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GREEN FINANCE AND ENTERPRISE INVESTMENT EFFICIENCY——A QUASI-NATURAL EXPERIMENT BASED ON GREEN FINANCE REFORM AND INNOVATION PILOT ZONES

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ABSTRACT
Exploring the impact of green finance pilot on enterprise investment efficiency is of great significance to coordinate the contradiction between economic development and environmental protection and achieve a win-win situation of pollution control and efficiency improvement. Based on the initial data of China's A-share enterprises from 2013 to 2020, using the quasi-natural experiment of establishing green finance reform and innovation pilot zone in 2017 to construct PSM-DID model to empirically test the impact of green finance pilot on investment efficiency of heavily polluting enterprises and green enterprises. The results show that: ①green finance pilot significantly reduces investment efficiency of heavily polluting enterprises by aggravating insufficient investment, but improves investment efficiency of green enterprises by improving insufficient investment and inhibiting excessive investment. ②The impact on investment efficiency of heavily polluting enterprises and green enterprises is reflected in non-state-owned enterprises. ③The inhibitory effect on investment efficiency of heavily polluting enterprises is mainly reflected in enterprises with low shareholding ratio of institutional investors, while the promoting effect on investment efficiency of green enterprises is reflected in enterprises with high shareholding ratio of institutional investors. Therefore, continuing to play the role of resource allocation, environmental risk review and supervision mechanism of green finance pilot, and on this basis, implementing differentiation policies for enterprises with different characteristics is an important work of green finance pilot policy.

Keywords:
Green finance pilot; investment efficiency; heavily polluting enterprises; green enterprises

Introduction

Lucid water and lush mountains are invaluable assets. Since the reform and opening up, the high pollution, high emission and high energy consumption associated with rapid economic development have brought serious problems of resource shortage and environmental pollution, which poses major challenges to the sustainable development of economy. In order to achieve the goals of "carbon peak" and "carbon neutralization" and green development on schedule, and promote high-quality economic development, green finance with the natural advantages of green capital supply and green resource allocation has emerged and developed rapidly under this background (Liu et al., 2017; Wang et al., 2021a). In June 2017, the executive meeting of the State Council decided to build green finance reform and innovation pilot zones (hereinafter referred to as "green finance pilot") in Zhejiang, Jiangxi, Guangdong, Guizhou and Xinjiang provinces (autonomous regions), which aims to play the role of resource allocation, guide the transfer of financial resources from heavily polluting industries to green industries, so as to help the development of green industries, and force the green transformation of heavily polluting

industries to fulfill social responsibilities and realize green development (Shen and Liao, 2020; Wang et al., 2021b).

As we all know, the investment decisions of enterprises not only determine the long-term development prospects of enterprises themselves, but also can promote the growth of national economy and upgrade economic structure from macroeconomic perspective. At the current stage of the transformation of China's economy from high-speed growth to high-quality development, the growth momentum of China's economy is facing the challenge of shifting from total investment to investment efficiency. However, most of the existing enterprises in China have inefficient investment. Excessive or insufficient investment leads to resource misallocation, and thus cannot achieve the best economic and social benefits (Zhu and Xiong, 2020). Therefore, how to inhibit excessive investment, alleviate insufficient investment and then improve investment efficiency is urgent to be solved. Green finance plays the role of resource allocation and tilts financial resources from highly polluting industries to green industries, which is bound to affect the free cash flow required by heavily polluting enterprises and green enterprises for investment decisions, then affect investment efficiency of enterprises.

By exploring the relationship between green credit and investment efficiency, existing studies have found that green credit inhibits excessive investment of heavily polluting enterprises by affecting debt maturity structure and commercial credit scale, and improves the problem of insufficient investment of heavily polluting enterprises (Wang et al., 2021a). In addition, green credit can inhibit excessive investment behavior of heavily polluting enterprises through strict bank credit contracts (Zhu and Tan, 2020) and the alleviation of agency problems (Ning et al., 2021), and the inhibitory effect shows an increasing trend in time. However, green credit is only a financing tool of green finance, and its implementation effect is not enough to fully reflect green finance pilot. And existing studies only discuss the impact on heavily polluting enterprises. whether green enterprises, as an important object of green financial resource flow, are deeply affected by green finance and play a significant role remains to be explored. Therefore, it is necessary to further explore the relationship between green finance pilot and investment efficiency. What is the impact of green finance pilot on enterprise investment efficiency? And for heavily polluting enterprises and green enterprises, are there differences? By answering the above questions, this paper hopes to provide empirical evidence and reference for the policy effect evaluation and subsequent improvement reform of green finance pilot.

Throughout the existing research, scholars respectively from carbon emissions (Ren et al., 2020), energy efficiency (Song et al., 2021), industrial structure upgrading (Hu et al., 2020), green economic growth (Lei et al., 2021), enterprise investment and financing behavior (Su and Lian, 2018), debt financing cost (Xu and Li, 2020), financing efficiency (Jin et al., 2021), green innovation (Hong et al., 2021), green total factor productivity (Lee and Lee, 2022), environmental and social responsibility (Sinha et al., 2021), enterprise value (Lai et al., 2021) and other macro and micro levels discussed the implementation effect of green finance. The research on the influencing factors of enterprise investment efficiency is more from the internal perspectives of management ability (Garcia-Sanchez et al., 2018), financing constraints (Islam and Luo, 2018), internal control quality (Lai et al., 2020), accounting conservatism (Lara et al., 2016), financial reporting quality (Houcine, 2017), equity incentive (Xie and Li, 2018), social responsibility (Fonseka et al., 2021), information disclosure (Dutta and Nezlobin, 2017), and the external perspectives of government intervention (Hao and Lu, 2018), government subsidies (Hu

et al., 2019), financial development (Naeem and Li, 2019), environmental uncertainty (Li et al., 2021a), monetary policy (Aktar and Abedin, 2021), product market competition (Boubaker et al., 2021) and so on.

