Exploring the Impact of Green Finance on Corporate Green Productivity: An Empirical Analysis from China with PSM-DID Model

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Abstract. The critical role of green finance cannot be ignored in the current financial system. To explore the practical effects of China's green finance policies, this study takes panel data of A-share listed companies from 2014 to 2022 as the sample, takes listed companies in 8 GFRI pilot zones as the research objects, and uses the PSM-DID model to study the relationship between green finance policies and green production of listed companies. The findings show that green finance benefits enterprises in the long run as well as the short term, while the former is more pronounced. Furthermore, green finance policies can have immediate impact on enterprises, boosting their green productivity by 0.53%. This study helps to provide theoretical framework for the Chinese government on how to optimize the green finance system based on the GFRI pilot zones and promote green production in enterprises.

Keywords: green finance; GFRI pilot zone; green productivity; PSM-DID

1 Introduction

China's economy has witnessed rapid and high-quality development over the past few decades, playing an increasingly critical role in the global economy. However, a series of environmental problems including air pollution, water scarcity, and land degradation have also been brought about by the rapid economic development [1], which seriously threaten the goal of sustainable development. In response to these challenges, China has begun to focus on establishing a green finance system, optimizing the allocation of resources through innovations in fiscal policy and financial instruments, thereby promoting a low-carbon and circular green economy.

In 2015, the launch of the Overall Plan for Ecological Civilization System Reform marked the comprehensive promotion of China's top-level design and institutional system construction of ecological civilization. In the same year, the following financial work conference also mentioned that the current social resource carrying capacity is approaching the upper limit [2], and financial transformation is imperative. The People's Bank of China and seven other ministries jointly released the Guiding Opinions on Building a Green Finance System in August of the following year. They suggested that the chief purpose of building a green finance system should be to encourage and mobilize more social capital to invest in the green industry. In June 2017, 8 green finance reform and innovation pilot zones (GFRI pilot zones) were settled in four

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provinces and one autonomous region (Fig. 1), which marks the transition of the green finance system from theory to practice.

Fig. 1. Spatial Distribution of GFRI Pilot Zones in China.

Existing research on green finance generally focuses more on sustainable development, carbon emissions and ESG. Fu et al. pointed out that an effective regulatory framework, influential role of institutional ownership, integration of all three ESG factors, and environmental risk management are crucial for promoting sustainable green finance [3]. By conducting the direct, indirect, and threshold effects examinations, Gan and Voda discovered that although green finance can increase carbon emission intensity (CEI) through structural change, the economies of scale and green technological innovation brought about by green finance have dynamic and nonlinear inhibitory impacts on CEI [4]. Apart from that, Wu and Liew concluded that Green finance policies can positively affect the green performance of listed companies, with state-owned enterprises, heavily polluting enterprises, and low-carbon pilot cities performing better in promoting ESG ratings through green finance [5].

Compared to traditional finance, green finance places more emphasis on environmental issues, which is precisely what China needs during the critical period of financial reform and transformation. At the same time, different from the bottom-up financial reform in the West, China's financial reform has demonstrated its distinct characteristics, namely top-down reform. Nowadays, China has achieved significant achievements in building a green financial system.

Lv and Zhou found that for heavily polluting listed businesses, GFRI may stimulate green investment (GI) by raising reputation costs and lending size, and that improved GI can further enhance enterprise value after GFRI implementation [6]. Xi et al. analyzed panel data from 19 listed banks in China during a 10-year period between 2008 and 2017 and discovered that the green credit ratio will improve listed firms' financial performance, even though it only looks at the current or one period lagged. Meanwhile, financial performance of listed banks can be considerably improved by using green reputation as an indicator to evaluate the quality of green credit [7].

However, the existing literature about green finance focuses more on the link between GFRI pilot zones and heavily polluting enterprises, or green products such as green credit and green

bonds, rather than targeting listed companies affected by policies. Although some articles have focused on the importance of constructing GFRI pilot zones, few have combined green performance of listed companies with the national construction of the whole green finance system. The lag in investigating into regional green finance systems will hinder the construction and promotion of green finance systems, leading to more practical difficulties for enterprises in carrying out green production activities. Therefore, it is crucial to conduct research on green finance and green productivity based on the GFRI pilot zones.

