

The Impact of Green Financial Policies on Debt Financing Costs of Clean Energy Enterprises - A Quasi-Natural Experiment Based on China's Green Financial Reform and Innovation Pilot Zone

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Abstract. Against the background of accelerating low-carbon economic transformation globally, China set up the Green Finance Reform Pilot Zone in 2017 with the goal of dual-carbon as its orientation. Based on the double-difference model (DID), this article empirically analyses the impact of green financial policies on the debt financing cost of clean energy enterprises by using China's A-share listed clean energy companies as the research samples from 2013-2023. The formation of China's Green Finance Pilot Reform Zone operated as a quasi-natural experiment starting in 2017. The study reveals that green finance policies decrease the debt financing costs of clean energy companies significantly. The empirical results satisfy both the parallel trend assumption and placebo tests. Heterogeneity analysis shows that the effect of the policy is more significant in small-scale, profitable and private enterprises, but limited in large-scale, loss-making and state-owned enterprises, which is mainly due to the differences in financing ability, risk sensitivity and governance mechanism. Based on this, this paper proposes to deepen the green finance reform, implement differentiated support policies, guide enterprises to take the initiative to dock the policy dividends, and strengthen green technology innovation and information disclosure. This study offers empirical insights and actionable guidance for enhancing the green finance policy framework and advancing the long-term growth of the clean energy sector.

Keywords: Green Financial Policies, Green Financial Reform Pilot Zones, Corporate Debt Financing Costs, Double Difference Models.

1. Introduction

The accelerated global low-carbon transformation demands energy system restructuring and carbon emission cuts, as required by the Paris Agreement's temperature goals. Promoting sustainable economic development is now an international consensus [1]. Responding to this, China proposed its dual-carbon strategic goal. It also constructed a world-leading green finance policy system, positioning the clean energy industry as the core engine for low-carbon transition. To achieve dual-carbon, China established Green Finance Reform Pilot Zones across five provinces and eight cities in 2017. These zones aim to guide capital towards green, low-carbon, and environmentally friendly activities through financial innovation and policy support.

As an important objective of green finance, clean energy firms are deeply related to the policies of the pilot zone. Moreover, the policy effect on corporate borrowing costs serves as a critical measure for evaluating the pilot zone's success. Although the pilot zone initially focused on regional pilots, its experience provides critical insights for scaling up green finance initiatives across China.

However, existing research predominantly examines the macro-level impact of green finance policies on the entire industry, while micro-empirical studies specifically targeting clean energy enterprises remain relatively scarce. Crucially, research quantifying the impact of these policies on clean energy firms' debt financing costs and their underlying mechanisms remains underdeveloped. Therefore, this article takes clean energy firms as its research object. It empirically examines how green finance policies affect their debt financing costs using the double difference model (DID). Further-more, it analyzes heterogeneity based on enterprise ownership, scale, and profitability. This study aims to provide a theoretical basis and practical reference for improving China's green finance

policy system. It further aims to foster environmentally responsible growth in renewable energy sectors while expediting realization of the dual-carbon objectives via public-private partnerships.

The paper begins with a literature review on green finance policy, financing cost determinants, and policy-debt financing cost links. It then introduces the DID methodology, followed by theoretical analysis and hypothesis development. Subsequent sections present empirical results, robustness checks (including parallel trends and placebo tests), and heterogeneity analysis. Based on these findings, the study draws conclusions and proposes recommendations. The paper concludes with a summary of the entire work.

2. Literature Review

Green finance, as an important tool for addressing climate change and promoting sustainable development, has received extensive attention in recent years from both the academic and policy communities. Some scholars have systematically analyzed 126 definitions of green finance and concluded that environment and finance are the most central dimensions in the definitions, emphasizing that green finance achieves the core objective of environmental protection through capital allocation [2]. At the level of policy effect, some scholars have proposed that green finance policies force heavy polluting enterprises to assume social responsibility and thus reduce corporate financing constraints [3]. Some scholars have also proposed that green financial policy can promote green innovation by alleviating financial mismatch and improving the quality of environmental information disclosure [4].

As an important factor affecting the efficiency of capital allocation and the sustainable development of enterprises, the research on the factors affecting the cost of enterprise financing has received extensive attention. From the perspective of micro enterprise characteristics, some scholars believe that enterprise scale, solvency, profitability and other factors will affect the cost of debt financing [5]. For example, the larger the enterprise scale, the stronger the scale effect, which enhances the credit rating and reduces the cost of enterprise debt financing. From the perspective of macro policy, some scholars suggest that industrial policy also affects the cost of debt, which enhances corporate financing capacity by reducing information asymmetry, and industries supported by policy are more likely to obtain low-interest loans [6].