Although the research on green finance and investment efficiency has been deepened with the development of society, there are still some research gaps in the existing literature. Firstly, although the literature studies on practical consequences of green finance is relatively rich, it mainly concentrates on green credit policy, and the mechanism design and measurement of green finance. Secondly, from micro perspective of enterprises, there are few literatures on green finance and enterprise investment efficiency, and no literature to concentrates on green finance pilot and enterprise investment efficiency. Thirdly, there are few studies on the difference in investment efficiency of heavily polluting enterprises and green enterprises caused by green finance pilot. Based on this, taking quasi-natural experiment of green finance pilot as starting point, PSM-DID model is constructed to multi-dimensionally test and deeply discuss the impact of green finance pilot on investment efficiency of heavily polluting enterprises and green enterprises respectively.

The possible innovations are as follows. Firstly, investigating the policy net effect produced by green finance pilot from micro perspective of enterprise investment efficiency, which not only further enriches the relevant literature of green finance, but also provides a new perspective for the research on influencing factors of investment efficiency. Secondly, taking heavily polluting enterprises and green enterprises as research objects and carrying out multi-dimensional discussions, which more intuitively understands the heterogeneous impact on different enterprises, and provide experience for the subsequent reform of green finance pilot. Thirdly, constructing PSM-DID model for empirical test, which effectively avoids the endogenous problems that may be caused by the measurement deviation of green finance indicators, the missing variables deviation of measurement model or the sample selectivity deviation, and enhance the accuracy and scientificity of research conclusions.

Theoretical analysis and research hypotheses

Green finance pilot and enterprise investment efficiency

In reality, the actual investment of enterprises deviates from the optimal value, resulting in inefficient investment due to the friction in capital market, that is, excessive investment or insufficient investment. Many studies have shown that information asymmetry and financing constraints are two important reasons affecting investment efficiency of enterprises. Information asymmetry is easy to lead to self-interest behavior of enterprise management, resulting in excessive investment. Financing constraint shows the difficulty of obtaining free cash flow, and the financing channels for enterprises to obtain cash flow are more dependent on financial institutions. The investment activities of enterprises are inseparable from free cash flow. The more the free cash flow is, the more it likely to cause excessive investment, and the opposite is to cause insufficient investment (Zhu and Tan, 2020).

For heavily polluting enterprises, on the one hand, green finance will make heavily polluting enterprises face more stringent audit mechanism and tight financing space, resulting in financing constraints, insufficient free cash flow and the risk of capital chain rupture, and thus aggravate insufficient investment and reduce investment efficiency. For example, in terms of green credit, financial institutions will strictly limit the loan amount of heavily polluting enterprises and increase loan interest rate, thereby reducing financing scale and increasing financing cost of heavily polluting enterprises (Li

et al., 2021b; Peng et al., 2021), which affects the acquisition of free cash flow and results in insufficient investment. In terms of green securities, more stringent issuance conditions are set. Heavily polluting enterprises without green transformation will be difficult to meet the qualification of issuing green securities, thereby reducing financing channels, resulting in tight financial sources and lower free cash flow, which is easy to cause insufficient investment. On the one hand, green finance takes into account environmental risks in audit process, forcing heavily polluting enterprises to disclose environmental information, which supervises the environmental behavior of heavily polluting enterprises. In addition, with the concept of environmental protection deeply rooted in the hearts of the people, the public's attention to environmental issues is gradually increasing, resulting in the rising compliance costs and public opinion pressure faced by heavy polluting enterprises (Wang et al., 2021). Therefore, heavily polluting enterprises may adjust their investment strategies in time due to cash flow shortages and reputation risks, placing greater emphasis on environmental impacts and longer-term competitiveness in the investment process, thereby increasing investment efficiency by reducing short-term blind investment.

For green enterprises, on the one hand, providing green capital for green industries is the main role of green finance. In terms of green credit, compared with heavily polluting enterprises, green enterprises can get more loan limits and lower loan interest rates (Lian, 2015; Xu and Li, 2020), which effectively alleviates the shortage of funds caused by long investment cycle and late return on investment. Green enterprises can also broaden financing channels and alleviate financing constraints through green bonds, green funds and other financing tools. Therefore, green finance may improve insufficient investment, thereby improving investment efficiency of green enterprises. On the other hand, the strict information disclosure review mechanism and supervision mechanism of green finance can effectively alleviate information asymmetry between financial institutions and green enterprises, investors and green enterprises (Khan et al., 2017), reduce the adverse selection risk of investors, thus inhibiting blind excessive investment caused by the self-interest behavior of management, and improving investment efficiency of green enterprises. Based on the above analysis, the hypotheses are proposed as follow.

Hypothesis 1a: Green finance pilot mainly aggravates insufficient investment and reduces investment efficiency of heavily polluting enterprises.

Hypothesis 1b: Green finance pilot mainly inhibits excessive investment and improves investment efficiency of heavily polluting enterprises.

Hypothesis 1c: Green finance pilot mainly improves insufficient investment and improves investment efficiency of green enterprises.

Hypothesis 1d: Green finance pilot mainly inhibit excessive investment and improves investment efficiency of green enterprises.