Considering the constraints in previous works, this study's contribution is as follows. Firstly, this paper explores the inherent connection between establishing a green finance system and green production in firms from multiple perspectives. From a macro perspective, this can provide a theoretical framework for the revision and promotion of the green finance system; from the micro level, this can provide reference opinions for enterprises on how to better carry out green production based on green finance policies. Secondly, this paper comprehensively considers various indicators of listed companies from multiple dimensions such as scale, financial indicators, corporate governance, and financing constraints, making the research results more realistic, reasonable, and reliable. Thirdly, this study was conducted on listed companies in the PTFZ pilot zone with PSM-DID model. The sample bias and confounding variables influences were corrected through the propensity score matching (PSM), and a control group was then selected from non-pilot areas by a differences-in-differences (DID) model, which helps to address potential endogeneity issues and make the empirical results more authentic and reliable.

The structure of the remaining parts is as follows: “Literature Review and Hypothesis” presents the relevant literature and the hypothesis to be verified in this study; “Empirical Results” contains the setting, use, analysis, and testing of the PSM-DID model; “Conclusions and Prospects” starts from both model and policy perspectives, providing references for the Chinese government to better construct a green finance system.

2 Literature Review and Hypothesis

With the increasing global attention to sustainable development goals, green finance, as one of the key tools to achieve these goals, has received widespread attention from the academic community for its long-term effects.

Divergent views exist among academics regarding the consequences of green financing. Zhao and Xing conducted time series analysis to study the China's sustainable development index from 1990 to 2020, and found that with a 1% in green finance market, the China Sustainable Development Index (SDI) was expected to increase by 0.31% and 0.69% respectively in the short and long term [8]. From a financial performance perspective, the research from Yu and Jin indicates that a company's green strategy promotes long-term performance, but hinders short-term performance[9]. Based on this, we propose a group of competitive hypothesis:

H1a: Green finance policies have both long-term and short-term impacts on enterprises.

H1b: Green finance policies only take long-term impact on enterprises.

In the course of green finance policies implementation, the efficiency of information dissemination is crucial. In other words, an effective information dissemination mechanism ensures that policy content can be quickly and accurately conveyed to target enterprises, thereby avoiding the problem of information lag. However, there are still problems with green finance policies nowadays, such as a lack of good policy support and incomplete legal construction, a lack of incentive and constraint mechanisms, and average guidance from financial institutions[10]. This to some extent affects the corresponding enthusiasm of local enterprises for policies. Therefore, we propose hypothesis 2 of this study:

H2: Local enterprises respond actively and rapidly to green finance policies.

In fact, the response of local enterprises to green finance policies ultimately needs to be translated into productivity. According to Chen et al., green finance has considerable impacts on green productivity[11]. Analogously, Lee and Lee predict that the evolution of green finance can greatly improve the green productivity level[12]. Therefore, we propose hypothesis 3 of this study:

H3: Green finance policies have promotional effect on the green productivity of enterprises.

3 Data and Methodology

3.1 Sample Selection and Data Sources

This article selects relevant economic data of A-share listed firms in China from 2014 to 2022. When selecting samples, the following steps should be taken: 1. Exclude listed enterprises in the finance industry; 2. Exclude companies identified as ST, * ST, PT, or insolvent, and delete observations with missing data. Due to the time span of 2014-2022 selected in this article, only companies listed before 2013 were selected for research, and 18,453 valid observations were ultimately obtained. The data on the scale, financial status, corporate governance, and financing constraints of listed companies are sourced from the CSMAR database, while indicators related to green production are sourced from the China Environmental Statistics Yearbook.

