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The Impact of Carbon Emission Trading Pilot Policy on the Cost of Corporate Debt Financing

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Abstract. Based on the data of A-share listed companies from 2010 to 2020, this paper regards the pilot of local carbon emissions trading as a quasi natural experiment, and uses a two-way fixed effect double difference model to investigate the impact of carbon trading policy on corporate debt financing costs. The results show that after the implementation of the pilot policy, the average debt financing cost of enterprises in the pilot area increased by about 0.71%, and remained stable in the replacement variable caliber, adjusted sample, placebo test and parallel trend test. The results of the mechanism show that the carbon trading pilot significantly depresses the cash holdings of enterprises, and the liquidity contraction increases the risk compensation requirements of creditors, which constitutes an important channel for policies to push up the cost of debt financing. Heterogeneity analysis further found that the rise in financing costs was mainly concentrated in non-state-owned enterprises and young enterprises. The research shows that the carbon market will generate observable short-term financing cost pressure in the pilot operation stage while forming long-term emission reduction incentives; Improving the financing support for enterprises' low-carbon transformation, improving the quality of carbon market information and implementing differentiated green financial policies will help reduce the liquidity constraints in the transformation process.

Keywords: carbon emission trading, Debt financing costs, Double difference, Cash holdings, Liquidity risk

1. Introduction

Debt financing cost is an important price index of risk pricing of financial institutions, which directly affects the investment, capital structure and low-carbon technology transformation ability of enterprises. Under the background of green transformation, the environmental risk exposure and emission reduction performance ability of enterprises gradually enter the risk assessment framework of creditors. Therefore, the carbon market may reshape debt pricing by changing the cash flow and information environment of enterprises. Since 2013, China has successively launched carbon emissions trading pilot projects in Beijing, Tianjin, Shanghai, Chongqing, Guangdong, Hubei and Shenzhen [1], and established monitoring, reporting and verification (MRV) systems. On the one hand, the carbon market internalizes the environmental cost through quota implementation, emission verification and low-carbon transformation, increasing the current capital demand of enterprises; On

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the other hand, MRV and environmental information disclosure also improve the standardization and verifiability of carbon emission information, and reduce the information search cost of creditors. The two channels are in opposite directions, so the net effect of policies on debt financing costs needs to be identified empirically.

The conclusions of existing studies on carbon trading and corporate financing conditions are not consistent. Some literatures found that the carbon trading pilot increased the cost of corporate debt financing or bond credit spread [2-4], and some studies pointed out that the carbon market could alleviate the financing constraints of high-carbon enterprises [5, 6]. Relevant studies also discussed the microeconomic consequences of carbon trading from the perspective of corporate financial performance and environmental information disclosure [7-9]. The above differences mean that the key to understanding the relationship between environmental regulation and financial resource allocation is to identify the specific channels through which carbon trading affects financing costs and the heterogeneity of enterprises.

From the perspective of debt pricing logic, there are at least three connection points between carbon trading and debt financing. First, environmental regulation changes the expected cash flow of enterprises, and creditors will include the performance expenditure and low-carbon transformation investment into the solvency assessment; Second, environmental risk will change the asset value and business fluctuation of enterprises, and then affect the default loss rate; Third, MRV and environmental information disclosure improve the external information environment and help reduce the information risk premium. The first two more directly affect the financial constraints of enterprises, and the third depends on the speed at which information enters the pricing system of financial institutions. Based on this difference, this paper focuses on the net effect and liquidity channel in the sample period.

Compared with existing studies, this paper does not limit the theoretical mechanism to a single "information transparency reduces financing costs", but clearly distinguish the compliance cost effect and information transparency effect in the opposite direction in the same framework. This can not only explain why the carbon market may generate short-term financing pressure, but also make the theoretical proposition consistent with the subsequent test of cash holding mechanism.

This paper analyzes the logic of "compliance cost - cash holdings - liquidity risk - debt pricing". Compared with the long-term financing dividend of improved information transparency, quota performance, verification and low-carbon technology transformation first form real cash expenditure, and directly affect the short-term solvency and risk exposure of enterprises. Based on the data of A-share listed companies from 2010 to 2020, this paper constructs a did model of carbon trading pilot, tests the average effect of policies on the cost of corporate debt financing, and further examines the heterogeneity of cash holding channels, ownership and corporate life cycle. The main findings of this paper are: carbon trading pilot significantly increased the cost of corporate debt financing; At the same time, the policy reduces the cash holdings of enterprises, and the liquidity contraction constitutes an important transmission channel for the rise of financing costs; This effect is more prominent in non-state-owned enterprises and young enterprises.

The increment of this paper is mainly reflected in two aspects. First, from the perspective of debt price rather than financing quantity, describe how carbon trading policy enters the risk pricing of creditors. Second, the short-term compliance expenditure and corporate liquidity are included in the unified analysis framework, which shows that the financing impact of the carbon market has obvious differences in the affordability of enterprises, so as to provide micro evidence for the synergy between the carbon market and green financial policies.

