Effect of green financial reform and innovation pilot zones on corporate investment efficiency

Short title: Green Finance and Investment Efficiency

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Abstract: To the best of our knowledge, this is the first study to examine the effect of pilot green financial reform and innovation zones on corporate investment efficiency. To this end, we rely on a quasi-natural experiment of China's introduction of this pilot policy in 2017. Our sample covers A-share listed Chinese companies from 2015 to 2020, and the difference-in-difference (DID) methodology has primarily been used for analysis. Our findings suggest that firms' inefficient and excessive investments are significantly reduced in the pilot zones. Furthermore, we uncover the mediation effect of agency problems and R&D investment between the establishment of the pilot zones and firms' investment efficiency, reduction of agency problems, and an increase in R&D investment which improves the investment efficiency of firms. Moreover, the investment efficiency of firms with higher equity checks and balances and non-heavy polluters increased significantly, and the inefficient investment of non-state-owned firms and fewer institutional investors' shareholdings decreased significantly, which suggests that the green financial reform and innovation pilot zone has significant financing regulation and investment disincentive effects. Our study has vital policy implications for governments worldwide that have previously committed to and/or are participating in providing green finance incentives.

Keywords: Green Finance; Corporate Investment; Investment Efficiency; Propensity Score Matching; Difference-In-Difference Model
JEL classifications: G11, G32, N72

1. Introduction

Green finance is one of the most prominent phenomena in financial markets in recent decades (Liu and Lee, 2021). The concept of low-emission development strategies is one of the sustainable development goals adopted by the United Nations for its 2030 agenda of sustainable development. Although many governments around the world have already committed to and/or are participating in providing green finance incentives, academic research on the potential corporate consequences is limited, owing to endogeneity issues (Lee et al., 2021; Luo et al., 2021). A recent policy experiment in China provides researchers with an excellent opportunity to investigate causality. The Chinese State Council's executive meeting in June 2017 decided to include five provinces (regions), namely Zhejiang, Jiangxi, Guangdong, Guizhou, and Xinjiang, as the first batch of pilot projects to build pilot zones for green financial reform and innovation with their own characteristics, marking the landing and implementation of green finance. This was aimed at improving the level of green sustainability of financial institutions, guiding the allocation of financial resources to environmental protection projects, and promoting ecological civilization and green development.

Among the various sources of pollution, the industrial activities of enterprises are a major contributor to environmental degradation. Therefore, it is very effective to increase the impact on the micro level, especially on the enterprise side, through green financial reform and innovation, to promote the transformation of enterprises. The

Abbreviations: DID – difference-in-difference

motivation of this paper is to examine the effect of the policies of the Green Finance Reform and Innovation Pilot Zone, which can improve the efficiency of enterprises' investments through certain channels.

In terms of the relationship between environmental energy and economic development, several scholars have long conducted in-depth studies showing the complexity of the relationship between economic growth and energy consumption (Lee and Chang, 2005; Lee and Chien, 2010; Lee and Chiu, 2011a, b; Lee et al., 2008). Unlike developed countries, most developing countries are still at a high energy consumption and pollution stage, and reconciling energy consumption with economic development has been a pressing challenge for developing countries (Lee, 2005; Lee and Chang, 2007; Wen et al., 2021c), while at the same time protecting the country from the risk of external energy shocks (Lee, 2017 2021; Lee and Lee, 2019). Therefore, it is all the more important for developing countries to take action to reallocate resources and promote the green transformation of industrial upgrading.

In the macro context of a green economy, micro-level impacts are an important criterion for evaluating the effects. Previous research on the effects of energy transition has focused on fund futures (Lee and Zeng, 2011; Guo et al., 2022), technological innovation (Lv et al., 2021b; Tao et al., 2022) and industry ratings (Yu et al., 2022; Yuan et al., 2022). With the rapid development and continuous innovation of financial products, green financial instruments have begun to influence the strategic goals of industrial enterprises, enhance their environmental responsibility and promote their green transformation.

Current research on green financial instruments is still limited to single instruments, for example, green credit can improve the core competitiveness of some banks (Luo et al., 2021), reduce the performance of heavy polluters by imposing financing constraints (Wen et al., 2021a), and significantly enhance green innovation (Yao et al., 2021; Hu et al., 2021). In addition, green bonds outperform ordinary bonds (Kanamura, 2020) and firms want to demonstrate their commitment to the environment by issuing green bonds (Flammer, 2021). The implementation of carbon trading may influence firms' investment and management decisions (Zhang and Wang, 2021), and firms will increase their emission reduction efforts to meet adjusted emission reduction targets (Liu et al., 2021). However, few studies have focused on the impact of the Green Finance Reform and Innovation Pilot Zone, a policy that combines various green finance instruments in an attempt to explore new pathways.

We fill the research gap by examining the impact of green financial reform and innovation pilot zones on corporate investment and resource allocation efficiency. Using a difference-in-difference (DID) model, we select a sample of Chinese listed companies from 2015 to 2020 and adopt Richardson's (2006) approach to measure the level of investment efficiency. In addition, we conducted a heterogeneity study as well as a mechanism test, where we followed Di Giuli and Laux (2021) and used causal mediation analysis in the instrumental variable regressions, i.e. Post × Treat as the instrumental variable, to examine the mechanism of the green financial reform and innovation pilot zone affecting the efficiency of corporate investment.

The sample period selected for this paper is long enough to establish causality, but

short enough to avoid potential contamination from other policy changes in China. The perspective of enterprise investment efficiency is chosen because effective resource allocation is an important guarantee for the healthy development of the real economy, and as an effective tool for measuring resource allocation efficiency, the investment efficiency of micro enterprises is an effective indicator of the real economy (for literature about various kinds of investments, see Su et al., 2020; Tao et al., 2021; Wen et al., 2021b; Yan et al., 2021).

The study found that the establishment of pilot zones significantly improved the efficiency of corporate investment, and the mechanism analysis found that the policy leads to a reduction in agency problems and an increase in R&D investment, thus improving investment efficiency. In addition, the investment efficiency of non-heavy polluting firms with higher equity checks and balances significantly increased, while the investment efficiency of firms with lower equity holdings by non-state and institutional investors significantly decreased, indicating that the pilot zone for green financial reform and innovation has significant financing regulation and investment disincentive effects.

Our study aims to contribute to the literature in the following ways. Firstly, much of the existing literature focuses on the effects of a single green financial instrument, and our study is one of the few to examine a pilot zone for green financial reform and innovation. This study aims to contribute to the existing knowledge on the impact of green financial reform on the microeconomy by exploring in depth the mechanisms underlying the impact of establishing a pilot zone on corporate investment efficiency.

Secondly, this study extends the literature on investment efficiency to green finance. While previous literature has focused on the factors influencing corporate investment efficiency both externally and internally (Chen et al., 2011; Ma et al., 2017; Wang et al., 2020), with little discussion on the impact of green finance policies, our study provides new evidence on how green finance affects corporate behaviour.

Finally, although the overall development index of green finance in China shows an upward trend, the level of economic development is not high (Lv et al., 2021a), and the successful implementation of this policy provides assistance to other developing countries in implementing green financial reforms. And this paper treats the establishment of the pilot area as a quasi-natural experiment, using the DID approach to conduct the study and passing both placebo and robustness tests to address possible endogeneity issues.

The remainder of this paper is organized as follows. Section 2 describes the institutional background and develops our hypotheses. Section 3 describes our research design, including the data and methodology. Section 4 presents our main empirical results. The possible mechanisms and robustness tests have been presented in Sections 5 and 6, respectively. Finally, Section 7 concludes the paper and derives some implications.

2. Institutional background and hypotheses development

2.1. Institutional background

Green finance refers to the financial sector's incorporation of environmental governance and protection factors into investment and financing activities, increasing the financing of clean projects on the one hand and reducing the supply of funds for polluting projects on the other, thus achieving a green allocation of funds (Jeucken and Bouma, 1999). Since the reform and opening up, China has experienced rapid industrialisation, which has promoted economic growth and financial development (Xu, 2018), but has generated serious environmental pollution. Developing green finance is an important step towards green development and an inherent requirement for promoting high-quality economic development. Compared to foreign countries, China's green finance started late but is developing rapidly (Zhou et al., 2020).

