

Research on the Impact of Low Carbon Economy on Financing Efficiency of Enterprises

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Abstract. This article focuses on the efficiency of corporate financing and uses data from A-share listed companies from 2009 to 2022 to conduct a quasi natural experiment on the implementation effect of low-carbon city pilot policies, examining whether the pilot policies can promote corporate financing efficiency. Research analysis reveals that policies have a promoting effect on corporate financing efficiency, mainly through reducing agency costs and improving the quality of environmental information disclosure. It has a significant positive impact on companies in the tertiary industry, enterprises facing major pollution challenges, large-scale enterprises, and state-owned enterprises. Finally, some insights are put forward on the development of low-carbon cities and the green transformation of enterprises in the context of dual carbon.

Keywords: low-carbon city pilot; Financing efficiency; DEA.

1. Introduction

With the increasingly prominent issue of global climate change, the construction of low-carbon cities has become one of the important issues for sustainable development on a global scale. In the process of developing low-carbon cities, the government has issued a series of pilot policies aimed at encouraging enterprises to adopt low-carbon technologies and innovation. As the basic unit of urban economy, enterprises' financing activities not only affect their own business development, but also directly affect the economic operation and development direction of the city.

Therefore, in-depth exploration of the impact of pilot policies on corporate financing efficiency can help to better understand the changes in corporate financing behavior after policy implementation, and provide reference for the government to formulate more effective support policies and optimize corporate financing strategies. This study aims to evaluate the impact of pilot policies on corporate financing efficiency, and explore the mechanisms and paths involved, providing theoretical references and policy recommendations for low-carbon city construction and sustainable development of enterprises.

1.1. Literature review

At present, the academic community generally believes that the low-carbon city pilot policy is compatible with the characteristics of three environmental regulatory policies, and belongs to a comprehensive environmental regulatory policy. Its impact on the financing efficiency of enterprises is multifaceted, promoting the green transformation of enterprises and society from multiple levels. Hong Tao et al. (2024)[1] found that enterprises located in low-carbon city pilot projects face smaller financing constraints than those not in the pilot projects, which is more conducive to financing for the former. Liu Xiaohong and Jiang Keshen (2020)[2] believe that strengthening environmental regulation by the government can enhance the environmental awareness of enterprises, encourage them to increase environmental investment, and achieve a win-win situation between financial and environmental performance, thereby improving financing efficiency and enhancing corporate value. Zheng Minggui et al. (2024) [3] found that voluntary environmental regulatory policies can alleviate financing constraints and improve financing efficiency for mature and profitable enterprises. Scholars such as Van et al. (2017) [4] argue that the impact of low-carbon city pilot policies on corporate financing efficiency is not linear, and it takes some time after policy implementation to gradually promote corporate financing efficiency.

At present, the academic community generally believes that the pilot low-carbon city policy combines the characteristics of three types of environmental regulations and belongs to a comprehensive environmental regulation policy. Its impact on the efficiency of corporate financing is multifaceted, and it can promote the green transition of enterprises and from multiple levels. Hong et al. (2024)[1] found that enterprises located in the pilot low-carbon city projects face less financing constraints than those participating in the pilot projects, which is conducive to the financing of the former. Liu and Jiang (2020)[2] believe that the government strengthened environmental can enhance corporate environmental awareness, encourage them to increase environmental investment, and achieve a win-win situation for financial and environmental performance, thereby improving financing efficiency and enhancing corporate. Zheng et al. (2024)[3] found that voluntary environmental regulation policies can alleviate the financing constraints of mature and profitable enterprises, and improve financing efficiency Van et al.(2017)[4] scholars believe that the impact of the pilot low-carbon city policy on the efficiency of corporate financing is not linear and it needs some time after the implementation of the policy to gradually improve the efficiency of corporate financing. Although the impact of the pilot policy on the efficiency of corporate is significant, there are still many gaps and issues in current research that need further exploration.

Although the impact of pilot policies on corporate financing efficiency is of great significance, there are still many gaps and issues that need to be further explored in current related research. Therefore, this study aims to explore the correlation between pilot policies and the measurement of corporate financing efficiency, and reveal the potential impact mechanism of policies on corporate financing efficiency. By fully understanding this relationship, we are expected to provide theoretical support and policy recommendations for promoting the construction of low-carbon cities, optimizing corporate financing structures, and promoting sustainable urban development.