3.2 Model Setting

This study refers to the study by Xiong et al. on the underlying connections between green finance and Green Total Factor Productivity (GTFP), which indicates that green finance policies are related to GTFP, and green finance can significantly foster the GTFP level of those listed companies[13]. Based on this, this article uses GTFP as the dependent variable to quantify the green productivity of listed companies. We also generate the explanatories as follows:

$$\text{treat} = \begin{cases} 1, \text{policy affected} \\ 0, \text{non} - \text{policy affected} \end{cases} \quad \text{time} \begin{cases} 1, \text{year } 2018 - 2022 \\ 0, \text{year } 2014 - 2017 \end{cases} \tag{1}$$

Based on this, we apply propensity score matching (PSM) to meet the assumption of common trend in the DID model, while avoiding the influence of other non-time-varying and uncontrollable factors on the dependent variable. Based on the sample data after PSM, we establish the DID model to study the relationship between green finance policies and green production of listed companies. The precise DID model setting is as follows:

$$GTFP_{i,t} = \alpha + \beta\, treat_i \times time_t + \mu_i + \lambda_t + \gamma\, X_{i,t} + \varepsilon_{i,t} \quad (2)$$

where μ_i represents the individual fixed effect, λ_t represents the time fixed effect, $X_{i,t}$ represents the set of control variables and $\varepsilon_{i,t}$ is a random error term. Specifically, the control variables include Size, Lev, ROA, CF, Grow, Indep, Dual, TOP3, INST and KZ, which are meticulously explained in Table 1.

Table 1. Variable Description.

Type	Variable	Explanation
Dependent	GTFP	Green Total Factor Productivity
Core Explanatory	treat×time	Cross-multiplying term of treat and time
Controls	Size	Natural logarithm (ln) of total assets
	Lev	Financial leverage: Asset-liability ratio
	ROA	Profitability: Return on assets
	CF	CFO / Total assets
	Grow	Growth rate of operating revenue
	Indep	Proportion of independent directors in the board
	Dual	If the chairman of the board and general manager are the same person, 1, otherwise 0
	TOP3	Shares held by the top 3 shareholders / Total shares
	INST	Shares held by institutional investors / Total number of share capital
	KZ	KZ financing constraints index

4 Empirical Results

4.1 Propensity Score Matching (PSM)

PSM uses covariates such as company size, financial leverage, and ROA to estimate propensity scores with Logit model, which is as follows:

$$P(X_i) = P(treat_i = 1 \mid X_i) = \frac{\exp(\gamma X_i)}{1 + \exp(\gamma X_i)} \quad (3)$$

After completing the selection of matching variables based on the results of Logit regression, this article uses the "nearest neighbor 1:1 matching" method to match the treatment group (treat=1) with the control group (treat=0). After matching, 18,278 observations were matched. From the results of t-test (Table 2), it can be clearly seen that except for ROA, Grow, and Dual, the other control variables do not meet the test of no significant difference between experimental group and control group before matching (p value < 10%). However, after propensity score matching, the p-value test results of all control variables are greater than 10%, indicating that the results of propensity score matching are reliable. Meanwhile, the absolute values of the standardized deviation after matching each covariate are all less than 10%. There is a significant decrease compared to before matching.

Table. 2. PSM Balance Test Result.

Variable	Matched Unmatched	Mean		% bias	% reduct | bias |	t-test	
		Treated	Control			t	p > | t |
Size	U	22.704	22.549	12.0	62.7	2.71	0.007
	M	22.704	22.761	-4.5		-0.71	0.479
Lev	U	0 .42692	0.44196	-7.9	71.8	-1.75	0.080
	M	0.42692	0.43115	-2.2		-0.36	0.715
ROA	U	0 .0347	0.02941	5.1	63.8	1.52	0.128
	M	0.03472	0.0328	1.9		0.31	0.759
CF	U	0.05553	0.04737	11.4	69.8	2.61	0.009
	M	0.05553	0.05306	3.4		0.58	0.562
Grow	U	0.2035	0.27448	-2.2	-43.4	-0.39	0.698
	M	0.2035	0.30525	-3.2		-0.61	0.543
Indep	U	0.38571	0.37685	13.9	95.1	3.56	0.000
	M	0.38571	0.38614	-0.7		-0.11	0.916
Dual	U	0.22302	0.23803	-3.6	-19.8	-0.82	0.413
	M	0.22302	0.24101	-4.3		-0.71	0.478
TOP3	U	0.47912	0.45526	14.5	51.2	3.62	0.000
	M	0.47912	0.46748	7.1		1.16	0.246
INST	U	0.48321	0.44753	14.3	81.6	3.53	0.000
	M	0.48321	0.47666	2.6		0.44	0.662
KZ	U	1.1492	1.5057	-18.1	91.7	-4.15	0.000
	M	1.1492	1.1196	1.5		0.24	0.814

From Fig. 2, it can be seen that the probability distribution of propensity scores for the first two groups of samples matched is significantly different, and there is a significant difference in value of kernel density; after matching, the distribution deviation of the propensity scores of the two groups of samples was corrected, with a high degree of overlap, indicating that the common trend assumption was met, further confirming the effectiveness of the matching results.