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2. Theoretical analysis and research hypothesis

2.1. Policy background and institutional characteristics

The pilot of carbon emission trading in China is a market-oriented environmental regulation with total amount control and quota trading as the core. In 2011, the national development and Reform Commission approved Beijing, Tianjin, Shanghai, Chongqing, Guangdong, Hubei and Shenzhen to carry out pilot projects. Since 2013, various markets have successively started trading, and gradually formed an institutional system linking quota allocation, transaction performance, emission accounting and supervision [1]. Compared with the traditional command and control environmental regulation, the carbon market enables enterprises to choose between the emission reduction cost and the quota purchase cost by forming a tradable emission right price, so as to convert the external environmental cost into the observable operating cost of enterprises.

The MRV system is an important basis for the operation of the carbon market. Enterprises need to continuously record and report emission data and accept verification, so that the emission information is more standardized and verifiable [9]. From the financing side, this institutional arrangement has two meanings: on the one hand, the environmental risk information is more sufficient, which is helpful for creditors to distinguish different carbon performance enterprises; On the other hand, performance constraints convert the originally externalized environmental costs into real cash expenditures, especially for enterprises that need to purchase quotas, update equipment and implement low-carbon transformation, which will directly occupy internal funds. Therefore, the carbon market not only changes the emission reduction behavior of enterprises, but also changes the cash flow structure of enterprises and the risk pricing basis of financial institutions.

There are differences in quota allocation, industries covered and performance rules among the pilot projects, but the common feature is that they have gradually entered the stage of continuous trading and performance from the stage of system construction around 2013. This paper regards 2014 as the unified policy period, and separately identifies the transition period in 2013 in the robustness test, in order to capture the relative changes in enterprise financing conditions after the pilot from start-up to normal operation. The institutional background also means that the policy impact is not a simple information disclosure event, but also includes the real cost constraint and the improvement of the information environment.

2.2. Carbon trading pilot and debt financing cost: two mechanisms

Carbon emissions trading internalizes the external cost of carbon emissions through total amount constraints and quota trading. For enterprises included in the scope of policy influence, quota purchase, emission verification, equipment upgrading and low-carbon technology transformation will form new cash expenditure; When it is difficult for the enterprise to fully absorb the above expenditures through internal funds, the liquidity buffer will decline, the short-term solvency and cash flow stability will weaken, and creditors will therefore increase their risk compensation requirements. The mechanism can be summarized as follows: carbon trading pilot → increase in compliance and transformation expenditure → decrease in cash holdings → increase in liquidity risk → increase in debt financing costs.

At the same time, the MRV system and carbon market regulation can improve the availability and verifiability of environmental information, and improve the external information environment of enterprises through information intermediaries such as analysts and rating agencies. After the reduction of information asymmetry, the information search cost and information risk premium of

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creditors are reduced, which theoretically can reduce the financing cost [10]. Therefore, the net impact of carbon trading on debt financing costs depends on the relative strength of "compliance cost effect" and "information transparency effect". Considering that the performance and technological transformation expenditures in the pilot operation stage are immediate, and the improvement of information transparency can be gradually reflected only after information production, transmission and debt pricing adjustment, this paper expects the compliance cost effect to be more direct in the sample period.

H1: the pilot policy of carbon emission trading has significantly increased the debt financing cost of enterprises in the pilot area.

This hypothesis emphasizes the net effect of the policy in the sample period, rather than denying the potential role of information transparency. If the information improvement brought by MRV is gradually absorbed by banks and bond markets, there is room for downward adjustment of long-term financing costs; However, in the pilot operation stage, the new performance and technological transformation expenses are paid before the information dividend, so it is easier for creditors to observe the cash flow pressure first. Therefore, the positive result of the average processing effect is not contradictory to the long-term improvement of the information environment in the carbon market, but reflects the chronological order of different mechanisms.

2.3. Liquidity channels for cash holdings

Cash holding is an important buffer for enterprises to cope with business fluctuations and financing frictions. The quota performance and low-carbon transformation expenses brought about by carbon trading will occupy the internal cash of the enterprise and reduce the liquidity available for debt repayment and daily operation. After the reduction of cash reserves, enterprises' dependence on external financing increases, creditors' assessment of refinancing risk and default risk increases, and the financing price increases accordingly. Therefore, if the liquidity channel is established, the policy should first significantly reduce cash holdings and show a significant negative relationship between cash holdings and financing costs in the regression of debt financing costs.

H2: the pilot of carbon emission trading will increase the cost of corporate debt financing by reducing corporate cash holdings and improving liquidity risk.

2.4. Ownership and life cycle heterogeneity

State owned enterprises usually have more stable bank relationships, financing channels and implicit credit support, and their debt pricing is relatively insensitive to short-term cash flow fluctuations; The financing price of non-state-owned enterprises is more dependent on their own operating conditions and liquidity, so the compliance cost is easier to be transmitted to the debt financing cost. Therefore, h3a: the driving effect of carbon trading pilot on debt financing cost is stronger in non-state-owned enterprises.

Young enterprises have less business accumulation, limited cash reserves and mortgaged assets, stronger external financing constraints, and weak ability to bear new compliance expenditure; Mature enterprises have more stable operating cash flow and internal capital buffer. Therefore, it is proposed that H3B: the driving effect of carbon trading pilot on debt financing cost is stronger in young enterprises.