Heterogeneity of property right nature of enterprises

Under different property right nature, the impact of green finance on enterprise investment efficiency may be different. Firstly, due to the political connection between state-owned enterprises and the government, state-owned enterprises are more likely to enjoy political assistance and financial assistance than non-state-owned enterprises, such as the loan funds with fewer restrictive terms and lower interest rates and larger loan scale, lower environmental tax incentives and various subsidies (Brandt and Li, 2003). Therefore, in the process that capital supply of green finance is inclined from heavily polluting industries to green industries, resulting in the reduction of free cash flow of heavily polluting enterprises,

non-state-owned heavily polluting enterprises are subject to greater financing constraints than state-owned heavily polluting enterprises (Cai et al., 2019), which are more likely to cause insufficient investment and reduce investment efficiency. In addition, non-state-owned heavily polluting enterprises are more sensitive to cash flow shortage and reputation risks that may be caused by negative reports and environmental protection administrative penalties. Therefore, non-state-owned heavily polluting enterprises may be more likely to adjust investment strategies to improve investment efficiency by reducing blind excessive investment. For green enterprises, although both state-owned green enterprises and non-state-owned green enterprises can effectively alleviate insufficient investment by improving financing constraints and obtaining more free cash flow, due to the social responsibility of state-owned enterprises, they will respond positively to national policies and invest more funds in environmental governance to improve the environment (Sun and Li, 2016). Therefore, the investment of state-owned green enterprises in environmental protection may increase, which weakens the improvement effect of green finance on insufficient investment. Based on the above analysis, the hypotheses are proposed as follow.

Hypothesis 2a: The impact of green finance pilot on investment efficiency of heavily polluting enterprises is mainly reflected in non-state-owned enterprises.

Hypothesis 2b: The impact of green finance pilot on investment efficiency of green enterprises is mainly reflected in non-state-owned enterprises.

Heterogeneity of shareholding ratio of institutional investors of enterprises

Compared with small investors, institutional investors have more advantages in scale economy, professional knowledge and risk identification, so they have more motivation and ability to participate in enterprise decision-making and affect their investment behavior. Research shows that institutional investors participate in enterprise management and form effective supervision over enterprise management, thereby reducing information asymmetry and restricting opportunistic behavior of management (Chen et al., 2017). In addition, institutional investors with information collection and cost advantages require enterprises to make more information disclosure to improve information transparency, alleviate information asymmetry and improve financing constraints (Zhen and Wang, 2016; Ward et al., 2020). Under different shareholding ratios of institutional investors, the impact of green finance on enterprise investment efficiency may be different. The higher the shareholding ratio of institutional investors is, the more disclosure power and cost advantage they have, and the stronger their ability in corporate governance and information disclosure is. Therefore, for heavily polluting enterprises, when faced with financing constraints and free cash flow shortage caused by green finance, heavily polluting enterprises with high shareholding of institutional investors can take timely countermeasures due to higher governance level, more professional knowledge level and risk-taking ability, so as to reduce the problem of insufficient investment caused by green finance. While heavily polluting enterprises with low shareholding of institutional investors seriously and obviously face insufficient investment caused by green finance. Similarly, for green enterprises with high shareholding of institutional investors, high governance level and professional resource allocation ability can make enterprises closer to the ideal state in investment decision-making, thus effectively improve investment efficiency. In addition, the higher and more transparent information disclosure quality of green enterprises also help to inhibit managerial opportunism, thereby inhibiting excessive investment. Based on the above analysis, the

hypotheses are proposed as follow.

Hypothesis 3a: Green finance pilot aggravates insufficient investment of heavily polluting enterprises mainly in enterprises with low shareholding ratio of institutional investors.

Hypothesis 3b: Green finance pilot improves investment efficiency of green enterprises mainly in enterprises with high shareholding ratio of institutional investors.

Materials and methods

Data

This paper takes A-share heavily polluting enterprises and green enterprises from 2013 to 2020 as initial research samples. Among them, heavily polluting enterprises are defined according to the "directory of classified management of environmental protection verification industry of listed companies" promulgated by the original ministry of environmental protection in 2008, selecting the industry code for B06, B07, B08, B09, C13, C14, C15, C17, C18, C19, C22, C25, C26, C27, C28, C29, C30, C31, C32, C33 and D44 as heavily polluting enterprises. Green enterprises are defined according to the "green industry guidance catalogue (2019 Edition)", selecting new energy vehicles, green buildings, green power, wind power, energy conservation and emission reduction, smart grid and solid waste treatment and other concept stock enterprises as green enterprises.

In order to ensure the validity of data and the reliability of research results, the following screening procedures are carried out: ①eliminate ST, * ST and PT enterprises. ②Eliminate the newly listed enterprises after 2013. ③Eliminate the enterprises with major changes in their main business during the study period; ④Eliminate enterprises with serious data loss and interpolate individual missing values. ⑤All continuous variables are subjected tailed by upper and lower 1% quantiles to eliminate the influence of extreme values. After screening, a total of 594 heavily polluting enterprises and 352 green enterprises are obtained, with a total of 7568 observations. The financial data involved in this paper are from CSMAR database.

Variable

Explained variable: investment efficiency (IE).