1.2. Hypothesis and Mechanism Analysis

(1) The impact of low-carbon pilot policies on the financing efficiency of enterprises

In the context of the current "dual carbon" goals, the implementation of low-carbon pilot measures is gradually increasing. These efforts aim to enhance the confidence level of investment and financing institutions, release positive signals, alleviate financial pressure on enterprises, improve the financing effectiveness of companies, and strengthen the financing efficiency of enterprises.

Assumption 1: The implementation of pilot policies may improve the financing efficiency of enterprises.

(2) The impact mechanism of policies on corporate financing efficiency

The implementation of low-carbon city pilot policies usually requires companies to pay more attention to disclosing environmental information. This will force companies to increase their investment in environmental protection projects, thereby increasing the likelihood of obtaining financing. The improvement of environmental information disclosure will enhance the transparency and reputation of enterprises, and help financial institutions more effectively evaluate the risks and value of enterprises. This will provide enterprises with a wider range of financing options, thereby promoting the improvement of financing efficiency.

Assumption 2: The low-carbon city pilot policy aims to improve financing efficiency by enhancing the degree of environmental information disclosure of enterprises.

The effectiveness of internal governance structure directly affects the financing efficiency of enterprises. The low-carbon city pilot policy has prompted enterprises to strengthen their internal environmental management, enhance their governance capabilities and transparency, and help reduce agency costs. A good internal governance structure can reduce enterprise risks, increase company value, thereby reducing financing costs, obtaining more financing, and improving efficiency.

Assumption 3: Low carbon pilot policies improve financing efficiency by reducing agency costs for enterprises.

2. Research Design

2.1. Sample sources and data processing

This article takes A-share companies and their cities from 2009 to 2022 as research samples. Process the relevant data as follows: (1) Exclude ST, delisted enterprises, and financial enterprises from 2009 to 2022; (2) Exclude enterprises with severe data gaps. The city data is sourced from the China Urban Statistical Yearbook; the main source of enterprise data is from CSMAR; a small amount of incomplete data is constructed using linear interpolation method. Finally, this article applies a 1% tail reduction to continuous variables to eliminate the influence of extreme values.

2.2. Model building

To verify the above assumptions, this study constructs the following benchmark regression model based on the multi period double difference method:

$$CE_{it} = \beta_0 + \beta_1 Policy_{it} + \lambda Z_{it} + \mu_i + \sigma_t + \varepsilon_{it} \quad (1)$$

Among them, CE_{it} is the t -th financing efficiency of the i -th listed company, expressed in city as whether it is a low-carbon city pilot city. If the company is located in a pilot city, $city=1$; otherwise, $city=0$. Before the implementation of policies in the city, $time=0$, and after implementation, $time=1$. Build an interaction term $Policy$. If the city where the enterprise is located belongs to the policy implementation area, the $Policy$ value is 1 during the policy implementation period, otherwise it is 0. β_0 represents the constant term, and Z_{it} represents the control variable. μ_i and σ_t represent individual fixed effects and time fixed effects of the sample, while ε_{it} represents other perturbation terms.

2.3. Variable definition

2.3.1. Explained variable: Corporate financing efficiency

Based on the applicability, usability, operability of the comprehensive evaluation indicators, this study ultimately selected the various indicators described in Table 1. Due to the non-negative nature of the indicators in the DEA model, the negative indicators in the initial dataset are dimensionless and adjusted to non-negative values before calculation. By inputting the calculation system into MAX DEA Pro software, the financing efficiency can be calculated.

Table 1. Index System for Measuring Enterprise Financing Efficiency.

project	Indicator Name	Indicator variables	Calculation formula
Input indicators	Financial expenses	financing cost	balance sheet
	Property ownership ratio	Financing risk	Liabilities/Owner's Equity
	Total assets	Financing scale	total assets
Intermediate indicators	Equity financing amount	Financing amount	Share capital+capital reserve
	Debt financing amount	Financing amount	Borrowing+payable bonds
	business income	Profit level	profit-statement
Output indicators	Net profit	Development level	profit-statement
	fixed assets	production level	balance sheet

2.3.2. Core explanatory variable: low-carbon city pilot policy

The pilot program for low-carbon cities has been initiated by the National Development and Reform Commission and relevant policies have been issued. So far, three batches of pilot cities have been launched. The dates are July 2010, November 2012, and January 2017, respectively. Round the years based on the availability of research data and the feasibility of the study. Considering the lack of reference for the first pilot, insufficient institutional framework, and weak policy execution, there is a certain lag in implementation. The implementation of pilot policies in the first phase will be postponed to 2011. The dates will be adjusted to 2011, 2013, and 2017, respectively.

