-liability ratio *(Lev)*, represented by the ratio of total liabilities to total assets; (4) Growth capability *(Growth)*, defined as the growth rate of operating income; (5) Firm age *(Age)*, measured by the natural logarithm of the firm's age plus one; (6) Ownership concentration *(Top1)*, represented by the shareholding proportion of the largest shareholder; (7) Board size *(Boardsize)*, measured by the natural logarithm of the number of board members; and (8) Independent director ratio *(Indep)*, which is the ratio of independent directors to the total number of board members.

### *3.3.4. Descriptive statistics*

Table 1 reports descriptive statistics for the key variables used in this study. The dependent variable, environmental protection investment (Invest), ranges from 0 to 9.9294, with a mean value of 0.3039, indicating considerable heterogeneity in firms' environmental investment intensity across the sample. The explanatory variable representing the green finance reform (Greenfin) has an average value of 0.0419, suggesting that approximately 4.19% of firms are located within green finance pilot zones. The distributions of the remaining control variables are generally consistent with normal patterns and align with those documented in prior empirical research. Hence, no further elaboration on these variables is necessary.

**Table 1.** Summary statistics

| Variable Name | Obs | Mean | SD | Min | Median | Max |
|---|---|---|---|---|---|---|
| Invest | 48,081 | 0.3039 | 1.3291 | 0.0000 | 0.0000 | 9.9294 |
| Greenfin | 48,081 | 0.0419 | 0.2003 | 0.0000 | 0.0000 | 1.0000 |

Table 1. Continued

| | | | | | | |
|---|---|---|---|---|---|---|
| Age | 48,081 | 2.0905 | 0.9337 | 0.0000 | 2.3026 | 3.4012 |
| Size | 48,081 | 22.2059 | 1.3045 | 19.7391 | 22.0022 | 26.2862 |
| Lev | 48,081 | 0.4217 | 0.2144 | 0.0518 | 0.4093 | 0.9550 |
| ROA | 48,081 | 0.0290 | 0.0733 | -0.3336 | 0.0343 | 0.1964 |
| Growth | 48,081 | 0.3546 | 0.9869 | -0.7682 | 0.1161 | 6.9545 |
| Indep | 48,081 | 37.8182 | 5.3751 | 33.3300 | 36.3600 | 57.1400 |
| Boardsize | 48,081 | 2.3723 | 0.2317 | 1.7918 | 2.3026 | 2.9444 |
| Top1 | 48,081 | 33.3588 | 14.8323 | 8.1400 | 30.9300 | 74.0200 |

# 4. Empirical analysis

## 4.1. Baseline results

Based on Model (1), the impact of green finance on corporate environmental investment is estimated, with the results presented in Table 2. Column (1) reports the regression results without control variables, indicating that the Green Finance Reform and Innovation Pilot Zone has a significant promoting effect on corporate environmental investment. After including control variables in Column (2), the regression coefficient of the pilot zone remains positive at the 1% significance level, further verifying its significant positive impact on corporate environmental investment. In terms of economic significance, taking Column (2) as an example, a one-unit increase in *Greenfin* leads to an increase of approximately 40.67% in the level of corporate environmental investment (calculated as 0.1236/0.3039). Overall, the baseline regression results indicate that the establishment of Green Finance Reform and Innovation Pilot Zones can significantly encourage firms to undertake environmental investment.

**Table 2.** Baseline results

| | (1) | (2) |
|---|---|---|
| Greenfin | 0.1204*** | 0.1236*** |
| | (0.0456) | (0.0454) |
| Age | | 0.0026 |
| | | (0.0176) |
| Size | | 0.0892*** |
| | | (0.0147) |
| Lev | | 0.3899*** |
| | | (0.0540) |
| ROA | | 0.2130** |
| | | (0.1022) |
| Growth | | -0.0110** |
| | | (0.0048) |