Referring to the research of He et al. (2019), the Richardson (2006) model is used to measure investment efficiency of enterprises by calculating the degree of deviation from optimal investment level, as shown in model (1). According to the research of Richardson (2006), the investment expenditure of an enterprise is composed of expected investment and unexpected expenditure. Among them, expected investment refers to the funds paid by enterprises to maintain normal operation, which is related to factors such as enterprise growth, financing constraints, enterprise scale and industry, while unexpected expenditure is not related to the above influencing factors, which is specifically reflected in the residual error in model (1). Therefore, this paper takes the absolute value of residual as the proxy variable of investment efficiency (IE). The larger the absolute value of residual is, the lower the investment efficiency of the enterprise is. In addition, $\varepsilon_{it} > 0$ represents excessive investment (Overinv) and $\varepsilon_{it} < 0$ represents insufficient investment (Underinv).

$$Inv_{it} = \alpha_0 + \alpha_1 Inv_{i,t-1} + \alpha_2 Growth_{i,t-1} + \alpha_3 Size_{i,t-1} + \alpha_4 Lev_{i,t-1} + \alpha_5 Cash_{i,t-1} + \alpha_6 Ret_{i,t-1} + \alpha_7 Age_{i,t-1} + Year + Ind + \varepsilon_{it} \quad (1)$$

Where, Inv_{it} and $Inv_{i,t-1}$ respectively represent the capital investment in year t and year t-1, that

is, the ratio of cash paid for fixed assets, intangible assets and other long-term assets to total assets at the beginning of the year. Growth、Size、Lev、Cash、Ret and Age represent business revenue growth rate, enterprise size, asset-liability ratio, cash holdings, stock return and enterprise age in year T-1 respectively. And Year and Ind represent the control time and industry respectively.

Explanatory variable: green finance pilot (Treat×Post).

The explanatory variable of this paper is green finance pilot, namely Treat×Post. Among them, Treat is the pilot area variable, the enterprise samples whose registered provinces are green finance pilot areas (Zhejiang, Jiangxi, Guangdong, Guizhou and Xinjiang) are taken as the treatment group, with the value of 1, and the rest areas are taken as the control group, with a value of 0. Post is the pilot time variable, the value of green finance pilot year and subsequent years (2017-2020) is 1, and the value of previous years (2013-2016) is 0.

Control variable

Based on the existing research, enterprise size (Size), enterprise age (Age), asset-liability ratio (Lev), return on total assets (Roa), business revenue growth rate (Growth), ownership concentration (Top1), equity balance (Balance) and board size (Board) are selected as control variables. In addition, the year, industry and area also are controlled to avoid the possible interference that different industries and areas cause to the accuracy of research conclusions. See Table 1 for the specific variable definition.

Table 1: Variable definition

Variable type	Variable name	Variable	Definition
Explained variable	Investment efficiency	*IE*	The absolute residuals of Richardson model
	Excessive investment	*Overinv*	The residual error of Richardson model is greater than 0
	Insufficient investment	*Underinv*	The residual error of Richardson model is less than 0
Explanatory variable	Pilot area variable	*Treat*	The province where the enterprise is registered is pilot area, and the value is 1, otherwise it is 0
	Pilot time variable	*Post*	The value of the pilot year and subsequent years (2017-2020) is 1, and the previous year (2013-2016) is 0
Control variable	Enterprise size	*Size*	Natural logarithm of total assets
	Enterprise age	*Age*	Natural logarithm of listed years
	Asset-liability ratio	*Lev*	Total liabilities / total assets
	Return on total assets	*Roa*	Net profit / total assets
	Business revenue growth rate	*Growth*	(Current year's operating income / previous year's operating income) -1
	Ownership concentration	*Top1*	Shareholding ratio of the first largest shareholder
	Equity Balance	*Balance*	Sum of shareholding ratio of the second to fifth

		shareholders / shareholding ratio of the first largest shareholder
Board size	*Board*	Natural logarithm of the number of directors

Design of PSM-DID model

Considering that treatment group and control group in the research sample in this paper contain different industries, which may cause selective deviation due to significant differences in individual characteristics, this paper attempts to use the propensity score matching method (PSM) to 1:1 match the samples of treatment group and control group on the basis of obtaining the propensity score by Logit regression to meet common trend hypothesis, and then construct DID model to empirically test the net effect of green finance pilot on investment efficiency of heavily polluting enterprises and green enterprises (Huang and Zhang, 2021).The effective combination of PSM and DID model can alleviate the endogenous problem caused by selectivity deviation of samples. The specific model is as follows:

$$IE_{it} = \beta_0 + \beta_1 Treat + \beta_2 Treat_i \times Post_t + \beta_3 Post + \beta_4 \sum Controls_{it} + Year + Ind + Area + \varepsilon_{it} \quad (2)$$

$$Overinv_{it} = \beta_0 + \beta_1 Treat + \beta_2 Treat_i \times Post_t + \beta_3 Post + \beta_4 \sum Controls_{it} + Year + Ind + Area + \varepsilon_{it} \quad (3)$$

$$Underinv_{it} = \beta_0 + \beta_1 Treat + \beta_2 Treat_i \times Post_t + \beta_3 Post + \beta_4 \sum Controls_{it} + Year + Ind + Area + \varepsilon_{it} \quad (4)$$

Where IE、Overinv、Underinv are explained variables, representing enterprise investment efficiency, excessive investment and insufficient investment respectively, Treat×Post is explanatory variable, Treat represents green finance pilot area, and Post represents green finance pilot time. β_2 is regression coefficient of green finance pilot affecting enterprise investment efficiency, which is the focus of this paper, Controls represents control variables. Year, Ind and Area respectively represent the fixed effects of controlling time, industry and area, ε_{it} is random disturbance terms.

Results and discussion

Descriptive statistics and correlation analysis

The results of descriptive statistics and correlation analysis of main variables including samples of heavily polluting enterprises and green enterprises are listed in Table 2 and Table 3 respectively. Table 2 shows there are 7568 observed samples, 2806 excessive investment samples and 4762 insufficient investment samples. And the mean values of enterprise investment efficiency (IE), excessive investment (Overinv) and insufficient investment (Underinv) are 0.0369, 0.0478 and -0.0309the maximum values are 0.2334, 0.3284 and -0.0007, and the minimum values are 0.0005, 0.0004 and -0.1369 respectively, indicating that investment efficiency (IE), excessive investment (Overinv) and insufficient investment (Underinv) among different enterprises have certain differences. In addition, the mean value of green finance pilot area (Treat) is 0.2833, indicating that green finance pilot area sample accounts for 28.33%. Table 3 show that the correlation coefficients between investment efficiency (IE) and control variables

are less than 0.5, and basically pass the correlation test of 1%, which means the selection of variables is more reasonable and no multicollinearity.