2.3.3. Control variables

This article selects total assets (size), asset liability ratio (lev), return on equity (roe), maximum shareholder proportion (top1), regional gross domestic product (lnGDP), regional foreign investment (lnFDI), and enterprise growth ability (growth) as control variables. All variable information is as follows:

Table 2. Selected variables and calculation methods.

Variable properties	Variable Name	Symbol	Calculation method
Dependent variable	Corporate financing efficiency	CE	Using a two-stage chain network DEA model to measure
Explanatory variables	Pilot policies for low-carbon cities	Policy	The interaction between policy implementation time and pilot cities
control variable	total assets	size	Natural logarithm of total assets
	Asset liability ratio	lev	Total liabilities/total assets
	Return on equity	roe	Net profit/net assets of the company
	The proportion of the largest shareholder	top1	The proportion of shares held by the largest shareholder to the total number of shares
	Urban Gross Domestic Product	lngdp	Taking the natural logarithm of urban gross domestic product
	Urban foreign investment	lnfdi	Take the natural logarithm of the amount of foreign investment in cities
	Enterprise growth capability	growth	Tobin Q value

3. Empirical analysis

3.1. Benchmark regression results

After considering the fixed effects of enterprises and time, Table 4 provides a detailed description of the overall impact of low-carbon pilot policies on corporate financing efficiency. The coefficient of the policy interaction term is 0.0082, which is significant at the 1% level, indicating that the financing efficiency of listed companies located in pilot cities has been improved. The pilot policy plays a crucial role in alleviating financing constraints faced by domestic enterprises and enhancing funding efficiency, thus confirming hypothesis 1 of the research work.

Table 3. Benchmark Regression Results.

VARIABLES	CE
Policy	0.0082*** (8.39)
control variable	YES
Corporate fixed effects	YES
Time fixed effect	YES
Observations	19,839
R-squared	0.915
Robust t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1	

3.2. Parallel trend test

The above research results show that the pilot policy can improve the financing efficiency of enterprises in the pilot areas, but this result may exist before implementation of the policy. To this end, this section introduces a parallel trend test as a precautionary measure before the event. Specifically, using 2011 as the reference period, the time trend of financing efficiency in the two

periods before the implementation of the policy and the six periods after the implementation (for simplicity, data for the six years after the announcement of the policy are combined into the sixth period on the x-axis in the following figure, with point 0 representing the of the policy implementation in 2011) in the pilot cities and sample enterprises in the pilot cities is analyzed. The test results are shown in the, which shows that the estimated coefficients before the implementation of the pilot policy are not statistically significant, that is, there are no significant differences between enterprises in pilot non-pilot cities before the implementation of the policy; after the implementation of the policy, significant differences appear, indicating that the research sample passes the parallel trend test.

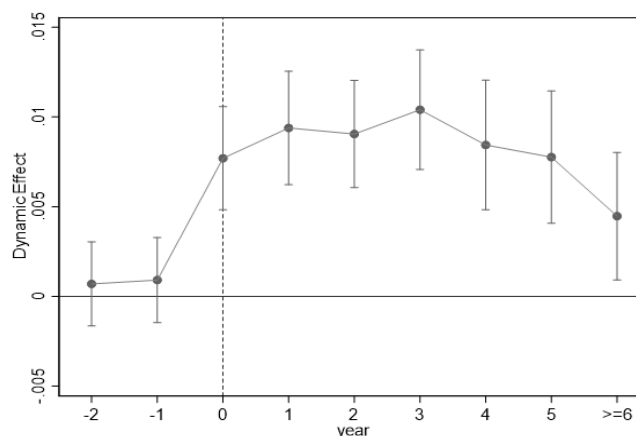


Fig 1. Sample parallel trend test.