Table 2. Continued

| | | |
|---|---|---|
| Indep | | 0.0012 |
| | | (0.0014) |
| Boardsize | | 0.0229 |
| | | (0.0299) |
| Top1 | | -0.0016 |
| | | (0.0010) |
| Year FE | Yes | Yes |
| Firm FE | Yes | Yes |
| N | 48,081 | 48,081 |
| Adj_$R^2$ | 0.3598 | 0.3621 |

Note: Robust standard errors in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

## 4.2. Robustness test

### *4.2.1. Parallel trend test*

The premise of the Difference-in-Differences (DID) method relies on the assumption that, prior to the policy shock, the treatment and control groups share common trends. However, since the parallel trend assumption cannot be directly verified, it is indirectly supported by examining the similarity of pre-treatment trends. Following the study by Hua et al. [7] we designate the year in which the city where a firm is located was selected as a Green Finance Reform and Innovation Pilot Zone as the base year. To conduct the pre-treatment trend test, the difference in environmental investment between the treatment group (firms affected by the pilot zone) and the control group (firms not affected) in the year prior to the base year is normalized to zero, with a 90% confidence interval applied. Considering the validity of sample identification, this paper bins the periods prior to and subsequent to the observation window. Only the estimation results for a seven-year window surrounding the base year are reported, as illustrated in Figure 1. It can be observed that prior to the policy shock of the pilot zone, the difference in environmental investment between the treatment and control groups is not statistically significant, failing to reject the hypothesis of parallel pre-treatment trends. In the sixth year following the event shock, the level of environmental investment in the treatment group significantly increases relative to the control group. This result indicates that the impact of the Green Finance Reform and Innovation Pilot Zone on corporate environmental investment exhibits a lagged effect.

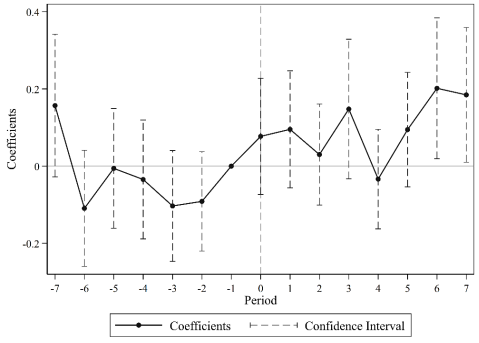


**Figure 1.** Parallel trends test

*4.2.2. Placebo test*

To mitigate potential bias from omitted variables and unobserved factors, this study conducts a placebo test by constructing a fictitious treatment group with a pseudo-policy dummy variable. Specifically, the implementation regions of the Green Finance Reform and Innovation Pilot Zones are randomly assigned to generate a pseudo-policy dummy variable, and the regression analysis is repeated 500 times. Theoretically, if the baseline regression is not affected by omitted variables or unobserved factors, the estimated coefficients of the pseudo-policy dummy variable should be close to zero. Figure 2 illustrates the distribution of the estimated coefficients obtained from these iterations. The results indicate that the estimated coefficients are closely clustered around zero and follow a normal distribution, with only a negligible number of coefficients falling to the right of the actual baseline regression coefficient (0.1236). These findings suggest that the positive impact of the Green Finance Reform and Innovation Pilot Zones on corporate environmental investment is not driven by omitted variables or other unobserved confounding factors, thereby further confirming the robustness of the baseline regression results.