Table 2: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
IE	7568	0.0369	0.0398	0.0005	0.2334
Overinv	2806	0.0478	0.0597	0.0004	0.3284
Underinv	4762	-0.0309	0.0252	-0.1369	-0.0007
Treat	7568	0.2833	0.4506	0.0000	1.0000
Post	7568	0.5000	0.5000	0.0000	1.0000
Size	7568	22.5771	1.2713	20.3036	26.525
Age	7568	2.4462	0.5432	1.0986	3.2958
Lev	7568	0.4349	0.1896	0.0656	0.8508
Roa	7568	0.0417	0.0527	-0.1472	0.2111
Growth	7568	0.1334	0.2937	-0.4192	1.6069
Top1	7568	0.3386	0.1470	0.0834	0.7409
Balance	7568	0.6878	0.5786	0.0300	2.6439
Board	7568	2.1462	0.1961	1.6094	2.7080

Table 3: Correlation analysis

	IE	*Size*	*Age*	*Lev*	*Roa*	*Growth*	*Top1*	*Balance*	*Board*
IE	1.000								
Size	-0.101***	1.000							
Age	-0.149***	0.357***	1.000						
Lev	-0.046***	0.511***	0.268***	1					
Roa	0.049***	0.038***	-0.030***	-0.357***	1.000				
Growth	0.214***	0.0110	-0.116***	0.0160	0.251***	1.000			
Top1	-0.019*	0.276***	0.0140	0.098***	0.109***	-0.021*	1.000		
Balance	0.040***	-0.085***	-0.141***	-0.082***	-0.037***	0.059***	-0.697***	1.000	
Board	-0.069***	0.236***	0.137***	0.132***	0.034***	-0.024**	0.033***	0.0130	1.000

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

Propensity score matching (PSM)

Table 4 lists balance test results after 1:1 matching using PSM. This paper selects enterprise size (Size), enterprise age (Age), return on total assets (Roa), business revenue growth rate (Growth), ownership concentration (Top1) and equity balance (Balance) are selected as covariates for propensity score matching. It can be seen that the standardized deviation of all covariates after matching is less than 10%. In addition, t-test results show that except for ownership concentration (Top1), there is no significant difference in the covariates of enterprise size (Size), enterprise age (Age), return on total assets (Roa), business revenue growth rate (Growth) and equity balance (Balance) after matching. The above results all show that the balance test results of matching are good. In addition, Fig. 1 and Fig. 2 show the kernel density function diagram of samples before and after propensity score matching, respectively, which clearly shows that the kurtosis and skewness of control group samples changed from large

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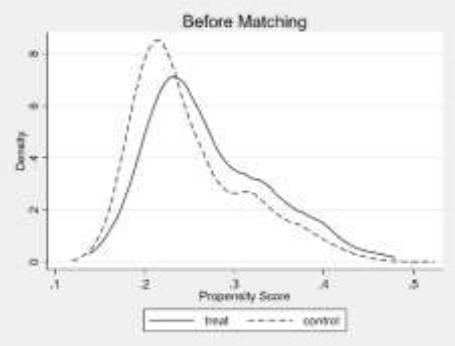
International Journal of Engineering Technology Research & Management

deviation to almost overlapping with the nuclear density distribution of treatment group samples after matching, indicating that the quality of propensity score matching is good and can be used for the next DID model test.

Table 4: Results of balance test

Variable	Unmatched	Mean		%reduct		t-test		V(T)/
	Matched	Treated	Control	%bias	|bias|	t	p>|t|	V(C)
Size	U	22.445	22.62	-14.7		-4.11	0.000	0.62*
	M	22.445	22.387	4.9	66.3	1.28	0.201	0.78
Age	U	2.4274	2.5332	-20.1		-5.93	0.000	0.98
	M	2.4274	2.4585	-5.9	70.6	-1.42	0.156	0.94
Roa	U	0.05204	0.04415	14.4		4.26	0.000	1.03
	M	0.05204	0.0531	-1.9	86.7	-0.45	0.654	0.89*
Growth	U	0.12504	0.11647	3.1		0.90	0.370	0.87*
	M	0.12504	0.11921	2.1	31.9	0.50	0.614	0.84*
Top1	U	0.33038	0.35292	-15.3		-4.49	0.000	0.96
	M	0.33038	0.31857	8.0	47.6	2.03	0.042	1.17*
Balance	U	0.72211	0.64752	13.3		3.90	0.000	0.93
	M	0.72211	0.73074	-1.5	88.4	-0.37	0.715	0.86*



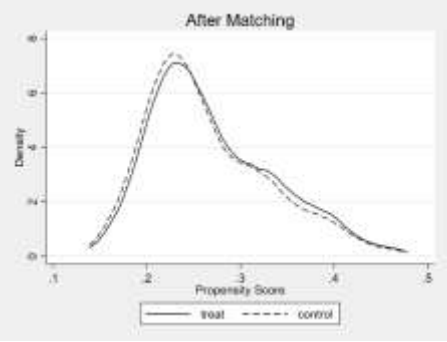


Fig. 1: Before propensity score matching *Fig. 2: After propensity score matching*

Discussion on the results of green finance pilot affecting enterprise investment efficiency