3.3. Robustness check

3.3.1 Placebo test

Placebo test is conducted in this paper to replace the treatment group cities with placebo, since there may be unknown explanatory variables and other factors affect the robustness of the model. Specifically, 121 cities are randomly selected from the sample cities as the false treatment group cities, and the remaining are used as the false control group cities, and the coefficients can be estimated accordingly. The above process is repeated 500 times, and the results are in the following figure. The regression coefficients are around 0 and follow a normal distribution, as indicated by the kernel density distribution and p values. Most of the values are greater than 0.1, and the regression results are not significant at the 10% level. Based on this, the placebo test is. The experiment group and control group settings do not show policy effects, and the conclusion that pilot policies significantly affect the efficiency of corporate financing still holds.

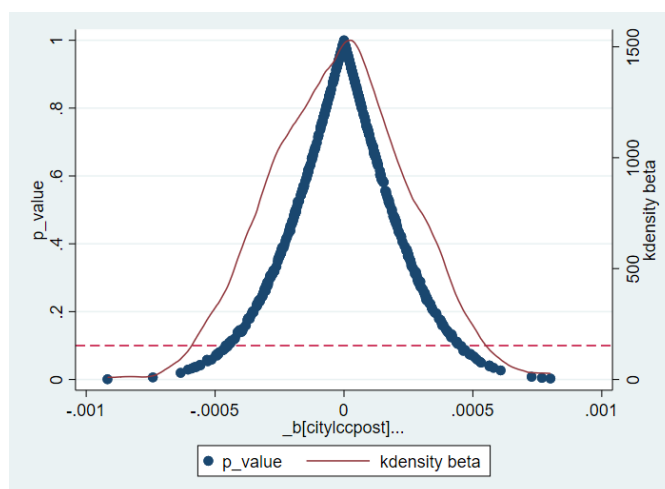


Fig 2. Placebo test.

3.3.2. PSM-DID

Factors such as reverse causality and sample selection bias may cause endogeneity issues. Using corporate financing efficiency as the dependent variable is unlikely to have an impact on the main explanatory variable - pilot policies, which largely alleviates endogeneity bias related to reverse causality. This article applies PSM-DID to address endogeneity issues caused by sample selection bias. After using nearest neighbor matching, kernel matching, and radius matching methods, the coefficient estimation of Policy successfully passed the 1% significance test. This further confirms that the pilot policy has indeed promoted the efficiency of corporate financing.

Table 4. PSM-DID regression test results.

VARIABLES	(1) CE	(2) CE	(3) CE
	Nearest Neighbor Matching	Nuclear matching	Radius matching
Policy	0.0075*** (4.93)	0.0081*** (8.38)	0.0082*** (8.39)
control variable	YES	YES	YES
Corporate fixed effects	YES	YES	YES
Time fixed effect	YES	YES	YES
Observations	6,712	19,529	19,839
R-squared	0.934	0.918	0.915

3.4. Heterogeneity analysis

3.4.1. Heterogeneity of enterprise ownership

Divide the sample data into state-owned enterprises and non-state-owned enterprises for regression analysis. The columns (1) to (2) of Table 5 describe the estimated impact of pilot policies on employment in enterprises with different ownership structures. In the field of state-owned enterprises, the estimated coefficient of Policy is 0.0117, which exceeds the significance test at the 1% level; On the contrary, in the non-state-owned enterprise group, the estimated coefficient of Policy is 0.0047, which also exceeds the significance test at the 1% level. State owned enterprises have the advantage of resource acquisition and are adept at absorbing additional costs related to environmental policies, thereby promoting the improvement of corporate financing efficiency.

Table 5. Heterogeneity test results 1.

VARIABLES	(1) CE	(2) CE	(3) CE	(4) CE
	state-owned enterprise	Non state-owned enterprises	Large enterprises	Small and medium-sized enterprises
Policy	0.0117*** (6.72)	0.0047*** (4.15)	0.0131*** (6.89)	0.0009 (1.35)
control variable	YES	YES	YES	YES
Corporate fixed effects	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES
Observations	6,826	13,283	9,829	9,686
R-squared	0.893	0.932	0.886	0.976

3.4.2. Heterogeneity of enterprise scale

Divide the sample enterprises into large enterprises and small and medium-sized enterprises based on the median of total assets, and conduct regression analysis separately. As shown in columns (3) and (4) of Table 6, for large enterprises, the estimated coefficient is 0.0131, which passes the significance test at the 1% significance level. For small and medium-sized enterprises, the estimated coefficient is 0.0009, which did not pass the significance test at the 10% level. Perhaps due to their

small capital size and weak market competitiveness, small and medium-sized enterprises face more financing constraints in their own development process, and their awareness of environmental protection may not be as profound as that of large enterprises. On the other hand, large enterprises can leverage their economies of scale to attract more relevant talents and capital, thereby playing a greater role in complying with policy requirements for low-carbon transformation and innovation.