Since the 18th Party Congress, the government has been actively engaged in building a green financial standards system. in September 2015, the Political Bureau of the Central Committee of the Communist Party of China (CPC) considered and adopted the General Programme for the Reform of the Ecological Civilization System, in which the strategy of establishing a green financial system was first proposed. in 2016, the People's Bank of China and seven other departments issued the Guiding Opinions on Building a Green Financial System, making China the first country in the world to have the central government promote the building of a In June 2017, an executive meeting of the State Council decided to include five provinces (regions) - Zhejiang, Jiangxi, Guangdong, Guizhou and Xinjiang - as the first batch of pilots to build pilot zones for green financial reform and innovation with their own characteristics, marking the landing and implementation of green finance.

The selection of the pilot zones is in line with three main principles: Firstly, it takes full account of regional location differences, with the five provinces (regions) located in the eastern, central and western regions respectively, basically covering the major administrative regions. Secondly, the differences in resource endowments were fully considered, with Guangdong and Zhejiang having more developed financial sectors and richer financial resources; while Jiangxi, Guizhou and Xinjiang are richer in natural resources. Thirdly, the differences in development stages and levels of industrial development were fully considered to explore the path of transformational development for different provinces and regions. Therefore, the selection of the pilot zones is fully representative, achieving full coverage in terms of spatial layout, resource endowment, development stage and industrial structure.

Each pilot green financial reform and innovation zone focuses on innovation to promote the development of green industries, and actively explores green financial standards, green financial product and service innovation, and incentive and constraint mechanisms. Guangdong focuses on developing green financial markets; Zhejiang explores the integration of green finance and financial technology; Jiangxi and Guizhou explore renewable energy development; and Xinjiang focuses on agriculture and clean energy resources.

At the beginning of 2020, 215 green franchised institutions were set up in the pilot zone, the scale of green credit and green bonds continued to grow, the actual amount of green industry investment funds arrived exceeded 148.8 billion yuan, the total amount of environmental equity transactions reached 3.7 billion yuan, the basic system of green

finance was gradually improved, and the development of green financial markets achieved initial results.

2.2. hypotheses development

This study analyzes the effect of green financial reforms and innovation pilot zones on corporate investment efficiency using two paths.

First, the pattern of corporate investment decisions and their efficiency ultimately reflect the agency problem that exists in the firm (Scharfstein and Stein, 2000). Overinvesting with free cash flow is a common method used by executives to obtain private benefits, and is an important indication of management agency problems (Shleifer and Vishny, 1994). Lara et al. (2016) find that financing constraints and agency problems are important factors that are affecting the efficiency of investments in China adversely. Principal-agent conflicts lead to an increase in agency costs and result in sub-optimal allocation of resources (Fama, 1980; Smith and Stulz, 1985); the problem of overinvestment in Chinese firms is equally caused by managers' misuse of corporate resources and their overconfident behavior (for example, Jiang and Kim, 2015).

Second, low-carbon energy transitions often require increased capital expenditure (Yu et al., 2022). Some studies point out that there is a significant positive correlation between the intensity of R&D expenditures and cash holdings, and that reducing financial constraints can enhance firms' innovation capacity and R&D investments (Gorodnichenko and Schnitzer, 2013). Given that R&D investments yield greater social benefits than private benefits, firms are demotivated as they cannot realize the entire

benefit of R&D investments. Government subsidies, in the form of income, can reduce the cost and risk of R&D. La Porta et al. (2000) and Richardson (2006) point out that R&D investments are usually accompanied by hard work from management to achieve technological innovation, and if the resulting returns go to shareholders, they only receive a share of the profits.

Accordingly, with the establishment of the green finance reform and innovation pilot zone, more stringent environmental regulations have raised shareholders' concerns about the transformation of corporate production methods to energy-efficient and low-carbon, putting more constraints and oversight on management's environmental governance decisions. As the degree of restriction and oversight on green financing increases, the goals of the management and shareholders will converge; managers will work harder to invest in green innovations and seek green development opportunities, thereby partially solving the agency problem. Simultaneously, as companies favor green projects, capital will gradually flow to green companies, and companies will rationalize their investment strategies and increase their R&D investment, thus making their investment more efficient.

Based on the above analysis, we propose the following hypothesis.

H1: The establishment of a pilot zone for green financial reform and innovation can improve the efficiency of corporate investment.

According to some studies, corporate investment decisions dominated by the interests of controlling shareholders under a centralized ownership structure prioritize

control gains over maximization of firm value, resulting in inefficient investments (Aggarwal and Samwick, 2006). However, the largest shareholders in firms with high equity checks and balances cannot fully control the important decisions of the firm. Therefore, firms with higher equity checks and balances are more likely to follow the policy trends of green finance and the green economy, adjust their investment strategies, and effectively restrain their major shareholders from affecting their investment efficiency.

Based on the above analysis, the following hypothesis is proposed.

H2: After the establishment of the pilot zone, the investment efficiency of companies with higher equity checks and balances improves significantly more than those with lower equity checks and balances.

In China's capital market, institutional investors often face difficulties in curbing management's agency behavior. Porter (1992) argues that institutional investors' fragmented shareholdings and frequent transactions prevent them from actively participating in the governance of investee companies, and that this leads to short-sighted management behavior. In addition to a high shareholding ratio, the institutional oversight of management also requires institutions to adhere to the concept of value investing. However, the short-term speculative tendencies of institutional investors in China are evident (Jiang and Kim, 2015). Cao et al. (2018) find that only institutional investors with long-term shareholdings can improve the efficiency of corporate investments by mitigating over- and underinvestment. The horizon of institutional

investors was also found to be important, with longer shareholdings having a greater effect on firm investment efficiency.

Based on the above analysis, we propose the following hypothesis.

H3: After the establishment of the pilot green finance reform and innovation zone, the investment efficiency of firms with a lower percentage of institutional investors' shareholding is more significantly enhanced than that of firms with a higher percentage of shareholding.

State-owned firms, with relatively stable capital flows, have a natural advantage over non-state owned firms as they do not need to consider financing constraints. Given that the green finance reform and innovation pilot zone mainly constrains and regulates credit supply among other aspects, non-state-owned firms tend to adjust their investment strategies, reduce non-essential investments, and increase R&D investment to obtain green credit to improve investment efficiency.

Based on the above analysis, we propose the following hypothesis.

H4: The improvement in corporate investment efficiency resulting from the establishment of the pilot green finance reform and innovation zone is more pronounced in non-state-owned firms than in state-owned firms.

The green finance pilot policy has opposing effects on different types of firms, demonstrating an institutional constraint effect on polluting firms and a green incentive effect on green firms. The constraint effect is significantly greater than the incentive

effect, indicating that firms in the pilot zone are yet to develop "compensatory benefits" that outweigh the cost of following the system, which may, to some extent, inhibit overall firm production levels in the pilot zone (Wang et al., 2020).

Based on the above analysis, we propose the following hypothesis.

H5: The establishment of the pilot zone will result in a more significant reduction in non-efficient investment in non-heavy polluters than in heavy polluters.

3. Research Design

3.1. Measurement of the efficiency of corporate investment

We follow Richardson (2006) and calculate the level of inefficient investments by firms using the following model:

$$\begin{aligned} Invest_t = {} & \beta_0 + \beta_1 Growth_{t-1} + \beta_2 Lev_{t-1} + \beta_3 Cashflow_{t-1} \\ & + \beta_4 FirmAge_{t-1} + \beta_5 Size_{t-1} + \beta_6 Return_{t-1} \\ & + \beta_7 Invest_{t-1} + Industry + Year + \xi_t \end{aligned} \quad (1)$$

In this model, *Invest* represents the level of investment made by the firm during the year; *Invest* = (expenditure on the acquisition of fixed assets, intangible assets, and other long-term assets + net cash paid for the acquisition of subsidiaries and other business units, net cash recovered from the disposal of fixed assets, intangible assets, depreciation of fixed assets, depreciation of oil and gas assets, depreciation of productive biological assets)/ total assets. Other control variables include firm growth

(*Growth*), that is, the growth rate of operating revenue, leverage level (*Lev*), cash and cash equivalents as a proportion of total assets (*Cashflow*), a firm's year of listing (*FirmAge*), size (*Size*), a firm's annual stock return (*Return*), industry fixed effects (*Industry*), and annual fixed effects (*Year*).

The residuals from the regression of Model (1) are the unanticipated levels of investment by the firm. A residual greater than 0 indicates overinvestment (*Overinv*); the larger the value, the less efficient the investment. A residual less than 0 indicates underinvestment (*Underinv*); the larger the value, the more efficient the investment. Moreover, the residual is taken as the absolute value, which indicates the deviation of the firm's investment from the theoretically expected value; the larger the deviation, the less efficient the firm's investment.