Table 5 shows the empirical estimation results of green finance pilot affecting enterprise investment efficiency. Among them, columns (1)-(3) are the empirical test of heavily polluting enterprises, and columns (4)-(6) are the empirical test of green enterprises. For heavily polluting enterprises, on the basis of controlling other variables affecting enterprise investment efficiency and time, industry and province, the regression coefficients of Treat×Post in column (1) and (3) are 0.00705 and -0.00496 respectively, which is significant at 10%, while the coefficient of Treat×Post on excessive investment (Overinv) in column (2) is not significant, indicating that green finance pilot inhibits investment efficiency and aggravates insufficient investment of heavily polluting enterprises. The above results verify Hypothesis 1a. That is, green finance pilot mainly reduces investment efficiency by aggravating insufficient investment of heavily polluting enterprises, but does not inhibit excessive investment. Hypothesis 1b

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International Journal of Engineering Technology Research & Management

does not pass the test. For green enterprises, the coefficients of Treat×Post are -0.0113, -0.0205 and 0.0087 respectively in column (4)-(6), which is significant at 5% or 10%. The results show that green finance pilot significantly promoting investment efficiency of green enterprises, which not only reflects in inhibiting excessive investment, but also in alleviating insufficient investment of green enterprises. The above results verify Hypothesis 1c and Hypothesis 1d.

The above results show that under the effects of green financial resource allocation, environmental risk review and supervision mechanism, green finance pilot increases financing cost and reduces financing channels of heavily polluting enterprises (Xu and Li, 2020; Peng et al., 2021), which has a negative impact on investment efficiency. However, green finance pilot alleviates financing constraints and strengthens information disclosure mechanism of green enterprises (Lian, 2015), which significantly promotes investment efficiency of green enterprises. Therefore, while green finance playing the role in resource allocation, the environmental risk review mechanism, information disclosure mechanism and supervision mechanism should be strictly improved to force enterprises to adjust investment decision-making and seek long-term development.

Table 5: Results of green finance pilot affecting enterprise investment efficiency

Variable	Heavily polluting enterprises			Green enterprises		
	(1)	(2)	(3)	(4)	(5)	(6)
	IE	Overinv	Underinv	IE	Overinv	Underinv
Treat×Post	0.00705*	0.00489	-0.00496*	-0.0113**	-0.0205*	0.00870**
	(1.96)	(0.60)	(-1.68)	(-2.40)	(-1.82)	(-2.16)
Size	-0.00183	-0.00104	0.00379***	0.0199***	0.0320**	-0.0163***
	(-1.27)	(-0.32)	(3.11)	(4.25)	(2.14)	(-3.22)
Age	-0.00859***	-0.0142***	0.00582***	-0.0337***	-0.0336	0.0237***
	(-3.31)	(-2.62)	(2.95)	(-4.89)	(-1.60)	(3.64)
Lev	0.0222**	0.0467*	-0.00863	-0.0101	0.0227	0.0529***
	(2.40)	(1.97)	(-1.20)	(-0.42)	(0.36)	(2.79)
Roa	0.0302	0.0264	-0.0221	-0.0559	0.0599	0.0328
	(1.24)	(0.46)	(-1.11)	(-1.26)	(0.47)	(0.85)
Growth	0.0219***	0.0471***	-0.000159	0.0312***	0.0573***	-0.0150***
	(4.41)	(5.12)	(-0.04)	(4.18)	(3.03)	(-2.84)
Top1	0.00654	0.0203	-0.00524	-0.0304	0.0181	0.00368
	(0.57)	(0.83)	(-0.60)	(-0.81)	(0.20)	(0.10)
Balance	0.00110	0.00104	-0.00126	-0.00329	0.0137	0.000243
	(0.44)	(0.18)	(-0.62)	(-0.57)	(0.99)	(0.04)
Board	-0.0144**	-0.0191	0.00657	-0.0176	-0.0119	0.00570
	(-2.50)	(-1.56)	(1.55)	(-1.40)	(-0.50)	(0.49)
_cons	0.110***	0.110*	-0.132***	-0.280***	-0.611**	0.243**
	(3.65)	(1.69)	(-5.14)	(-2.90)	(-2.09)	(2.35)
Year	YES	YES	YES	YES	YES	YES
Ind	YES	YES	YES	YES	YES	YES
Area	YES	YES	YES	YES	YES	YES

iJETRM
International Journal of Engineering Technology Research & Management

N	1874	689	1185	1301	539	762
R^2	0.0981	0.195	0.101	0.106	0.184	0.148

t statistics in parentheses

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

Discussion on enterprise heterogeneity

Discussion on the heterogeneity of property right nature of enterprises

Considering China's special background of property right nature, the samples of heavily polluting enterprises and green enterprises are respectively grouped according to property right nature to test the policy effect difference that green finance pilot affecting investment efficiency of heavily polluting enterprises and green enterprises under different property right nature. From the grouping results of property right nature of heavily polluting enterprises in Table 6, the regression coefficients of Treat×Post of non-state-owned enterprises group are 0.00685 and -0.00544 respectively in column (4) and (6), which are significant at 10%, while column (1)-(3) of state-owned enterprises group are not significant. Similarly, the grouping results of property right nature of green enterprises in Table 7 show that the coefficients of Treat×Post of non-state-owned enterprises group are -0.0126 and 0.00993 respectively in column (4) and (6), which are significant at 10%. The regression coefficients of Treat×Post in column (5) is -0.0161, t value is -1.62, which is close to 10%. The above results show green finance pilot affecting investment efficiency of heavily polluting enterprises and green enterprises are all mainly reflected in non-state-owned enterprises, which verifies Hypothesis 2a and Hypothesis 2b.