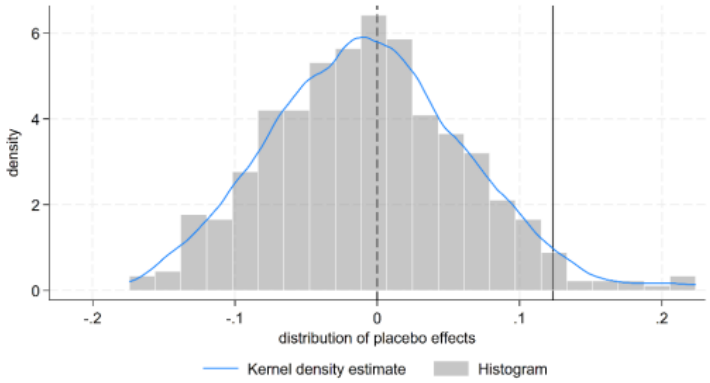


**Figure 2.** Placebo test

*4.2.3. Propensity score matching–difference-in-differences*

To reduce potential sample selection bias in the DID estimation, this study applies the Propensity Score Matching (PSM) method to identify comparable treatment and control groups, upon which the DID analysis is subsequently performed. Companies located within the green finance reform pilot zones are defined as the treatment group, while those outside the pilot zones serve as the control group. The covariates used for matching are selected based on the control variables included in model (1), and propensity scores are estimated using a logit regression model. This study adopts 1:4 nearest-neighbor matching to ensure that each treated firm is matched with four comparable non-treated firms. Model (1) is then re-estimated using the matched samples. As reported in Table 3, column (1), the coefficient of the treatment variable remains significantly positive, indicating that the baseline conclusion are robust after controlling for potential sample selection and model specification biases.

**Table 3.** More robustness test

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | PSM-DID | Alternative dependent variable | Excluding the COVID-19 period | Interaction fixed effects |
| Greenfin | 0.1014* | 0.1373*** | 0.1374** | 0.1115** |
| | (0.0548) | (0.0463) | (0.0556) | (0.0457) |

Table 3. Continued

| | | | | |
|---|---|---|---|---|
| Controls | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | |
| Industry×Year FE | | | | Yes |
| Firm FE | Yes | Yes | Yes | Yes |
| N | 13,191 | 48,081 | 34,880 | 48,015 |
| Adj_$R^2$ | 0.3648 | 0.3669 | 0.3689 | 0.3770 |

Note: Robust standard errors in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

*4.2.4. Alternative dependent variable*

To rule out potential interference caused by the measurement method of the dependent variable on the regression results, this paper, drawing on relevant studies [24, 36], adopts an alternative measure for the dependent variable. Specifically, expenditures related to pollution control and environmental protection recorded under administrative expenses are added to the total capitalized environmental investment. This sum is then standardized by net assets and multiplied by 100. Column (2) of Table 3 presents the regression results using this alternative measurement. As observed, the regression coefficient for the Green Finance Reform and Innovation Pilot Zone is 0.1373 and is significant at the 1% level, which remains consistent with the baseline regression results.

*4.2.5. Excluding the COVID-19 period*

The global outbreak of COVID-19 at the end of 2019 severely impacted socio-economic operations and increased the risks of industrial and supply chain disruptions. To eliminate interference related to COVID-19, this paper excludes sample data from 2019 to 2022 and re-conducts the test. As shown in Column (3) of Table 3, the coefficient of *Greenfin* remains positive and is statistically significant at the 5% level. These results indicate that the baseline regression findings remain robust.

*4.2.6. Interaction fixed effects*

To control for uncontrollable factors that vary with the industry, this paper further includes industry×year fixed effects in the regression analysis. The results, as shown in Column (4) of Table 3, indicate that the coefficient of *Greenfin* is 0.1115 and is significant at the 5% level, which is consistent with the baseline regression results. This demonstrates that the findings of this study remain robust even after accounting for the impact of unobservable time-varying factors at the industry level.

## 4.3. Mechanism test

To further explore how green finance reforms promote firms' environmental protection investment, this study examines two potential mediating mechanisms: government environmental subsidies and environmental regulation intensity.

*4.3.1. Government environmental subsidies*

In practice, green finance policies are often accompanied by fiscal instruments such as environmental subsidies or tax incentives [37]. As the implementation of green finance reform pilot zones, local governments tend to strengthen fiscal support for firms engaged in green projects, thereby forming a complementary policy effect. Enhanced access to environmental subsidies improves the expected returns on environmental projects, ultimately encouraging higher levels of environmental investment.