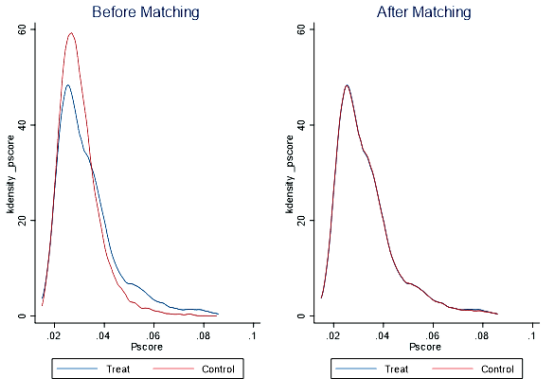

Fig. 2. Kernel Density Estimation.

4.2 Parallel trend test

The parallel trend hypothesis is tested through regression analysis by multiplying the time dummy variable before policy implementation with the policy dummy variable in the GFRI pilot zones.

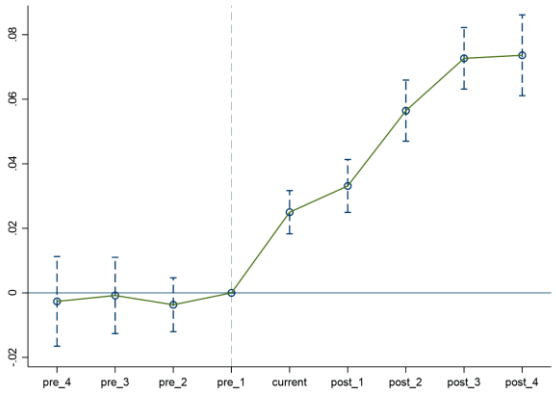

Fig. 3. Result of Parallel Trend Test.

Usually, when conducting parallel trend tests, the processing of the previous period needs to be omitted, so the coefficient of pre_1 (year 2017) is 0. As is seen in Fig. 3, before the year of policy implementation (i.e. current), a parallel trend test is conducted with a confidence interval containing 0 (i.e. pre_4 ~ pre_2), indicating that the policy is not effective before the policy implementation point. In the period of policy implementation and after (i.e. post_1 ~ post_4), the confidence interval does not include 0, indicating that it is significant and the green, that is, the policy has played an increasingly significant promoting role and the green finance policy is effective in supporting green production in enterprises. In addition, after the the green finance policy is issued, the dynamic effects of the policy in various years have shown a continuous upward trend since 2018, which illustrates the sustainability, long-term and short-term

effectiveness of the policy. Therefore, hypothesis H1a and H2 are accepted, while hypothesis H1b is refused.

4.3 Differences-In-Differences (DID)

This article incorporates the samples after PSM into the DID analysis framework, and uses the model (Eq. 2) to test the impact of constructing a green finance system on the green productivity of listed companies.

Table. 3. PSM-DID Regression Result.

GTFP	Coef.	Robust Std. Err.	t	p > | t |	[95% Conf. Interval]	
did	0.0532308	0.0052216	10.19	0.000	0.0429909	0.0634706
Size	0.0947025	0.0023582	40.16	0.000	0.090078	0.0993269
Lev	-0.1938032	0.010812	-17.92	0.000	-0.2150059	-0.1726004
ROA	-.0637606	0.0094876	-6.72	0.000	-0.0823661	-0.0451552
CF	0.3278781	0.0158299	20.71	0.000	0.296835	0.3589211
Grow	-0.0003005	0.0005259	-0.57	0.568	-0.0013319	0.0007309
Indep	0.079463	0.0186004	4.27	0.000	0.0429868	0.1159392
Dual	-0.0026503	0.0023714	-1.12	0.264	-0.0073008	0.0020002
TOP3	-0.1852341	0.0150871	-12.28	0.000	-0.2148206	-0.1556477
INST	-0.0646905	0.0093942	-6.89	0.000	-0.0831129	-0.046268
KZ	0.0245474	0.000793	30.96	0.000	0.0229923	0.0261024
_cons	-0.9794684	0.0546945	-17.91	0.000	-1.086727	-0.8722103