3.2. Model specification and variable definitions

The following DID model is used in this study to examine the impact of the green financial reform and pilot innovation zones on firm investment efficiency. Firms whose registered provinces are in the green financial reform and innovation pilot zones are considered as the experimental group, and firms in other provinces are considered as control group.

$$\begin{aligned}\text{Absinv}_t = {} & \beta_0 + \beta_1 post_t \times treat_t + \beta_2 post_t + \beta_3 treat_t + \beta_i controls_t \\ & + Firm + Province + Year + \varepsilon_t\end{aligned} \tag{2}$$

In the above model, *Absinv* is the explanatory variable that measures the firm's inefficient investment. As the model controls for firm fixed effects (*Firm_F.E.*), regional fixed effects (*Province_F.E.*), and year fixed effects (*Year_F.E.*), the coefficient on the interaction term $\beta_1 post_t \times treat_t$ is the DID statistic. Specifically, *treat* indicates whether the province in which the firm is registered is a green financial reform and innovation pilot zone province; when *treat* = 1, it indicates firms in pilot zone provinces (experimental group) and when *treat* = 0, it indicates firms in non-pilot zone provinces (control group). *Post* is a point-in-time dummy variable for the pilot implementation of the green financial reform and innovation pilot zone, which takes the value of 1 for the current and subsequent years (2017–2020) and 0 for the years before the proposal (2015–2016).

Based on the literature (Chen et al., 2011), this study also controls for firm size (*Size*), leverage level (*Lev*), return on assets (*ROA*), operating net cash flow (*Cashflow*), capital expenditure (*Cap*), market value (*TobinQ*), years of listing (*FirmAge*), board size (*Board*), and independent director share (*Indep*). Table 1 lists the definitions of all the variables used in this study.

[Insert Table 1 about here]

3.3. Sample and data

We have used A-share listed companies in China from 2015 to 2020 as our sample. The sample was first screened according to the following principles. First, sample observations of listed companies in the financial sector were excluded. Second,

observations of ST and *ST companies in the sample period were excluded. Third, sample observations with missing relevant financial data were excluded. After screening, a final sample of 14,324 observations was obtained. All business finance and corporate governance data in this study come from the Accounting Research (CSMAR) database. To exclude the influence of extreme values, all continuous variables were winsorized at the 1% and 99% levels.

3.4. Descriptive analysis

Table 2 presents descriptive statistics for each of the main variables in this study. The mean value of *Absinv* is 0.0275, the maximum value is 0.1591, the minimum value is 0.0004, and the standard deviation is 0.0287, implying significant differences in investment efficiency among different companies in China. The other control variables are largely consistent with established studies, and are not repeated here.

[Insert Table 2 about here]

4. Empirical Results

The results of the benchmark and heterogeneity tests have been presented in this section.

4.1. Benchmark test

Table 3 presents the results of the DID test for the effect of the green finance reform and innovation pilot zone on firms' investment efficiency. Column (1) shows the effect of green financial reform and the innovation pilot zone on firm investment

efficiency. The estimated coefficient of the reform and innovation pilot zone policy (*Post*×*Treat*) is -0.00278, with a t-value of -2.20, which is significantly negative at the 5% level, equivalent to 9.75% of the standard deviation of *Absinv* in the sample; column (2) examines the effect of the pilot zone trial on firm underinvestment. The estimated coefficient of reform and innovation pilot zone policy (*Post*×*Treat*) is 0.00032 and statistically insignificant; the estimated coefficient of reform and innovation pilot zone policy (*Post*×*Treat*) is -0.00895 and the t-value is -3.26, which is significantly negative at the 1% level, in column (3). This is generally consistent with hypothesis H1 and suggests that the green finance reform and innovation pilot zone have a significant effect on firms' investment efficiency and mainly reduces the over-investment of firms in the pilot zone.

[Insert Table 3 about here]

4.2. Heterogeneity tests

The differential effect of piloting green financial reform and innovation zones was analyzed using heterogeneity tests.

First, listed companies were classified into two groups: high (*Balance* = 1) and low (*Balance* = 0), based on whether the equity checks and balances (shareholding ratio of the second to fifth largest shareholders/ ratio of the largest shareholder) were higher than the industry median in the same year. We found that the coefficient of *Post*×*Treat* is significantly negative at the 5% level among firms with high equity checks and balances, whereas it is negative and insignificant among firms with low equity checks

and balances. This is consistent with hypothesis H2, indicating that the policy effect is mainly reflected in firms with high equity checks and balances.

In addition, we divided the listed companies into two groups, the high institutional investor shareholding group (*Inshold* = 1) and the low institutional investor shareholding group (*Inshold* = 0), based on whether the institutional investor shareholding ratio is higher than the industry median in the same year. We found that the results of the study are primarily applicable to the low institutional investor shareholding group, as shown in columns (3) and (4) in Table 4, which is consistent with hypothesis H3.

[Insert Table 4 about here]

Second, by dividing the listed companies into two groups according to the nature of ownership, state-owned firms (*SOE* = 1) and non-state-owned firms (*SOE* = 0), we find that the effect of the green financial reform and innovation pilot zone on the investment efficiency of companies is mainly reflected among non-state-owned companies, as shown in columns (1) and (2) in Table 5. This is consistent with hypothesis H4, indicating that the establishment of the pilot zone has a more pronounced effect on non-state-owned firms, while the inefficient investments of state-owned firms remain unaffected.

[Insert Table 5 about here]

In addition, listed companies were classified as heavy polluters (*Heavy* = 1) and

non-heavy polluters (*Heavy* = 0). They were classified according to [2008] No. 373), and the Guide to Environmental Information Disclosure for Listed Companies [2010] No. 78, which mainly covers 16 industries, including thermal power, iron, steel, cement, electrolytic aluminum, coal, metallurgy, chemical, petrochemical, building materials, paper, brewing, pharmaceutical, fermentation, textile, tannery, and mining. We found that the green financial reform and innovation pilot zone had an effect on the investment efficiency of non-heavily polluting firms. The relevant results are presented in columns (3) and (4) of Table 5, which is consistent with hypothesis H5.

5. Mechanism Analysis

Based on the logic of the theoretical analysis, the trial implementation of the green financial reform and innovation pilot zone will require firms to transform their production methods to energy-conserving, emission-reducing, and low-carbon emitting techniques. Furthermore, it will require the government to control the credit allocation of banks strictly, thus strengthening shareholders' attention to corporate governance, reducing managers' over-investment, and rationalizing the use of corporate funds. Referring to existing corporate governance literature (Ang et al., 2000), this study uses the management expense ratio to measure the corporate agency problem (*Mfee*). The higher the management expense ratio, the more severe the agency problem. Moreover, overhead is used as a mediating mechanism to influence the efficiency of corporate investments in the test area.

With the development of green finance policies, institutional pressure has

encouraged firms to increase their green innovation-related R&D investments and promote their green innovation activities. The mismatch between the source and maturity of funds has also been an important obstacle to green innovation. Banks tend to grant loans to firms that meet policy requirements, such as those with green innovation and green R&D, which will also use the funds received for R&D investment to further expand their own R&D achievements and consolidate the scale of green credit to gradually form a virtuous circle. Therefore, this study adopts the ratio of R&D investment (RD) as a mediating mechanism to influence the efficiency of firms' investment in the pilot zone.

The methods currently used for validating mediating mechanisms are applicable to psychology and are unsuitable for addressing or validating the mediating role in economics, which is prone to endogeneity problems. Therefore, this study does not use these methods. Instead, we follow Di Giuli and Laux (2021) and use causal mediation analysis in the regression of instrumental variables, that is, using *Post*×*Treat* as the instrumental variable.

Our aim was to test whether the creation of a pilot zone could affect the efficiency of business investment through the intermediate steps of agency problems and R&D input. Using an instrumental variables approach, we could obtain estimates for the two steps of this channel. We used the *Post*×*Treat* indicator variable (referred to as “test area” hereinafter) as an instrumental variable in a linear regression setup of instrumental variables. As a result, we obtained the statistical effect of the test area on the agency problem as a “first-stage” estimate, and the effect of the agency problem on the

efficiency of business investment as a "second-stage" estimate.

To prove our hypotheses, we should find that the test area is significantly negatively related to the firm's agency problem and significantly positively related to the firm's R&D input. Furthermore, the agency problem and R&D input should be significantly related to the firm's investment efficiency. From Table 3, we know that the test area is related to investment efficiency; therefore, the agency problem and R&D input provide two new pieces of evidence in the decomposition: whether the test area is associated with the agency problem and R&D input, and whether the agency problem and R&D input are further associated with firm investment efficiency. If the link between the test area and agency problems and R&D inputs is irrelevant or contrary to expectations, our assumptions based on these two channels cannot be verified, suggesting the existence of pathways other than agency problems and R&D inputs.