Based on this analysis, this paper introduces government environmental subsidies as a mediating variable. Following the study by Bai et al. [37], government subsidies related to environmental protection were manually screened based on keywords such as "energy saving", "environmental protection", "emission reduction", "governance", and "green" to determine the total annual amount of corporate environmental subsidies. The total amount was then standardized by the firm's total assets and multiplied by 100. Column (1) of Table 4 presents the results of the mediation effect test for environmental subsidies. The results show that the regression coefficient of *Greenfin* is 0.0101 and is significant at the 10% level. This indicates that green finance can increase environmental subsidies, thereby alleviating financing pressures on enterprises and prompting them to allocate more capital to environmental protection initiatives.

**Table 4.** Mechanism test

| | (1) | (2) |
|---|---|---|
| | GS | ERI |
| Greenfin | 0.0101* | 0.0641*** |
| | (0.0060) | (0.0128) |
| Controls | Yes | Yes |
| Year FE | Yes | Yes |
| Firm FE | Yes | Yes |
| N | 15,332 | 42,495 |
| Adj_$R^2$ | 0.3846 | 0.3351 |

Note: Robust standard errors in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

*4.3.2. Environmental regulation intensity*

The Green Finance Reform and Innovation Pilot Zones may be accompanied by stricter environmental regulation, thereby increasing the marginal cost of corporate non-compliance. Consequently, firms are more likely to allocate funds to ecological and environmental protection projects to ensure financing eligibility and avoid regulatory sanctions [2]. Therefore, this paper introduces environmental regulation intensity as a mediating variable. Following the methodology of Shao et al. [38], environmental regulation intensity is measured by the ratio of the word count of sentences containing environment-related keywords to the total word count in the annual work reports of prefecture-level city governments. The results of the mechanism test for environmental regulation intensity are presented in Column (2) of Table 4. The regression coefficient of *Greenfin* is 0.0641 and is statistically significant at the 1% level. This result indicates that green finance can induce firms to increase environmental investment by strengthening regional environmental regulation intensity.

## 4.4. Heterogeneity analysis

*4.4.1. Enterprise ownership*

The expected impact of the Green Finance Reform and Innovation Pilot Zones on corporate environmental investment may vary due to differences in enterprise ownership. Consequently, this paper divides the sample into State-Owned Enterprises (SOEs) and Non-State-Owned Enterprises (NSOEs) to conduct a heterogeneity analysis. These two types of enterprises differ significantly in terms of organizational structure, management models, and sources of funding. Regarding policy influence, SOEs may receive greater attention and support from government departments, whereas NSOEs rely to a certain extent on market competition.

Table 5 presents the heterogeneity analysis of the impact of green finance on corporate environmental investment. The results show that the coefficient of *Greenfin* is statistically insignificant for State-Owned Enterprises (SOEs), while it is significantly positive at the 1% level for Non-State-Owned Enterprises (NSOEs). This indicates that the promoting effect of green finance on environmental investment is mainly concentrated in non-state-owned firms. This difference may stem from variations in financing conditions and organizational flexibility between state-owned and non-state-owned enterprises. State-owned enterprises receive stronger government support and have easier access to credit, which weakens the marginal impact of green finance policies on their environmental investment. In contrast, non-state-owned enterprises, which rely more on market-based financing and face greater credit constraints, respond more actively to green financial incentives, thereby enhancing their environmental investment. Moreover, the relatively rigid structures of state-owned enterprises may slow their response to policy adjustments, whereas non-state-owned firms, with more flexible governance and decision-making mechanisms, can adapt more efficiently to green finance policies and capitalize on emerging financing opportunities.

**Table 5.** Enterprise ownership

| | (1) | (2) |
|---|---|---|
| | State-owned enterprises | Non-state-owned enterprises |
| Greenfin | 0.0359 | 0.2217*** |
| | (0.0606) | (0.0656) |
| Controls | 15,114 | 32,901 |
| Year FE | Yes | Yes |
| Firm FE | Yes | Yes |
| N | Yes | Yes |
| Adj_$R^2$ | 0.3704 | 0.3707 |

Note: Robust standard errors in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

*4.4.2. Industry nature*

The sample is divided into heavily polluting firms and non-heavily polluting firms. As shown in Table 6, the regression coefficient of *Greenfin* in column (1) is positive but not statistically significant for heavily polluting firms, while the coefficient in column (2) is significantly positive for non-heavily polluting firms. This suggests that green finance has a more pronounced promoting effect on environmental investment in non-heavily polluting enterprises.