where did=treat×time

It is not difficult to see from Table 3 that the double difference coefficient of DID is about 0.53, which falls within the 95% coefficient interval and is significant, indicating that the policy has played a significant promoting role.

This result indicates that the green finance system has promotional effect on the green production of enterprises. Specifically, after the settlement of the GFRI pilot zones in China, the average green productivity of the experimental group cities increased by about 0.53%. The construction of the green finance system in China has a strong empowering influence on the green production of companies. Therefore, hypothesis H3 is accepted.

4.4 Placebo Test

In the testing of the DID model, a counterfactual placebo test should be used to determine whether it is influenced by policy rather than other factors, in order to guarantee the reliability of this study. To avoid the problem of missing variables, we conduct 500 random sampling experiments to determine whether there is a significant difference between the coefficients and the baseline estimation results, and conduct regression with DID model.

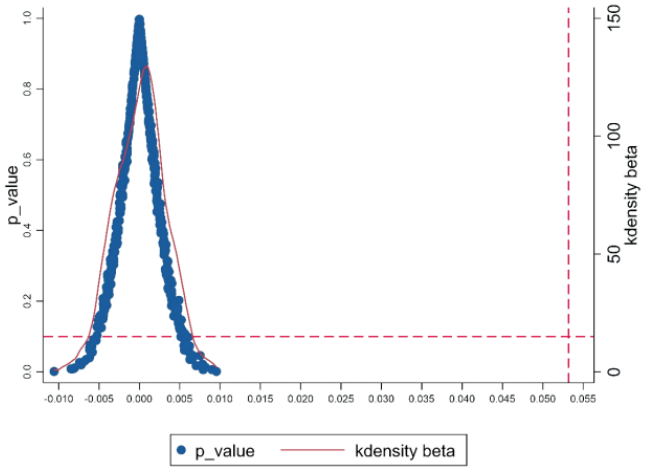

Fig. 4. Result of Placebo Test.

Fig. 4 shows that the vast majority of effective observations are distributed around 0 on the horizontal axis, implying that there is no significant missing variables in the DID model setting. Therefore, the benchmark regression (Eq.2) of this paper passes the placebo test and further demonstrates the robustness of the regression results.

5 Conclusions and Prospects

5.1 Conclusions

This article examines the effectiveness and achievements of developing a green finance system in China, drawing on the State Council's policy of establishing GFRI pilot zones in four provinces and one autonomous region. By comparing the pilot zones with non-pilot zones, as well as the relationship between green finance and enterprise green productivity before and after policy implementation, this paper investigates the connection between green finance and green production capacity in Chinese enterprises.

Through PSM-DID model, this article derives that China's green finance system has a promoting effect on the green productivity of enterprises. By establishing GFRI pilot zones under the green finance system, the average green productivity of listed companies will increase by 0.53%, which indicates the effectiveness of building a green finance system. This empirical evidence underscores the tangible benefits of the green finance system in fostering sustainable business operations and contributing to the broader goals of ecological conservation and environmental protection.

Moreover, this study has also examined the evolution of the intrinsic link between green finance and enterprise green productivity pre and post-implementation of the policy. The analysis indicates a discernible shift towards more environmentally conscious business practices, highlighting the transformative power of well-designed financial policies in driving green innovation and sustainable development.

5.2 Prospects

Based on the conclusions above, this article recommends the following policy implications:

Firstly, the Chinese government should expand and improve the GFRI pilot zones in order to create a more effective green finance system. Serving as an important platform for green finance practice, the success of the GFRI pilot zones has a demonstrative effect on green finance promotion and implementation in China, and even globally.