Facing financing constraints caused by the inclination of green financial resources, state-owned enterprises with political assistances also bear greater social responsibility (Sun and Li, 2016), so green finance is more likely to cause financing constraints to non-state-owned heavily polluting enterprises (Cai et al., 2019), and the role of improving investment efficiency of non-state-owned green enterprises will also be more obvious than that of state-owned green enterprises that actively undertake social responsibility.

Table 6: Grouping results of property right nature of heavily polluting enterprises

Variable	State-owned enterprises			Non-state-owned enterprises		
	(1)	(2)	(3)	(4)	(5)	(6)
	IE	Overinv	Underinv	IE	Overinv	Underinv
Treat×Post	0.000771	-0.00222	-0.00193	0.00685*	0.00422	-0.00544*
	(0.20)	(-0.21)	(-0.61)	(1.86)	(0.54)	(-1.96)
_cons	0.0877***	0.127**	-0.0897***	0.102***	0.0997*	-0.155***
	(3.31)	(2.09)	(-4.19)	(4.00)	(1.78)	(-7.41)
Controls	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES
Ind	YES	YES	YES	YES	YES	YES
Area	YES	YES	YES	YES	YES	YES
N	2072	704	1368	2680	984	1696
R^2	0.0864	0.135	0.152	0.110	0.210	0.101

t statistics in parentheses

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

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International Journal of Engineering Technology Research & Management

Table 7: Grouping results of property right nature of green enterprises

Variable	State-owned enterprises			Non-state-owned enterprises		
	(1)	(2)	(3)	(4)	(5)	(6)
	IE	Overinv	Underinv	IE	Overinv	Underinv
Treat×Post	0.00596	0.0196**	-0.00457	-0.0126***	-0.0161	0.00993***
	(1.02)	(2.40)	(-0.88)	(-2.91)	(-1.62)	(2.90)
_cons	-0.0000366	0.337	0.0808	-0.216**	-0.388	0.123*
	(-0.00)	(1.55)	(0.70)	(-2.49)	(-1.44)	(1.69)
Controls	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES
Ind	YES	YES	YES	YES	YES	YES
Area	YES	YES	YES	YES	YES	YES
N	878	325	553	1938	793	1145
R^2	0.096	0.240	0.093	0.082	0.133	0.092

t statistics in parentheses

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

Discussion on the heterogeneity of shareholding ratio of institutional investors of enterprises

This paper groups the samples of heavily polluting enterprises and green enterprises respectively according to the mean value of shareholding ratio of institutional investors to test the differences of green finance pilot on enterprises investment efficiency under different shareholding ratios of institutional investors. Table 8-9 lists the grouping results of shareholding ratio of institutional investors of heavily polluting enterprises and green enterprises respectively. From the grouping results of heavily polluting enterprises in Table 8, the regression coefficients of Treat×Post in column (1)-(3) of high shareholding ratio of institutional investors group are not significant. While in the low shareholding ratio of institutional investors group, the coefficients of Treat×Post in column (4) is 0.00432 and t value is 1.62, which is close to the significance level of 10%. And the regression coefficients of Treat×Post in column (6) is -0.00444, which is significant at 10%, indicating that the inhibitory effect of green finance pilot on investment efficiency and the aggravating effect on insufficient investment of heavily polluting enterprises are mainly reflected in enterprises with low shareholding ratio of institutional investors, which verifies Hypothesis 3a. The results in Table 9 show that in high shareholding ratio of institutional investors group, the coefficients of Treat×Post are -0.0100 and 0.00928 respectively in column (1) and (3), which both are significant at 1%. While the coefficients of Treat×Post of low shareholding ratio of institutional investors group in column (4)-(6) are not significant.

The above results indicate that the on effect of green finance pilot promoting investment efficiency of green enterprises is mainly reflected in enterprises with high shareholding ratio of institutional investors, and it is mainly to improve insufficient investment of green enterprises in enterprises with high shareholding ratio of institutional investors, which verifies Hypothesis 3b. Enterprises with higher shareholding ratio of institutional investors have higher cost advantages, governance level and professional level, which can improve the quality of information disclosure and restrain managerial opportunism, and then improve inefficient investment of enterprises (Chen et al., 2017; Ward et al., 2020).

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International Journal of Engineering Technology Research & Management

Table 8: Grouping results of shareholding ratio of institutional investors of heavily polluting enterprises

Variable	High shareholding ratio of institutional investors			Low shareholding ratio of institutional investors		
	(1) IE	(2) Overinv	(3) Underinv	(4) IE	(5) Overinv	(6) Underinv
Treat×Post	0.00689	0.00560	-0.00306	0.00432	-0.000740	-0.00444*
	(1.36)	(0.52)	(-0.91)	(1.62)	(-0.10)	(-1.66)
_cons	0.124***	0.129**	-0.107***	0.112***	0.0742	-0.141***
	(4.72)	(2.15)	(-5.37)	(3.83)	(1.22)	(-5.13)
Controls	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES
Ind	YES	YES	YES	YES	YES	YES
Area	YES	YES	YES	YES	YES	YES
N	2066	745	1321	2686	943	1743
R^2	0.113	0.194	0.153	0.080	0.184	0.103

t statistics in parentheses

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

Table 9: Grouping results of shareholding ratio of institutional investors of green enterprises