We show how this method works using the following equations.

$$Mfee_t = \beta_0 + \beta_1 post_t \times treat_t + \beta_2 Control\ variables + Fixed\ effects + \epsilon_1 \quad (3)$$

$$\text{Absinv}_t = \beta_0 + \beta_1 Mfee_t + \beta_2 Control\ variables + Fixed\ effects + \epsilon_2 \quad (4)$$

$$RD_t = \beta_0 + \beta_1 post_t \times treat_t + \beta_2 Control\ variables + Fixed\ effects + \epsilon_1 \quad (5)$$

$$\text{Absinv}_t = \beta_0 + \beta_1 RD_t + \beta_2 Control\ variables + Fixed\ effects + \epsilon_2 \qquad (6)$$

The results are presented in Table 6. Column (1) shows that the test area has a significant inhibitory effect on the agency problem of firms, which is significant at the 1% statistical level, whereas column (2) shows that the existence of the agency problem or the increase in agency costs increases firms' inefficient investment significantly. Column (3) shows the effect of the test area establishment on firms' R&D investment, and the results show a significant positive effect, increasing firms' R&D investment. The results in column (4) also indicate that with an increase in R&D expenditure, firms' investment efficiency increases significantly. Therefore, R&D expenditure contributes significantly toward firms' investment efficiency. These results are consistent with the previous hypothesis, proving the influence of agency problems and R&D investment on investment efficiency.

[Insert Table 6 about here]

6. Robustness

Considering that the results of this study may have been caused by other events before the establishment of the green finance reform and innovation pilot zone, this study used a placebo test to shift the policy implementation time forward by one and two years, and selected 2015 and 2016 as the time when the dummy policy occurred. Therefore, the effect of the virtual policy shock does not exist, and the DID estimates in the fourth part are more reliable. Table 7 presents the results.

[Insert Table 7 about here]

In addition, the following four robustness checks were carried out. First, because of the outbreak of the COVID-19 pandemic in 2020, the state took rapid and beneficial measures to protect people's health and maintain social stability by adopting closed management and shutting down large areas of firms and factories. This may have led to an unpredictable effect on investment at the firm level and may have biased the results of this study. Therefore, we removed the sample observations in 2020 to re-examine the effect of the green financial reform and innovation pilot zone on firm investment efficiency. The results are shown in column (1) of Table 8, and we find that the regression results are still significantly negative at the 5% level, which is consistent with our previous results.

[Insert Table 8 about here]

Second, we excluded data for both 2019 and 2020 to narrow the sample interval to prevent more interference from other unobservable factors. The regression results, which are shown in column (2) of Table 8, are still significant.

Considering that the green finance reform and innovation pilot zone was formally implemented in June 2017 and that 2017 is the year of incomplete shock, we exclude all observations in 2017 for the DID estimation. As shown in column (3) of Table 8, the estimated coefficient of the interaction term remains significantly negative.

Furthermore, we exclude companies listed after 2015 from the sample to eliminate

the impact of a company's initial listing on the company's long-term or short-term investment plans, and re-examine the impact of the test area's establishment on the company's investment efficiency. Column (4) in Table 8 demonstrates that the regression results remain significantly negative, largely consistent with the results in Section 4.

Finally, to overcome the endogeneity problem and the heterogeneity bias of the sample, a better account of whether the pilot implementation of the green finance reform and innovation pilot zone policy affects the efficiency of corporate investment is provided. In this study, the nearest neighbor matching method was chosen for matching, and a year-by-year matching method was chosen to find a matched control group for the experimental group each year. Furthermore, a hypothesis test of matching parallel trends was conducted to check whether there was a significant deviation in the matching variables between the experimental and control groups; if the absolute value of the deviation was less than 10%, the matching effect was sound, and the matching estimation was valid. Table 9 presents the results of the matching tests conducted in this study.

[Insert Table 9 about here]

The test results show that the standard deviations of the matched experimental and control groups for firm size, leverage level, return on assets, net cash flow from operations, capital expenditure, TobinQ, firm age, board size, proportion of independent directors, dual employment, proportion of shares held by the largest

shareholder, management shareholding, and stock returns are significantly less than 10%, indicating that the matching variables and methods selected in this study are reasonable and meet the prerequisites for using the DID method. Moreover, none of the t-values after matching were significant, indicating no significant difference between the experimental and control groups in terms of matching variables after matching.

Columns (1) and (3) of Table 10 show the results of basic regression of the propensity score matching method on the effect of inefficient investment levels and over-investment profiles, respectively. The estimated coefficients of -0.00278 and -0.00909 for *Post*×*Treat* are significantly negative at the 5% and 1% statistical levels, respectively.

[Insert Table 10 about here]

To further test the dynamic effect of the green financial reform and innovation pilot zone policy on the efficiency of enterprise investment and conduct parallel trend tests, this study introduces *Pre_2*, *Pre_1*, *Current*, *Post_1*, *Post_2*, and *Post_3* in the model to denote two years before the implementation of the green credit policy, the year of the policy, and the first three years after the implementation of the policy, respectively, and annual dummy variables to test the long-term performance of the policy. Table 11 and Figure 1 present the test results for the dynamic effect of the green financial reform and innovation pilot zone. The effect is not significant before the policy implementation, and the regression coefficients of the policy implementation

year and each year after the implementation are significantly negative, which implies that the green financial reform and innovation pilot zone has a long-term effect on the investment efficiency of firms. The absolute value of the coefficients shows a decreasing trend, indicating that the green financial reform and innovation pilot zone policy has a decreasing time trend in inhibiting firms' inefficient investment.

[Insert Table 11 about here]

[Insert Figure 1 about here]

7. Conclusion and implications

This study is the first to examine the impact of green finance reforms and innovation zone policy on corporate investment efficiency, using a DID model to analyze a quasi-natural experiment of a pilot green financial reform and innovation zone that was implemented in China in 2017. Our sample covers A-share listed Chinese companies from 2015 to 2020, which is long enough to establish a causal relationship, but also short enough to avoid potential contamination from other policy changes in China.

The results show that the establishment of the test area can significantly improve firms' investment efficiency, and the findings of this paper remain unchanged after robustness tests such as the PSM-DID method, changing the time interval, changing the sample size and shifting the time point of the policy forward. The micro effects of the policy can also be significantly heterogeneous depending on the ownership, corporate governance structure and nature of the firm. The mechanism analysis suggests that the

implementation of the policy can improve the investment efficiency of firms by reducing their agency costs and boosting R&D investment.

Based on the above conclusions, this paper puts forward the following three policy implications: (1) Changing the investment pattern of polluting enterprises and promoting the transformation of green development should be the more desired effect of the policy to encourage, support and guide financial institutions in the pilot zone to increase their financial support for the transformation and upgrading of polluting enterprises, and to avoid the "floating green phenomenon". The study found that the policy did not have a significant impact on the investment efficiency of heavy polluters, while it is still worth studying whether heavy polluters fraudulently obtained green credit through misrepresentation and over-investment due to mergers and acquisitions of green enterprises. (2) Increase financial support for green enterprises, raise the requirements for environmental protection and establish a long-term mechanism to support the development of green innovation. The research in this paper shows that the establishment of the pilot zone has not significantly changed the phenomenon of under-investment in pilot enterprises. Financial institutions in the pilot zone should provide more suitable financial support to SMEs and enterprises with financing difficulties, improve the positive incentive mechanism for state-owned enterprises and heavily polluting enterprises to participate in green projects, fully motivate enterprises to increase their green R&D investment, promote enterprises to consciously adjust their investment and development strategies, conduct a virtuous cycle, and avoid a "punitive effect " (3) China is still a developing country, and unlike developed countries,

developing countries are still at the stage of high energy consumption and high pollution. Therefore, this top-down experience of the Chinese government in exploring green financial reform and innovation policies is worthy of reference and learning from other developing countries. Against the backdrop of an increasingly integrated global environment, economy and destiny, China should also continue to improve and promote green finance policies to help other developing countries develop their economies in harmony with the environment in subsequent international cooperation.