Secondly, in order to observe the heterogeneity of green finance across different regions, the Chinese government should expand the number of GFRI pilot zones within the existing provinces, or in the provinces located in central and northeastern China, so that more listed companies can receive policy coverage and we can better inspect the response level of different regions to green finance policies.

The current results indicate that although the GFRI pilot zone policy has contributed to the advancement of the green finance system to some extent, its promotional effect on enterprise green productivity has not yet achieved the expected effect. As the direct beneficiaries and implementers of green finance, improvement in green productivity in enterprises is crucial to attaining sustainable development.

Based on this, it is not hard to conclude that strengthening the construction of green finance standard system is the key to further building a green finance system. The Chinese government should promote the development of unified green finance project evaluation standards and certification systems to ensure the authenticity and effectiveness of green finance projects. Through clear evaluation criteria, enterprises and investors can have a clearer understanding on the further value of green finance, thereby stimulating more green financial activities.

References

[1] Gan, T., Yang, H., & Liang, W. (2021). How do urban haze pollution and economic development affect each other? Empirical evidence from 287 Chinese cities during 2000–2016. Sustainable Cities and Society, 65, 102642. https://doi.org/10.1016/j.scs.2020.102642.

[2] Huang, H., & Zhang, J. (2021). Research on the Environmental Effect of Green Finance Policy Based on the Analysis of Pilot Zones for Green Finance Reform and Innovations. Sustainability, 13(7), 3754. https://doi.org/10.3390/su13073754.

[3] Fu, C., Lu, L. & Pirabi, M. Advancing green finance: a review of climate change and decarbonization. DESD 2, 1 (2024). https://doi.org/10.1007/s44265-023-00026-x.

[4] Gan, C., & Voda, M. (2023). Can green finance reduce carbon emission intensity? Mechanism and threshold effect. Environmental Science and Pollution Research, 30(1), 640–653. https://doi.org/10.1007/s11356-022-22176-9.

[5] Wu, J., & Liew, C. Y. (2023). Green finance and environmental, social, and governance: evidence from Chinese listed companies. Environmental Science and Pollution Research International, 30(51), 110499–110514. https://doi.org/10.1007/s11356-023-30139-x.

[6] Lv, D., & Zhou, C. (2023). Can the Green Finance Reform and Innovation Improve Green Investment of Heavily Polluting Enterprises? Sustainability, 15(15), 11677. https://doi.org/10.3390/su151511677.

[7] Xi, B., Wang, Y., & Yang, M. (2022). Green credit, green reputation, and corporate financial performance: evidence from China. Environmental Science and Pollution Research, 2401–2419. https://doi.org/10.1007/s11356-021-15646-z.
[8] Zhao, Z., Xing, Z. Corporate management, green finance, and sustainability. Humanities and Social Science Communications 11, 6 (2024). https://doi.org/10.1057/s41599-023-02490-4.
[9] Yu, W., Jin, X. Long-term and short-term effects of green strategy on corporate performance: evidence from Chinese listed companies. Environmental Science and Pollution Research 29, 24112–24130 (2022). https://doi.org/10.1007/s11356-021-17548-6.
[10] Zhang, P. (2021). Investigation and Research on the Effect and Evaluation of Green Finance Policy Implementation. Finance, 11(06), 506–511. https://doi.org/10.12677/fin.2021.116055.
[11] Chen, J., Abbas, J., Najam, H., Liu, J., & Abbas, J. (2023). Green Technological Innovation, green Finance, and Financial Development and their role in green Total Factor Productivity: Empirical insights from China. Journal of Cleaner Production, 382, 135131. https://doi.org/10.1016/j.jclepro.2022.135131.
[12] Lee, C.-C., & Lee, C.-C. (2022). How does green finance affect green total factor productivity? Evidence from China. Energy Economics, 107(105863), 105863. https://doi.org/10.1016/j.eneco.2022.105863.
[13] Xiong Y., Dai Y. & Wang Y. (2023). Research on the Impact of Green Finance on Green Total Factor Productivity Exploration of Financial Theory (05), 57-68 Doi: 10.16620/j.cnki.jrjy.2023.05.007.