Variable	High shareholding ratio of institutional investors			Low shareholding ratio of institutional investors		
	(1) IE	(2) Overinv	(3) Underinv	(4) IE	(5) Overinv	(6) Underinv
Treat×Post	-0.0100***	-0.00849	0.00928***	-0.00871	-0.00602	0.00827
	(-2.60)	(-1.03)	(2.80)	(-1.22)	(-0.40)	(1.53)
_cons	-0.0849	-0.210	0.0515	-0.277**	-0.370	0.238**
	(-1.08)	(-0.70)	(0.75)	(-2.26)	(-1.36)	(2.25)
Controls	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES
Ind	YES	YES	YES	YES	YES	YES
Area	YES	YES	YES	YES	YES	YES
N	1456	579	877	1360	539	821
R^2	0.081	0.170	0.082	0.100	0.157	0.117

t statistics in parentheses

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

Robustness test

In order to ensure the reliability of the above research results, the robustness test is carried out by replacing investment efficiency measurement method, replacing matching method and placebo test, as shown in Table 10. In view of space constraints, only the robustness test of green enterprises is mainly listed to discussed. First of all, reference the selection of relevant variables in measuring enterprise investment efficiency by Xiao (2010), the enterprise investment efficiency is re-calculated. The regression results of Treat×Post in column (1)-(3) are all significant, indicating that green finance pilot

significantly promotes investment efficiency by improving insufficient investment and inhibiting excessive investment of green enterprises, which is consistent with Hypothesis 1c and Hypothesis 1d. Secondly, select the kernel matching to re-match samples, and then combined with DID model to verify whether there are differences under different matching methods. From column (4)-(6), the regression coefficients of Treat×Post are significant at 5% or 10% respectively, which are basically the same as the above results. Finally, a placebo test is conducted to verify whether green finance pilot as virtual policy affects enterprise investment efficiency. That is, assuming that the occurrence time of the policy is 2016, 2013-2015 as the period before green finance pilot and 2016-2020 as the period after green finance pilot. The coefficients of Treat×Post in column (7)-(9) are not significant, which means that affecting enterprise investment efficiency does not exited before the implementation of green finance pilot, that is, green finance pilot does significantly affect IE, Overinv and Underinv.

Table 10: Results of robustness test

Variable	Replacing investment efficiency			Kernel matching			Placebo test		
	(1)	(2)	(3)	(4)	(5)	(6)	(7	(8)	(9)
	IE	Overinv	Underinv	IE	Overinv	Underinv	IE	Overinv	Underinv
Treat×Post	-0.0140***	-0.0222**	0.00888**	-0.00739**	-0.0176**	0.00513*	0.00304	0.0116	0.00513
	(-3.12)	(-2.38)	(2.37)	(-2.07)	(-2.16)	(1.83)	(0.64)	(0.94)	(1.35)
_cons	-0.298***	-0.349	0.243***	-0.144**	-0.113	0.111*	-0.196**	-0.373	0.229**
	(-2.74)	(-1.03)	(2.65)	(-2.05)	(-0.65)	(1.65)	(-2.03)	(-1.36)	(2.17)
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
N	1295	538	757	2793	1110	1683	1301	539	762
R^2	0.108	0.181	0.090	0.081	0.045	0.079	0.099	0.176	0.141

t statistics in parentheses

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

Conclusion and implication

Research conclusions

Exploring the relationship between green finance pilot and enterprise investment efficiency is of great significance to evaluate the effectiveness of green finance pilot, coordinate the contradiction between economic development and environmental protection, and achieve a win-win situation of pollution control and efficiency improvement. Based on the panel data of A-share heavily polluting enterprises and green enterprises from 2013 to 2020, PSM-DID model is constructed to explore the impact of green finance pilot as the quasi-natural experiment on investment efficiency of heavily polluting enterprises and green enterprises, and the different impact under different property right nature and shareholding ratios of institutional investors. The main conclusions are as follows. ①Green finance pilot significantly reduces investment efficiency of heavily polluting enterprises, which is mainly manifested in aggravating insufficient investment. And green finance pilot effectively promotes investment efficiency of green enterprises, which is through alleviating insufficient investment and inhibiting excessive investment. ②The inhibitory effect of green finance pilot on investment efficiency of heavily polluting enterprises and the promoting effect on investment efficiency of green enterprises are all reflected in non-state-owned enterprises. ③The inhibitory effect of green finance pilot on investment efficiency of heavily polluting enterprises by aggravating insufficient investment is mainly

reflected in enterprises with low shareholding ratio of institutional investors, and the promoting effect on investment efficiency of green enterprises is mainly reflected in enterprises with high shareholding ratio of institutional investors.

Policy implications

Based on the above results, this paper draws the following enlightenment: ①For green enterprises, green finance pilot can effectively promote investment efficiency, alleviate insufficient investment and inhibit excessive investment of green enterprises through resource allocation and supervision mechanism, so continuing to strengthen the synergy of market regulation and supervision mechanism, increase the construction of green finance pilot area is necessary, which is conducive to carry out a wider range of promotion to fully realize the dual role of pollution control and efficiency improvement played by green finance. ②For heavily polluting enterprises, green finance pilot has a significant aggravating effect of financing constraints on heavily polluting enterprises, resulting in aggravating insufficient investment and reducing investment efficiency, which means the information disclosure mechanism and supervision mechanism of green finance have not affected the change of heavily polluting enterprises in excessive investment. Therefore, strengthening the reform and improvement of information disclosure mechanism and supervision mechanism, forcing heavily polluting enterprises with excessive investment to adjust their investment structure for financial institutions is important. In addition, for heavily polluting enterprises that actively seek green transformation, it is necessary to increase financial support to help them improve investment efficiency while pursuing green transformation. ③There are significant differences in the impact of green finance pilot on enterprise investment efficiency under different property right nature and shareholding ratios of institutional investors. Therefore, when formulating green finance policies, the government should comprehensively consider the heterogeneity of different characteristics of enterprises and formulate differentiated systems. For example, when improving green financial support for non-state-owned enterprises and enterprises with high shareholding ratio of institutional investors, increase green financial support and incentive system for enterprises with shareholding ratio of institutional investors, so as to help enterprises to improve investment efficiency while pursuing green development.

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iJETRM
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