Research presents varied findings on green finance pilot zones' impact. Some studies indicate these zones significantly lower debt financing costs for environmental protection enterprises by enhancing commercial credit and reducing information asymmetry [7]. However, other research finds the policy expands green enterprises' financing scale without significantly reducing costs, suggesting support manifests through resource allocation rather than direct subsidies [8]. Additional studies show polluting enterprises face significant financing scale reductions but no substantial cost increases, reflecting policy constraints focused on incremental restriction over stock penalty [9]. Further evidence notes sustained reductions in retail enterprises' debt financing costs due to improved credit levels [10].

3. Double Difference Model

This research employs the Difference-in-Differences (DID) methodology, an econometric method based on a quasi-natural experiment, which is mainly used to assess the causal effects of a policy or event on the treatment group and control group [11]. The core idea is to eliminate time trends and inherent differences between groups through two differencing: the first differencing: compares pre-post policy changes in the treatment group (removing time trends); and the second differencing: uses the control group's temporal change as a counterfactual benchmark, eliminating inherent differences between groups.

DID models are widely used in public policy, economics, sociology and medicine. The following equation shows the traditional double difference model:

$$y_{it} = \gamma_0 + \gamma_1 treat_i + \gamma_2 post_t + \gamma_3 treat_i \times post_t + \gamma_4 X_{it} + \varepsilon_{it} \quad (1)$$

where y_{it} denotes the observation of individual i at time t . $treat_i$ denotes the treatment group dummy variable. $post_t$ represents the temporal indicator, while $treat_i \times post_t$ captures the treatment-time joint effect. X_{it} denotes the set of control variables and ε_{it} denotes the random error term.

4. Research Hypotheses and Research Design

4.1. Theoretical Analysis and Research Hypothesis

Green finance policies substantially decrease corporate debt financing costs via three primary mechanisms. First policy incentives and low-cost funding play a crucial role as structural monetary instruments supply financial institutions with economical capital which allows them to offer preferential loans for green initiatives. Businesses actively modernize their operations to comply with policy requirements and secure these financial advantages. Second risk-sharing arrangements contribute significantly where innovative insurance solutions alleviate uncertainty-related financing demands while government subsidies transfer risks externally thus reducing lenders' risk premi-ums for environmentally friendly projects. Third improved transparency matters greatly since standardized classification systems and disclosure protocols diminish information gaps thereby boosting institutional confidence and decreasing financing costs. Consequently, this study proposes the following hypotheses:

H1: Green finance policies help reduce the cost of debt financing for clean energy companies.

4.2. Research Design

4.2.1. Model construction

This study utilizes China's 2017 Green Finance Reform Pilot Zone initiative as a poli-cy-driven natural experiment, designating clean energy enterprises in pilot provinces as the treatment group and comparable firms in non-pilot provinces as the control group. The following fixed-effects double-difference model is constructed:

$$debtcost_{ijt} = \beta_0 + \beta_1 did_{ijt} + \beta_2 X_{ijt} + \delta_j + \gamma_t + \varepsilon_{ijt}, \quad (2)$$

where $debtcost_{ijt}$ denotes the cost of debt financing of the clean energy enterprise i in province j in period t . did_{ijt} denotes whether enterprise c in province j is in pilot zone in period t . X denotes the relevant control variables. δ_j accounts for persistent cross-province differences using location dummies, as this study focuses more on the effects of the policy itself. This facilitates accurate estimation of the reform's causal impact on firms. γ_t represents temporal indicators that account for period-specific confounding factors. ε_{ijt} denotes the residual term.

4.2.2. Variable setting

The explained variable is Financing cost ($debtcost$), and it is measured as Interest Expense/Total Liabilities; The explanatory variable is did ($treat \times post$), where the location of the firm belongs to the Green Finance Reform Pilot Zone, $treat$ is taken as 1, and 0 otherwise. Furthermore, for the variables in 2017 and later, $post$ is taken as 1, and 0 otherwise.

Five control variables are incorporated in the analysis. Firm scale (Size) is measured using total assets transformed via natural log. Capital structure (Lev) reflects the proportion of debt relative to total assets. is measured as earnings relative to mean asset base. Liquidity position (Cashflow) reflects operational cash generation scaled by asset holdings. Expansion momentum (Growth) captures year-on-year revenue expansion.