The possible explanation for this difference lies in the firms' environmental attributes and financing constraints. Heavily polluting firms face stricter environmental regulations and higher compliance costs, making it more difficult for them to obtain green financing and rapidly adjust to the green financial standards. In contrast, non-heavily polluting firms generally have better environmental performance and credit conditions, allowing them to respond more actively to green financial incentives. Consequently, green finance policies can more effectively guide financial resources toward environmentally friendly firms, encourage cleaner production, and enhance the overall efficiency of green capital allocation.

**Table 6.** Degree of enterprise pollution

| | (1) | (2) |
|---|---|---|
| | Polluting heavily | Polluting non-heavily |
| Greenfin | 0.2406 | 0.0989** |
| | (0.1477) | (0.0454) |
| Controls | Yes | Yes |
| Year FE | Yes | Yes |
| Firm FE | Yes | Yes |
| N | 8,875 | 39,144 |
| Adj_$R^2$ | 0.3342 | 0.3756 |

Note: Robust standard errors in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

## 5. Conclusion

Using the establishment of China's Green Finance Reform and Innovation Pilot Zones as a quasi-natural experiment, this paper selects Shanghai and Shenzhen A-share listed companies from 2011 to 2024 as the research sample and employs a Difference-in-Differences (DID) model to deeply examine the impact of green finance policies on corporate environmental investment and its underlying mechanisms. The results indicate that the establishment of the pilot zones significantly enhanced the level of corporate environmental investment. This conclusion remains robust after a series of tests, including parallel trend tests, placebo tests, PSM-DID estimation, and the use of alternative dependent variables. This confirms that as a market-oriented environmental governance tool, green finance can effectively guide the resource allocation of micro-enterprises and prompt them to increase substantive environmental inputs. Mechanism tests reveal that the pilot policy promotes corporate environmental investment primarily through the dual pathways of "fiscal incentives" and "regulatory constraints". On one hand, the implementation of the pilot policy is accompanied by increased government environmental subsidies. This not only directly alleviates firms' financing constraints but also enhances the expected returns on investment by lowering the marginal costs of environmental projects, thereby incentivizing firms to proactively increase environmental inputs. On the other hand, the pilot policy strengthens regional environmental regulation intensity, raising the potential costs and risks of non-compliance. This compels firms to increase environmental investment to maintain financing eligibility and avoid regulatory sanctions, reflecting the policy's "forcing effect". Heterogeneity analysis further reveals significant structural differences in the policy's implementation effects across firms with different characteristics. Regarding ownership structure, the pilot zones have a distinct promoting effect on the environmental investment of Non-State-Owned Enterprises (NSOEs). A possible reason is that NSOEs typically face stronger financing constraints and possess more flexible operational decision-making mechanisms, making them more sensitive to the financial support and policy dividends provided by green finance; in contrast, State-Owned Enterprises (SOEs), due to their inherent financing advantages and relatively rigid organizational structures, show a weaker response to policy incentives. Regarding industry attributes, the policy significantly promotes environmental investment in non-heavily polluting firms. The likely reason is that heavily polluting firms face stricter environmental regulations and higher credit thresholds, making it difficult for them to easily obtain green credit support, which limits their ability to utilize financial resources for green transformation.

Based on the above conclusions, this paper suggests that policymakers should further deepen green finance reform, expand the scope of pilot zones in due course, and focus on building a synergistic mechanism that emphasizes both "incentives and constraints". This involves reducing corporate green transition costs through fiscal subsidies while maintaining appropriate environmental regulatory pressure. Additionally, high attention should be paid to the structural imbalance of policy effects. For SOEs, a green performance evaluation mechanism should be established to stimulate their endogenous motivation. For heavily polluting firms, differentiated transition finance products should be developed to help them overcome financing bottlenecks, thereby promoting the comprehensive realization of green and low-carbon development in the economy and society.

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