3.5. Analysis of Impact Mechanisms

The aforementioned research results indicate that pilot policies have a positive impact on improving corporate financing efficiency. However, the specific mechanism by which pilot policies lead to an improvement in corporate financing efficiency has not been fully studied. Based on the theoretical analysis mentioned earlier, financing efficiency can be divided into fundraising efficiency and allocation efficiency. On the one hand, pilot policies have improved the level of corporate environmental disclosure, reduced financing uncertainty, and improved financing efficiency. On the other hand, by regulating corporate expenditures, strengthening supervision over capital allocation, corporate executives, and important stakeholders, we can reduce agency costs and enhance allocation efficiency.

This study aims to explore the specific mechanisms of environmental information disclosure level and agency cost as two influencing paths. The level of environmental information disclosure is represented by the KV index (kv), and the agency cost is represented by the management fee rate (DC).

$$KV_{it} = \beta_0 + \beta_1 Policy_{it} + \lambda Z_{it} + \mu_i + \sigma_t + \varepsilon_{it} \quad (2)$$

$$DC_{it} = \beta_0 + \beta_1 Policy_{it} + \lambda Z_{it} + \mu_i + \sigma_t + \varepsilon_{it} \quad (3)$$

$$CE_{it} = \beta_0 + \beta_1 Policy_{it} + \beta_2 KV_{it} + \beta_3 DC_{it} + \lambda Z_{it} + \mu_i + \sigma_t + \varepsilon_{it} \quad (4)$$

Table 6. Impact mechanism testing.

VARIABLES	(1) kv	(2) DC	(3) CE	(4) CE	(5) CE
kv			-0.0075*** (-5.17)		-0.0075*** (-5.18)
DC				-0.0166* (-1.83)	-0.0169* (-1.86)
Policy	-0.0081** (-1.97)	-0.0019* (-1.71)	0.0082*** (8.36)	0.0082*** (8.37)	0.0081*** (8.33)
control variable	YES	YES	YES	YES	YES
Corporate fixed effects	YES	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES	YES
Observations	19,839	19,839	19,839	19,839	19,839
R-squared	0.545	0.561	0.915	0.915	0.916

The results of the mediation effect test are shown in Table 6. Through the results in columns (1) to (2), we can find that the pilot policy has reduced the KV index and agency costs. The lower the KV index, the higher the degree of information disclosure in the financing environment. Columns (3) to (5) reveal that both the KV index and agency costs have a significant negative impact on the financing efficiency of enterprises. This indicates that by improving the quality of environmental information disclosure, improving the external financing environment, and enhancing the internal financing efficiency of enterprises, policies can enhance the financing efficiency of enterprises. Therefore, this study confirms the correctness of hypotheses 2 and 3.

4. Conclusion and recommendations

This article is based on the low-carbon city pilot policy to construct a quasi-natural experiment. Based on the data of A-share listed companies from 2009 to 2022, and using the multi period double difference method, it is found that: (1) after the implementation of the low-carbon city pilot, the financing efficiency of enterprises in the jurisdiction has improved compared to those in non-pilot jurisdiction. This conclusion remains robust after undergoing parallel trend tests, placebo tests, and PSM-DID tests. (2) In heterogeneity testing, pilot policies have a more significant positive impact on large-scale enterprises and state-owned enterprises. (3) The pilot policy aims to improve the efficiency of corporate financing by increasing the level of environmental information disclosure and reducing agency costs, improving the external financing environment and internal governance mechanisms.

In summary, this article elaborates on the following suggestions: (1) Encourage more cities to join low-carbon city pilot policies, identify implementation paths that align low-carbon development with local economic and environmental characteristics, provide financial incentives for pilot areas that have shown positive results, and fully utilize the demonstration of pilot measures and urban brand effects. (2) Promote the establishment of more green financing platforms to meet the multi-level financing needs of enterprises. Officials should also maximize their basic guiding role in institutional design, organizational coordination, administrative supervision, and market incentives.

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