4.2.3. Sample selection and data sources

In this paper, China's A-share listed companies from 2013-2023 are selected as the initial sample, and the sample of clean energy companies is selected with reference to the classification of clean energy companies in China's Green Industry Guidance Catalogue (2023 Edition). In addition, based on the existing studies, the sample processing procedure is as follows: (1) excluding the existence of missing data; (2) considering that the policy will only start to be implemented in 2017, excluding the companies listed after 2016; and (3) excluding the ST and ST* companies. Following these procedures, the study retains 2,393 qualified firm-year observations. The financial data for all publicly traded corporations were sourced from two authoritative Chinese financial databases: CSMAR and Wind. In order to exclude the effect of extreme values, this paper shrinks the sample data by 5% up and down. The descriptive statistics of variables are shown in Table 1:

Table 1. Descriptive statistics for variables

VarName	Obs	Mean	SD	Min	Median	Max
debtcost	2393	0.020	0.014	0.000	0.019	0.066
did	2393	0.186	0.389	0.000	0.000	1.000
Size	2393	22.717	1.343	20.231	22.551	26.086
Lev	2393	0.499	0.182	0.082	0.507	0.893
ROA	2393	0.030	0.055	-0.221	0.031	0.177
Cashflow	2393	0.049	0.059	-0.118	0.048	0.228
Growth	2393	0.150	0.341	-0.486	0.093	1.978

As shown in Table 1, the debt financing cost of clean energy enterprises ranges from a minimum of 0.000 to a maximum of 0.066, with a mean value of 0.020 and a standard deviation of 0.014. This indicates substantial variation in debt financing costs across different firms.

5. Empirical Analyses and Tests

5.1. Benchmark Regression Analysis

This empirical analysis examines how China's Green Finance Reform Pilot policy affects borrowing expenses for renewable energy firms. The baseline regression results from Model (1) reveals several key findings. As presented in Table 2, the coefficient estimate reaches -0.0039 ($p < 0.05$) without accounting for enterprise characteristics, while the inclusion of corporate covariates yields a stronger effect of -0.0043 ($p < 0.01$). These estimates suggest that each policy intensity increment corresponds to a 0.0043 percentage point decline in clean energy companies' capital borrowing expenses. The evidence strongly supports the debt cost reduction effect of the green finance policy intervention, thereby confirming our first research hypothesis.

Table 2. Benchmark regression results

Variables	Debtcost with no control variables	Debtcost with control variables
Did	-0.0039**	-0.0043***
	(-2.660)	(-3.041)
Size		0.002***
		(3.474)
Lev		0.015***
		(3.058)
ROA		-0.058***
		(-4.874)
Cashflow		0.022***
		(2.638)
Growth		-0.003***
		(-3.034)
_cons	0.021***	-0.034**
	(77.237)	(-2.691)
Province	YES	YES
Year	YES	YES
N	2393	2393
r2	0.199	0.366
R2_a	0.185	0.354
F	7.073	46.835

5.2. Robustness Tests

5.2.1. Parallel trend test

The validity of the difference-in-differences approach requires meeting the parallel trends condition, implying comparable borrowing expense trajectories between treatment and control groups during the pre-intervention period. Based on this premise, this paper constructs the corresponding model:

$$debtcost_{ijt} = \alpha_0 + \alpha_t \sum_{t=-3}^3 did_{ijt} + \alpha_2 X_{ijt} + \delta_j + \gamma_t + \varepsilon_{ijt}. \quad (3)$$

The dummy variable *did* indicate observations identified as pre-pilot year *k*, the year of the policy, and post-policy years. The dummy variable for non-pilot areas is 0. The empirical results demonstrate strong support for the parallel trends assumption and immediate policy effects. Figure 1 reveals statistically insignificant estimates for the α_t coefficients across all pre-treatment periods at conventional levels ($p > 0.05$). Notably, the treatment effect emerges immediately in the policy implementation year, with α_t becoming significantly negative ($p < 0.05$), suggesting that the green finance initiative produced instantaneous reductions in eco-friendly firms' borrowing costs. At the same time, it reveals that these effects persist without diminishing over time. This pattern confirms both the absence of anticipatory effects and the sustained influence of the policy intervention.