The limitations of this paper and directions for further research are as follows. (1) The establishment of this pilot zone for green finance reform and innovation, with five provinces supporting different sectors through green finance loans. Due to the availability of data and sample size, this paper cannot discuss the direct impact of the policy on different industries, and further research is needed to investigate the differences in the effects of different regions. (2) Following the promulgation of the Green Finance Reform and Innovation Pilot Zone policy in 2017 and the establishment of a pilot zone in Gansu Province in 2019, the Chinese government is now also considering the inclusion of more municipalities in the pilot scheme, and further due diligence studies on more pilot zones can be conducted subsequently. (3) As enterprises can obtain green investments in the pilot zones while making non-green investments in other regions and thus enjoy lower costs, there is the possibility of such arbitrage. Because of the unavailability of data, such cases are not tested in this paper and can be further investigated subsequently.

Reference

Aggarwal, R. K., & Samwick, A. A. (2006). Empire-builders and shirkers: Investment, firm performance, and managerial incentives. *Journal of Corporate Finance*, 12(3), 489-515.

Ang, J. S., Cole, R. A., & Lin, J. W. (2000). Agency costs and ownership structure. *Journal of Finance*, 55(1), 81-106.

Cao, Y., Dong, Y., Lu, Y., & Ma, D. (2020). Does institutional ownership improve firm investment efficiency? *Emerging Markets Finance and Trade*, 56(12), 2772-2792.

Chen, S., Sun, Z., Tang, S., & Wu, D. (2011). Government intervention and investment efficiency: Evidence from China. *Journal of Corporate Finance*, 17(2), 259-271.

Di Giuli, A., & Laux, P. A. (2021). The effect of media-linked directors on financing and external governance. *Journal of Financial Economics*, forthcoming.

Fama, E. F. (1980). Agency problems and the theory of the firm. *Journal of Political Economy*, 88(2), 288-307.

Gorodnichenko, Y., & Schnitzer, M. (2013). Financial constraints and innovation: Why poor countries don't catch up. *Journal of the European Economic Association*, 11(5), 1115-1152.

Guo, X., Liang, C., Umar, M., & Mirza, N. (2022). The impact of fossil fuel divestments and energy transitions on mutual funds performance. *Technological Forecasting and Social Change*, 176, 121429.

Hu, G., Wang, X., & Wang, Y. (2021). Can the green credit policy stimulate green innovation in heavily polluting enterprises? Evidence from a quasi-natural experiment in China. *Energy Economics*, 98, 105134.

Jeucken, M. H., & Bouma, J. J. (1999). The changing environment of banks. *Greener Management International*, 27, 21-35.

Jiang, F., & Kim, K. A. (2015). Corporate governance in China: A modern perspective. *Journal of Corporate Finance*, 32, 190-216.

Kanamura, T. (2020). Are green bonds environmentally friendly and good performing assets?. *Energy Economics*, 88, 104767.

Kang, H., Jung, S. Y., & Lee, H. (2020). The impact of Green Credit Policy on manufacturers' efforts to reduce suppliers' pollution. *Journal of Cleaner Production*, 248, 119271.

La Porta, R., Lopez-de-Silanes, F., Shleifer, A., & Vishny, R. (2000). Investor protection and corporate governance. *Journal of Financial Economics*, 58(1-2), 3-27.

Lara, J. M. G., Osma, B. G., & Penalva, F. (2016). Accounting conservatism and firm investment efficiency. *Journal of Accounting and Economics*, 61(1), 221-238.

Lee, C. C. (2005). Energy consumption and GDP in developing countries: a cointegrated panel analysis. *Energy Economics*, 27(3), 415-427.

Lee, C. C., & Chang, C. P. (2005). Structural breaks, energy consumption, and economic growth revisited: evidence from Taiwan. *Energy Economics*, 27(6), 857-872.

Lee, C. C., & Chang, C. P. (2007). Energy consumption and GDP revisited: a panel analysis of developed and developing countries. *Energy Economics*, 29(6), 1206-1223.

Lee, C. C., & Chien, M. S. (2010). Dynamic modelling of energy consumption, capital

stock, and real income in G-7 countries. *Energy Economics*, 32(3), 564-581.
Lee, C. C., & Chiu, Y. B. (2011a). Electricity demand elasticities and temperature: Evidence from panel smooth transition regression with instrumental variable approach. *Energy Economics*, 33(5), 896-902.
Lee, C. C., & Chiu, Y. B. (2011b). Nuclear energy consumption, oil prices, and economic growth: Evidence from highly industrialized countries. *Energy Economics*, 33(2), 236-248.
Lee, C. C., & Lee, C. C. (2019). Oil price shocks and Chinese banking performance: Do country risks matter? *Energy Economics*, 77, 46-53.
Lee, C. C., & Zeng, J. H. (2011). Revisiting the relationship between spot and futures oil prices: evidence from quantile cointegrating regression. *Energy Economics*, 33(5), 924-935.
Lee, C. C., Chang, C. P., & Chen, P. F. (2008). Energy-income causality in OECD countries revisited: The key role of capital stock. *Energy Economics*, 30(5), 2359-2373.
Lee, C. C., Lee, C. C., & Ning, S. L. (2017). Dynamic relationship of oil price shocks and country risks. *Energy Economics*, 66, 571-581.
Lee, C. C., Wang, C. W., Ho, S. J., & Wu, T. P. (2021). The impact of natural disaster on energy consumption: international evidence. *Energy Economics*, 97, 105021.
Liu, L., & He, L. Y. (2021). Output and welfare effect of green credit in China: Evidence from an estimated DSGE model. *Journal of Cleaner Production*, 294, 126326.
Liu, M., & Lee, C. C. (2021). Capturing the dynamics of the China crude oil futures: Markov switching, co-movement, and volatility forecasting. Energy Economics, 103, 105622.
Liu, X., Ji, Q., & Yu, J. (2021). Sustainable development goals and firm carbon emissions: Evidence from a quasi-natural experiment in China. *Energy Economics*, 103, 105627.
Luo, S., Yu, S., & Zhou, G. (2021). Does green credit improve the core competence of commercial banks? Based on quasi-natural experiments in China. *Energy Economics*, 105335.
Lv, C., Bian, B., Lee, C. C., & He, Z. (2021a). Regional gap and the trend of green finance development in China. *Energy Economics*, 102, 105476.
Lv, C., Shao, C., & Lee, C. C. (2021b). Green technology innovation and financial development: Do environmental regulation and innovation output matter? *Energy Economics*, 98, 105237.
Porter, M. E. (1992). Capital disadvantage: America's failing capital investment system. *Harvard Business Review*, 70(5), 65-82.
Reboredo, J. C. (2018). Green bond and financial markets: Co-movement, diversification and price spillover effects. *Energy Economics*, 74, 38-50.
Richardson, S. (2006). Over-investment of free cash flow. *Review of Accounting Studies*, 11(2-3), 159-189.
Scharfstein, D. S., & Stein, J. C. (2000). The dark side of internal capital markets: Divisional rent-seeking and inefficient investment. *Journal of Finance*, 55(6), 2537-2564.

Shleifer, A., & Vishny, R. W. (1994). Politicians and firms. *Quarterly Journal of Economics*, 109(4), 995-1025.

Smith, C. W., & Stulz, R. M. (1985). The determinants of firms' hedging policies. *Journal of Financial and Quantitative Analysis*, 20(4), 391-405.

Su, C. W., Qin, M., Tao, R., & Umar, M. (2020). Financial implications of fourth industrial revolution: Can bitcoin improve prospects of energy investment? *Technological Forecasting and Social Change*, 158, 120178.

Tao, R., Su, C. W., Naqvi, B., & Rizvi, S. K. A. (2022). Can Fintech development pave the way for a transition towards low-carbon economy: A global perspective. *Technological Forecasting and Social Change*, 174, 121278.

Tao, R., Su, C. W., Xiao, Y., Dai, K., & Khalid, F. (2021). Robo advisors, algorithmic trading and investment management: Wonders of fourth industrial revolution in financial markets. *Technological Forecasting and Social Change*, 163, 120421.

Wang, H., Luo, T., Tian, G. G., & Yan, H. (2020). How does bank ownership affect firm investment? Evidence from China. *Journal of Banking & Finance*, 113, 105741.

Wen, H., Lee, C. C., & Zhou, F. (2021a). Green credit policy, credit allocation efficiency and upgrade of energy-intensive enterprises. *Energy Economics*, 94, 105099.

Wen, H., Lee, C. C., & Zhou, F. (2021b). How does fiscal policy uncertainty affect corporate innovation investment? Evidence from China's new energy industry. *Energy Economics*, 105767.

Wen, H., Li, N., & Lee, C. C. (2021c). Energy intensity of manufacturing enterprises under competitive pressure from the informal sector: Evidence from developing and emerging countries. *Energy Economics*, 104, 105613.

Xu, T. (2018). Investigating environmental Kuznets curve in China–aggregation bias and policy implications. *Energy policy*, 114, 315-322.

Xu, X., & Li, J. (2020). Asymmetric impacts of the policy and development of green credit on the debt financing cost and maturity of different types of enterprises in China. *Journal of Cleaner Production*, 264, 121574.

Yan, L., Mirza, N., & Umar, M. (2021). The cryptocurrency uncertainties and investment transitions: Evidence from high and low carbon energy funds in China. *Technological Forecasting and Social Change*, 121326.

Yao, S., Pan, Y., Sensoy, A., Uddin, G. S., & Cheng, F. (2021). Green credit policy and firm performance: What we learn from China. *Energy Economics*, 101, 105415.

Yin, W., Zhu, Z., Kirkulak-Uludag, B., & Zhu, Y. (2021). The determinants of green credit and its impact on the performance of Chinese banks. *Journal of Cleaner Production*, 286, 124991.

Yu, B., Li, C., Mirza, N., & Umar, M. (2022). Forecasting credit ratings of decarbonized firms: Comparative assessment of machine learning models. *Technological Forecasting and Social Change*, 174, 121255.

Yuan, H., Feng, Y., Lee, C. C., & Cen, Y. (2020). How does manufacturing agglomeration affect green economic efficiency? *Energy Economics*, 92, 104944.

Zhang, Y. J., & Wang, W. (2021). How does China's carbon emissions trading (CET) policy affect the investment of CET-covered enterprises?. *Energy Economics*, 98, 105224.

Zhong, M., & Gao, L. (2017). Does corporate social responsibility disclosure improve firm investment efficiency? Evidence from China. *Review of Accounting and Finance*, 16(3), 348-365.

Zhou, X., Tang, X., & Zhang, R. (2020). Impact of green finance on economic development and environmental quality: a study based on provincial panel data from China. *Environmental Science and Pollution Research*, 27(16), 19915-19932.

Table 1. Definition of variables

Variable	Definition
Absinv	Absolute value of residuals from the model (1)
Post	Dummy variable, 1 for 2017 and thereafter, 0 for other years
Treat	Dummy variable, 1 for the province in which the company is located in the test area, 0 for others
Size	Natural logarithm of the company's total assets at the end of the year
Lev	Total liabilities at the end of year / Total assets at the end of year
ROA	Net profit / average balance of total assets
Cashflow	Net cash flow from operating activities/total assets at the end of the year
Cap	Fixed assets intangible assets and other long-term assets/total assets
TobinQ	(Market capitalization outstanding + non-marketable shares x net assets per share + book value of liabilities)/total assets
FirmAge	ln (current year - year of incorporation + 1)
Board	Natural logarithm of the total number of board members
Indep	Percentage of independent directors on the board
Dual	Dummy variable, 1 for the same person as the chairman and managing director; 0 if not the same person
Top1	Shareholding of the largest shareholder at the end of the year as a proportion of the total shares of the company
Mshare	Management shareholding as a percentage of total company shares at the end of the year
Return	Annual individual share returns considering reinvestment of cash dividends

Noted: This table presents the definitions for all variables.

Table 2. Summary statistics

Variable	N	Mean	Max	Min	Median	SD
Absinv	14324	0.0275	0.1591	0.0004	0.0188	0.0287
Size	14324	22.4149	26.3951	19.7158	22.2463	1.2690
Lev	14324	0.4274	0.9901	0.0536	0.4201	0.1965
ROA	14324	0.0368	0.2442	-0.4147	0.0362	0.0688
Cashflow	14324	0.0515	0.2581	-0.1942	0.0496	0.0657
Cap	14324	0.0432	0.6419	0.0000	0.0306	0.0433
TobinQ	14324	2.1092	17.6759	0.7992	1.6385	1.5179
FirmAge	14324	2.9656	3.5553	2.0794	2.9957	0.2845
Board	14324	2.1181	2.7081	1.6094	2.1972	0.1973
Indep	14324	0.3769	0.6000	0.3077	0.3636	0.0538
Dual	14324	0.2757	1.0000	0.0000	0.0000	0.4469
Top1	14324	0.3312	0.7418	0.0838	0.3093	0.1437
Mshare	14324	0.1325	0.7021	0.0000	0.0119	0.1867
Return	14324	0.1053	2.2809	-0.5758	-0.0247	0.5166

Noted: This table reports descriptive statistics (namely, observations (N), mean, maximum (Max), minimum (Min), median, standard deviation (SD)). The sample contains 14324 firm-year observations over the period 2015–2020. See Table 1 for variable definitions.

Table 3. Results of the benchmark model

	(1)	(2)	(3)
Variable	Absinv	Underinv	Overinv
Post×Treat	-0.00278**	0.00032	-0.00895***
	(-2.20)	(0.29)	(-3.26)
Size	0.00228*	0.00168	0.01086***
	(1.83)	(1.33)	(3.58)
Lev	0.01313***	0.00361	0.03575***
	(3.04)	(0.90)	(3.42)
ROA	0.01920***	0.00020	0.04746***
	(3.48)	(0.04)	(3.25)
Cashflow	-0.00959**	-0.00179	-0.02674**
	(-2.17)	(-0.44)	(-2.32)
Cap	0.29352***	-0.31702***	0.48944***
	(22.56)	(-15.87)	(23.17)
TobinQ	-0.00072**	0.00077**	-0.00331***
	(-2.16)	(2.20)	(-3.55)
FirmAge	-0.01646	-0.02427***	-0.02236
	(-1.61)	(-2.72)	(-0.93)
Board	-0.00929***	-0.00118	-0.02606***
	(-2.66)	(-0.40)	(-2.93)
Indep	-0.00476	0.01022	-0.03913
	(-0.48)	(1.17)	(-1.57)
Dual	-0.00010	0.00016	-0.00348
	(-0.10)	(0.19)	(-1.36)
Top1	-0.00067	0.00162	0.01602
	(-0.10)	(0.24)	(1.12)
Mshare	0.00228	0.00680	0.00047
	(0.47)	(1.55)	(0.03)
Return	0.00141**	-0.00309***	0.00837***
	(2.00)	(-4.57)	(5.39)
Constant	0.03024	0.05890	-0.12269
	(0.73)	(1.53)	(-1.27)
N	14,182	8,221	4,488
R-squared	0.468	0.484	0.625
Firm FE	YES	YES	YES
Province FE	YES	YES	YES
Year FE	YES	YES	YES
Adj R-squared	0.317	0.273	0.409

Noted: The robust standard errors clustered by the firm are reported in the parenthesis, *, **, and *** represent significance at the 10%, 5%, and 1% levels, based on firm, province, and year fixed effects, respectively.

Table 4. Heterogeneity test 1: Corporate governance dimensions

	(1)	(2)	(3)	(4)
Variable	Balance=1	Balance=0	Inshold=1	Inshold=0
Post×Treat	-0.00404**	-0.00115	-0.00252	-0.00415**
	(-2.03)	(-0.67)	(-1.33)	(-2.28)
Size	0.00370*	-0.00155	0.00241	0.00201
	(1.77)	(-0.80)	(1.21)	(0.99)
Lev	0.02371***	0.01572**	0.00668	0.02238***
	(3.39)	(2.58)	(1.06)	(3.43)
ROA	0.01671**	0.02183**	0.01683*	0.02043***
	(2.22)	(2.27)	(1.78)	(2.92)
Cashflow	-0.00471	-0.00972*	-0.01605**	-0.00399
	(-0.66)	(-1.69)	(-2.56)	(-0.60)
Cap	0.28768***	0.29196***	0.31105***	0.26404***
	(13.59)	(16.03)	(16.56)	(12.61)
TobinQ	-0.00130**	-0.00013	-0.00048	-0.00090*
	(-2.46)	(-0.26)	(-0.92)	(-1.78)
FirmAge	-0.02426	-0.00261	0.00098	-0.01915
	(-1.37)	(-0.19)	(0.07)	(-1.33)
Board	-0.01420**	-0.00516	-0.01256**	-0.00544
	(-2.55)	(-1.13)	(-2.42)	(-1.14)
Indep	-0.02475*	0.01752	-0.00999	0.00240
	(-1.67)	(1.33)	(-0.71)	(0.17)
Dual	0.00190	-0.00215	-0.00052	-0.00030
	(1.23)	(-1.61)	(-0.36)	(-0.22)
Top1	0.01060	0.00620	-0.00235	0.00570
	(0.58)	(0.64)	(-0.27)	(0.37)
Mshare	-0.00810	0.00422	0.00826	0.00188
	(-1.03)	(0.60)	(0.68)	(0.33)
Return	0.00300***	0.00040	0.00171*	0.00130
	(2.87)	(0.39)	(1.66)	(1.22)
Constant	0.03588	0.05169	-0.01535	0.03164
	(0.51)	(0.88)	(-0.26)	(0.50)
N	6,868	6,847	6,931	6,945
R-squared	0.468	0.511	0.504	0.473
Firm FE	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Adj R-squared	0.287	0.352	0.348	0.300

Noted: The robust standard errors clustered by the firm are reported in the parenthesis, *, **, and *** represent significance at the 10%, 5%, and 1% levels, based on firm, province, and year fixed effects, respectively.