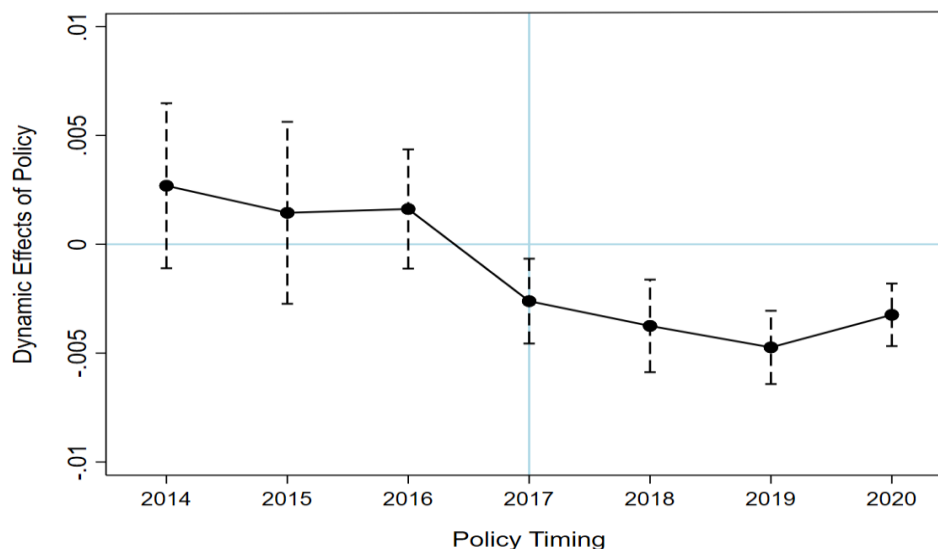


Fig. 1 Parallel trend test

5.2.2. Placebo test

To ensure the robustness of our findings against potential confounding influences, we implement a falsification test through random reassignment. Specifically, we construct a counterfactual scenario where 59 treatment firms are randomly selected while preserving the original policy timeline, then re-estimate the difference-in-differences model with this synthetic sample. According to the above method, re-peated sampling 500 times to obtain the results shown in Figure 2, the results demonstrate that the virtual regression coefficients are smaller than the regression of the true coefficient, which indicates that the results are overwhelmingly attributable to the Green Finance Reform Pilot Zone, with negligible confounding effects from others.

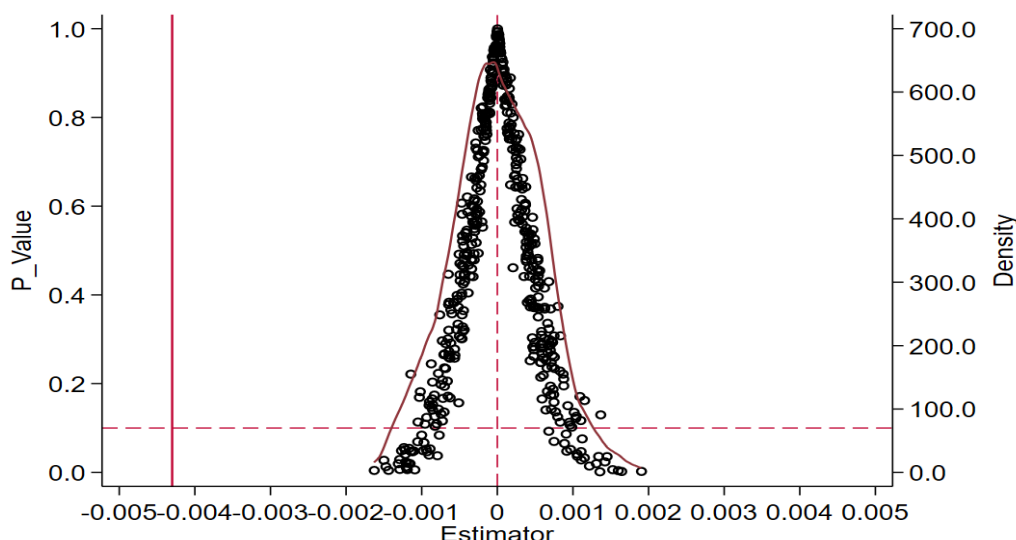


Fig. 2 Placebo test

5.2.3. Heterogeneity Analysis

In terms of enterprise size, in column (2) and (3) of the Table 3, it can be seen that in large-scale enterprises, the coefficient of did is not significant at the 10% significance level, indicating that in large-scale enterprises, the green finance policy does not have a significant impact on the cost of debt financing, probably because of the existing strong financing capacity and credit rating; in small-scale enterprises, the coefficient of did is significant at the 5% significance level is significantly negative, indicating that among small-scale firms, the policy significantly reduces the cost of debt financing for small-scale firms.