Table 5. Heterogeneity test 2: Nature of business dimension

	(1)	(2)	(3)	(4)
Variable	SOE=1	SOE=0	Heavy=1	Heavy=0
Post×Treat	0.00021	-0.00309*	-0.00148	-0.00286*
	(0.10)	(-1.89)	(-0.63)	(-1.91)
Size	0.00509**	0.00181	-0.00047	0.00334**
	(2.27)	(1.12)	(-0.17)	(2.23)
Lev	-0.00524	0.02078***	0.01590*	0.01246**
	(-0.65)	(3.97)	(1.71)	(2.41)
ROA	0.02184**	0.01714***	0.01144	0.01953***
	(1.97)	(2.72)	(0.86)	(3.22)
Cashflow	-0.00157	-0.01261**	-0.01292	-0.00850*
	(-0.27)	(-2.11)	(-1.41)	(-1.69)
Cap	0.30630***	0.28796***	0.27590***	0.30000***
	(12.83)	(18.15)	(12.71)	(17.82)
TobinQ	0.00040	-0.00114***	-0.00142**	-0.00042
	(0.67)	(-2.66)	(-2.25)	(-1.08)
FirmAge	-0.00816	-0.00966	-0.00974	-0.01514
	(-0.49)	(-0.74)	(-0.50)	(-1.25)
Board	-0.01333**	-0.00595	-0.00444	-0.01008**
	(-2.22)	(-1.35)	(-0.71)	(-2.46)
Indep	-0.00512	-0.00411	-0.00105	-0.00724
	(-0.34)	(-0.31)	(-0.06)	(-0.62)
Dual	-0.00221	0.00065	-0.00120	0.00042
	(-1.54)	(0.53)	(-0.61)	(0.38)
Top1	-0.01483*	0.00501	-0.00718	0.00485
	(-1.66)	(0.52)	(-0.65)	(0.58)
Mshare	0.01866	-0.00424	0.00463	0.00067
	(1.27)	(-0.80)	(0.46)	(0.12)
Return	-0.00101	0.00219**	0.00143	0.00133
	(-0.95)	(2.44)	(1.10)	(1.56)
Constant	-0.04296	0.01300	0.06416	0.00269
	(-0.62)	(0.24)	(0.79)	(0.05)
N	4,658	9,449	3,996	10,128
R-squared	0.491	0.460	0.452	0.476
Firm FE	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Adj R-squared	0.348	0.293	0.290	0.322

Noted: The robust standard errors clustered by the firm are reported in the parenthesis, *, **, and *** represent significance at the 10%, 5%, and 1% levels, based on firm, province, and year fixed effects, respectively.

Table 6. Testing intermediary mechanisms

	(1)	(2)	(3)	(4)
Variable	Mfee	Absinv	RD	Absinv
Post×Treat	-0.00236***		0.32868**	
	(-2.69)		(2.29)	
Mfee(RD)		1.17656*		-0.01092*
		(1.68)		(-1.75)
Size	-0.01431***	0.01911*	-0.13665	0.00028
	(-8.34)	(1.81)	(-0.43)	(0.08)
Lev	0.00804**	0.00366	-2.47544***	-0.01201
	(2.25)	(0.46)	(-2.73)	(-0.58)
ROA	-0.02635***	0.05021**	-7.76701***	-0.06613
	(-5.35)	(2.52)	(-7.91)	(-1.26)
Cashflow	0.01380***	-0.02583**	-1.85751***	-0.02618*
	(4.57)	(-2.27)	(-2.97)	(-1.86)
Cap	0.01775***	0.27264***	3.67868***	0.32846***
	(2.95)	(14.50)	(3.83)	(10.95)
TobinQ	0.00206***	-0.00315**	-0.05767	-0.00147**
	(6.47)	(-2.04)	(-1.17)	(-2.08)
FirmAge	-0.02660***	0.01484	-0.05958	-0.01529
	(-2.90)	(0.59)	(-0.04)	(-0.75)
Board	0.00899***	-0.01987***	-0.08941	-0.00831
	(3.05)	(-2.63)	(-0.21)	(-1.45)
Indep	0.02291***	-0.03172	0.20447	-0.00280
	(2.90)	(-1.52)	(0.15)	(-0.16)
Dual	-0.00054	0.00053	0.06466	-0.00010
	(-0.86)	(0.43)	(0.62)	(-0.06)
Top1	0.00693	-0.00882	-0.21893	-0.01055
	(1.44)	(-0.90)	(-0.25)	(-0.89)
Mshare	0.00379	-0.00218	0.13143	0.00107
	(0.89)	(-0.28)	(0.25)	(0.16)
Return	-0.00270***	0.00458**	-0.03487	0.00153
	(-6.46)	(2.17)	(-0.55)	(1.49)
Constant	0.40173***		9.50113	
	(8.63)		(1.26)	
N	14,182	14,182	12,353	12,353
R-squared	0.799	-0.277	0.870	-0.655
Firm FE	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Adj R-squared	0.742	-0.282	0.831	-0.662

Noted: The robust standard errors clustered by the firm are reported in the parenthesis, *, **, and *** represent significance at the 10%, 5%, and 1% levels, based on firm, province, and year fixed effects, respectively.

Table 7. Results from the placebo test

	(1)	(2)
Variable	2015	2016
Post×Treat	0.00050	-0.00172
	(0.35)	(-1.42)
Size	0.00188	0.00196
	(1.53)	(1.59)
Lev	0.01255***	0.01255***
	(2.77)	(2.77)
ROA	0.02067***	0.02057***
	(3.27)	(3.26)
Cashflow	0.00073	0.00072
	(0.16)	(0.16)
Cap	0.28837***	0.28878***
	(21.55)	(21.60)
TobinQ	-0.00043	-0.00042
	(-1.11)	(-1.09)
FirmAge	-0.00702	-0.00605
	(-0.76)	(-0.66)
Board	-0.00267	-0.00287
	(-0.80)	(-0.86)
Indep	0.00458	0.00426
	(0.44)	(0.41)
Dual	-0.00020	-0.00019
	(-0.20)	(-0.19)
Top1	-0.00654	-0.00669
	(-1.06)	(-1.08)
Mshare	-0.00168	-0.00192
	(-0.34)	(-0.39)
Return	0.00208***	0.00203***
	(2.66)	(2.61)
Constant	-0.00534	-0.00888
	(-0.14)	(-0.23)
N	12,661	12,661
R-squared	0.450	0.450
Firm FE	YES	YES
Province FE	YES	YES
Year FE	YES	YES
Adj R-squared	0.302	0.302

Noted: The robust standard errors clustered by the firm are reported in the parenthesis, *, **, and *** represent significance at the 10%, 5%, and 1% levels, based on firm, province, and year fixed effects, respectively.

Table 8. Subsample analysis

	(1)	(2)	(3)	(4)
Variable	2015-2019	2015-2018	Year ≠ 2017	Age>5
Post×Treat	-0.00287**	-0.00369**	-0.00240*	-0.00267**
	(-2.18)	(-2.55)	(-1.83)	(-2.12)
Size	0.00389**	0.00695***	0.00188	0.00234*
	(2.44)	(3.20)	(1.50)	(1.76)
Lev	0.01361**	0.01783**	0.01038**	0.00958**
	(2.53)	(2.40)	(2.34)	(2.13)
ROA	0.01733**	0.01426	0.01880***	0.01633***
	(2.51)	(1.55)	(3.13)	(2.82)
Cashflow	-0.00469	0.00176	-0.01033**	-0.00827*
	(-0.92)	(0.28)	(-2.06)	(-1.78)
Cap	0.28320***	0.28211***	0.29698***	0.27916***
	(17.61)	(13.33)	(20.67)	(19.25)
TobinQ	-0.00072*	-0.00074	-0.00060*	-0.00070*
	(-1.75)	(-1.58)	(-1.75)	(-1.89)
FirmAge	-0.02105	-0.02050	-0.01754*	-0.01829*
	(-1.64)	(-1.15)	(-1.67)	(-1.74)
Board	-0.00884**	-0.00884*	-0.00955**	-0.00982***
	(-2.28)	(-1.95)	(-2.40)	(-2.85)
Indep	-0.00154	0.00018	-0.00335	-0.00419
	(-0.13)	(0.01)	(-0.32)	(-0.41)
Dual	-0.00077	-0.00232	-0.00021	0.00009
	(-0.65)	(-1.56)	(-0.20)	(0.09)
Top1	-0.00749	-0.00771	0.00592	-0.00033
	(-0.90)	(-0.65)	(0.85)	(-0.05)
Mshare	0.00295	0.00130	0.00316	0.00501
	(0.49)	(0.16)	(0.59)	(0.92)
Return	0.00210**	0.00269**	0.00120	0.00148**
	(2.35)	(2.53)	(1.59)	(1.97)
Constant	0.00812	-0.06347	0.04055	0.03670
	(0.16)	(-0.89)	(0.95)	(0.83)
N	10,791	8,049	12,011	11,937
R-squared	0.484	0.532	0.499	0.432
Firm FE	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Adj R-squared	Firm	Firm	Firm	Firm

Noted: The robust standard errors clustered by the firm are reported in the parenthesis, *, **, and *** represent significance at the 10%, 5%, and 1% levels, based on firm, province, and year fixed effects, respectively.

Table 9. Results from the PSM balance Test

Variable	Type	mean		standardized Bias /%	Standardized Bias Change /%	T	P > | t |
		treat	control				
Size	Before	22.302	22.467	-13.3	82.7	-7.26	0.000
	After	22.302	22.274	2.3		1.11	0.266
Lev	Before	.41849	.43154	-6.7	77.3	-3.69	0.000
	After	.41847	.4155	1.5		0.73	0.465
ROA	Before	.04034	.03514	7.4	70.3	4.20	0.000
	After	.0403	.03876	2.2		1.02	0.306
Cashflow	Before	.05674	.04903	11.7	93.8	6.54	0.000
	After	.05672	.05624	0.7		0.35	0.728
Cap	Before	.04917	.04048	19.7	96.8	11.22	0.000
	After	.04895	.04867	0.6		0.29	0.772
TobinQ	Before	2.1648	2.0836	5.4	82.4	2.98	0.003
	After	2.1636	2.1779	-0.9		-0.45	0.656
FrimAge	Before	2.9414	2.9767	-12.3	98.8	-6.92	0.000
	After	2.9415	2.9419	-0.1		-0.07	0.945
Board	Before	2.1042	2.1244	-10.3	82.2	-5.71	0.000
	After	2.1043	2.1079	-1.8		-0.86	0.387
Indep	Before	.37874	.376	5.1	60.3	2.84	0.005
	After	.37873	.37982	-2.0		-0.95	0.343
Dual	Before	.3309	.25023	17.8	97.5	10.08	0.000
	After	.33068	.33267	-0.4		-0.20	0.841
Top1	Before	.32642	.33337	-4.9	85.1	-2.69	0.007
	After	.32644	.3254	0.7		0.35	0.725
Mshare	Before	.16269	.11861	23.4	96.1	13.21	0.000
	After	.16264	.16436	-0.9		-0.41	0.684
Return	Before	.12257	.09734	4.8	82.0	2.72	0.007
	After	.12222	.11766	0.9		0.40	0.686

Table 10. Results from the PSM-DID method

	(1)	(2)	(3)
Variable	Absinv	Underinv	Overinv
Post×Treat	-0.00278**	0.00032	-0.00909***
	(-2.20)	(0.29)	(-3.31)
Size	0.00211	0.00169	0.00990***
	(1.62)	(1.34)	(3.24)
Lev	0.01325***	0.00370	0.03711***
	(3.05)	(0.92)	(3.51)
ROA	0.01956***	0.00022	0.04919***
	(3.54)	(0.04)	(3.36)
Cashflow	-0.00949**	-0.00165	-0.02687**
	(-2.15)	(-0.40)	(-2.32)
Cap	0.29654***	-0.31707***	0.49783***
	(23.33)	(-15.87)	(23.30)
TobinQ	-0.00073**	0.00077**	-0.00334***
	(-2.20)	(2.20)	(-3.58)
FirmAge	-0.01673	-0.02424***	-0.02310
	(-1.63)	(-2.72)	(-0.96)
Board	-0.00930***	-0.00118	-0.02567***
	(-2.66)	(-0.40)	(-2.88)
Indep	-0.00499	0.01022	-0.03882
	(-0.50)	(1.17)	(-1.55)
Dual	-0.00008	0.00016	-0.00350
	(-0.08)	(0.19)	(-1.37)
Top1	-0.00098	0.00162	0.01590
	(-0.15)	(0.24)	(1.11)
Mshare	0.00229	0.00679	0.00038
	(0.47)	(1.55)	(0.03)
Return	0.00140**	-0.00308***	0.00841***
	(1.99)	(-4.57)	(5.41)
Constant	0.03496	0.05862	-0.10091
	(0.81)	(1.52)	(-1.04)
N	14,172	8,218	4,478
R-squared	0.465	0.484	0.622
Firm FE	YES	YES	YES
Province FE	YES	YES	YES
Year FE	YES	YES	YES
Adj R-squared	0.313	0.273	0.404

Noted: The robust standard errors clustered by the firm are reported in the parenthesis, *, **, and *** represent significance at the 10%, 5%, and 1% levels, based on firm, province, and year fixed effects, respectively.

Table 11. Estimation results for the dynamic effects.

	(1)
Variable	Absinv
Pre_2	-0.00599
	(-1.43)
Pre_1	0.01045
	(0.73)
current	-0.01561***
	(-2.70)
Post_1	-0.01296**
	(-2.29)
Post_2	-0.01366**
	(-2.22)
Post_3	-0.01141**
	(-2.27)
Controls	YES
N	16,153
R-squared	0.287
Firm FE	YES
Province FE	YES
Year FE	YES
Adj R-squared	0.114

Noted: The robust standard errors clustered by the firm are reported in the parenthesis, *, **, and *** represent significance at the 10%, 5%, and 1% levels, based on firm, province, and year fixed effects, respectively.

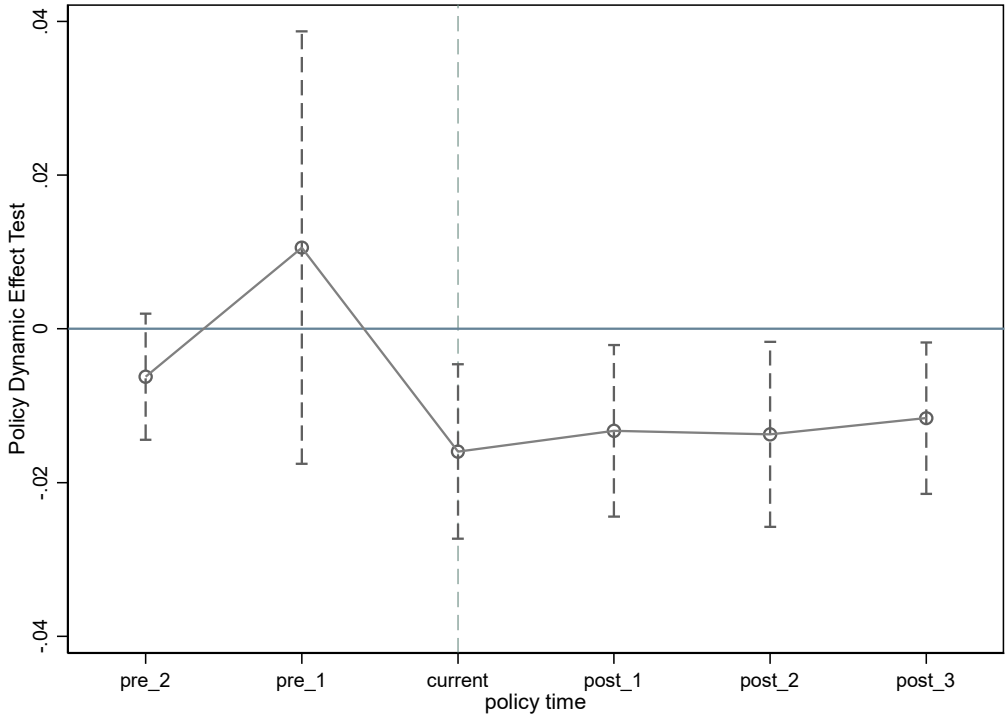

Figure 1. The parallel trend test for inefficient investment