Table 3. Benchmark regression results

	Large Scale	Small Scale	Profits	Losses	SOEs	POEs
did	-0.002	-0.005	-0.004	-0.006	-0.003	-0.005
	(-0.755)	(-2.108)	(-2.996)	(-1.116)	(-1.505)	(-2.859)
Size	0.003	0.000	0.002	0.001	0.003	0.000
	(5.512)	(0.058)	(3.435)	(2.245)	(4.707)	(0.565)
Lev	0.014	0.020	0.014	0.017	0.013	0.022
	(3.339)	(3.088)	(2.430)	(3.857)	(1.575)	(3.837)
ROA	-0.058	-0.055	-0.086	-0.020	-0.044	-0.046
	(-7.267)	(-3.464)	(-2.927)	(-1.781)	(-1.380)	(-5.081)
Cashflow	0.016	0.018	0.026	0.040	0.042	0.011
	(1.355)	(2.507)	(2.562)	(3.685)	(3.131)	(1.298)
Growth	-0.003	-0.003	-0.003	-0.002	-0.000	-0.004
	(-2.869)	(-2.600)	(-2.992)	(-0.805)	(-0.341)	(-4.091)
_cons	-0.053	0.010	-0.034	-0.016	-0.060	0.002
	(-4.228)	(0.402)	(-2.541)	(-1.238)	(-3.922)	(0.117)
Province	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES
N	1197	1196	2095	296	892	1457
r2	0.524	0.309	0.371	0.452	0.478	0.315
r2_a	0.505	0.286	0.357	0.366	0.451	0.295
F	82.339	26.127	22.336	16.862	17.717	27.478

6. Recommendations

The research findings permit the derivation of these conclusions: green finance policy can significantly reduce the cost of debt financing for clean energy enterprises. This policy has different effects on different types of enterprises, and it has a significant effect on reducing the cost of corporate debt for small-scale, profitable, private enterprises. On the contrary, the effect on large-scale, loss-making, state-owned enterprises is not significant.

Therefore, this study proposes the following recommendations: Firstly, the government should further deepen the reform of green financial policies, expand the Green Finance Reform Pilot Zone, summarize the successful experience of policy implementation in the pilot zones, and gradually extend it to the non-test zones, so as to enhance the improvement of the national green financial system.

Secondly, the government should provide targeted policy support: For small enterprises, strengthen financing channels, establish dedicated green micro-loans, and lower financing barriers. Large enterprises should be encouraged to lead green industry funds, supporting SME transformation and fostering industrial synergy. Loss-making enterprises pursuing green transition should receive interest subsidies or grants to ease financing constraints. For SOEs, optimize governance by including green project investment in performance metrics to enhance policy responsiveness. For profitable and private enterprises, deepen stabilization policies, encouraging long-term credit agreements with financial institutions to reduce financing volatility risks.

Thirdly, clean energy enterprises should actively leverage policy dividends to invest in green R&D, driving sustainable transformation. They must seize green finance policy opportunities by proactively applying for support instruments like green credit and bonds to reduce financing costs. Concurrently, enhancing corporate governance and transparency is crucial—through improved environmental disclosure, regular publication of emissions data and green project progress—to build investor confidence, alleviate financing constraints, and further lower debt costs.

7. Conclusion

According to the DID model, this investigation quantitatively assesses the debt market consequences of sustainable investment regulations for alternative energy providers. The analysis reveals that environmental finance regulations lead to substantial declines in borrowing expenses for renewable power companies, with results robust to pre-trend validation and falsification checks. Second, the policy is heterogeneous, with significant effects on small-scale, profitable and private firms, but limited effects on large-scale, loss-making and state-owned enterprises (SOEs), mainly due to differences in financing capacity, risk sensitivity and governance mechanisms.

The theoretical contributions of this research are as followed. Focusing on the micro subject of clean energy enterprises, a comprehensive investigation of how environmental finance regulations influence capital acquisition costs for renewable energy providers, which provides a more operational basis for the government to optimize the policy design. However, the sample of this paper only covers A-share listed clean energy enterprises and does not include non-listed SMEs, and the study has not quantitatively analyzed the potential intermediary mechanism of the policy.

Follow-up research can be expanded in the following ways: first, expanding the sample coverage to enhance the universality and external validity of the findings; and second, constructing a systematic intermediation effect detection framework to obtain more accurate and comprehensive conclusions, so as to systematically optimize the green finance policy system.

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