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3. Research design

3.1. Data, samples and variables

This paper selects China's A-share listed companies from 2010 to 2020 as the initial sample. The corporate finance and governance data are from the CSMAR database, and the pilot areas and start-up time of carbon emission trading are sorted out according to the policy documents. Sample processing includes: eliminating listed companies in the financial industry; Eliminate st, *st enterprises; Continuous variables were subjected to 1% and 99% bilateral tailing. Finally, 26661 Enterprises - annual observation values were obtained, covering 3715 listed companies.

The explained variable fincost is measured by "interest expense/average interest bearing liabilities", in which the average interest bearing liabilities are the average value of short-term borrowings at the beginning and end of the period, non current liabilities due within one year, long-term borrowings, bonds payable and other interest bearing liabilities. The core policy variable policy is pilot × post: when the enterprise is registered in seven pilot areas, the pilot is 12014 years old and post is 1. The mechanism variable cash is the cash holding level of the enterprise. Control variables include enterprise size(Size), asset liability ratio(Lev), profitability, growth(ROA), tangibility(Tangibility) and age(Age). The robustness test further adopts the alternative financing cost caliber, the adjustment policy time point and sample setting.

The reason for adopting 2014 as the unified policy time point is that local pilot projects started trading in 2013, and basically entered the stage of continuous performance and stable operation after 2014. The robustness test further controls 2013 as a transition period separately to avoid the mechanical impact of the unified time point setting on the estimation results. Since the core policy variables are jointly determined by the location and year of the enterprise, the fixed effect of the enterprise absorbs the characteristics of the enterprise that does not change with time, and the fixed effect of the year controls the macro financing environment and national institutional changes.

Fincost is a price based financing index. Compared with the financing balance or financing constraint index, it more directly reflects the pricing of corporate risk by creditors. Cash depicts the internal liquidity buffer of enterprises; When compliance expenditure compresses cash reserves, creditors will simultaneously observe higher refinancing dependence and weaker short-term debt service buffer, thus demanding higher interest rate compensation.

3.2. Econometric model

The benchmark model is set as:

$$FinCost_{it} = \alpha + \beta Policy_{it} + \gamma X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

Where, μ_i and λ_t are the fixed effect of enterprises and the fixed effect of years respectively, X_{it} is the control variable at the enterprise level, and β measures the relative change of debt financing costs of enterprises in the pilot area after the implementation of the pilot policy. The regression criteria were wrongly clustered at the enterprise level. The mechanism test first estimates the impact of the policy on cash holdings with cash as the explanatory variable, and then incorporates cash into the financing cost regression; Heterogeneity analysis estimated the policy coefficient in the samples of state-owned/non-state-owned enterprises and young/mature enterprises respectively.

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4. Empirical results

4.1. Benchmark results

Table 1. Carbon trading pilot and corporate debt financing costs

variable	(1) FE	(2) FE+control
Policy	0.0108***(0.0019)	0.0071***(0.0013)
Size	—	-0.0004(0.0007)
Lev	—	0.0574***(0.0026)
ROA	—	0.0073*(0.0044)
Growth	—	0.0025***(0.0004)
Cash	—	-0.1088***(0.0045)
Tangibility	—	0.0281***(0.0034)
Age	—	0.0205***(0.0012)
Firm fixed effect	yes	yes
Fixed year effect	yes	yes
Observed value	26,661	26,661
Number of enterprises	3,715	3,715
Within R^2	0.0543	0.3530

Note: the standard error of enterprise level clustering is in brackets; *, * *, * * * are significant at 10%, 5% and 1% levels respectively. The following table is the same.

Table 1 shows that the core policy variable policy is significantly positive at 1% level after only controlling the two-way fixed effect and adding the enterprise control variable. After adding the control variable, the coefficient is 0.0071, which means that after the implementation of the pilot policy, the cost of corporate debt financing in the pilot area has increased by about 0.71% on average compared with non pilot areas. This result supports H1, indicating that the compliance cost and cash flow pressure in the sample period exceed the financing price reduction effect brought by the improvement of information transparency.

In the control variables, the leverage ratio is significantly positive and the cash holding is significantly negative, respectively corresponding to higher financial risk and stronger liquidity buffer. The Asset Tangibility coefficient is significantly positive, indicating that under the background of carbon constraint in this sample, the debt pricing is not only determined by the mortgage value. Enterprises with a relatively high proportion of fixed assets usually have stronger capital intensive characteristics, the capital demand for equipment renewal and low-carbon transformation is higher, and the transformation expenditure exposure will enter the risk assessment of creditors, so its financing cost shows a positive relationship.

4.2. Liquidity channel

Table 2. Liquidity channels of cash holdings

Variable	(1) Cash	(2) FinCost	(3) FinCost+Cash
Policy	-0.0262***(0.0043)	0.0100***(0.0015)	0.0071***(0.0013)
Size	-0.0018(0.0028)	-0.0002(0.0008)	-0.0004(0.0007)

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Table 2. (continued)

Lev	-0.1663***(0.0115)	0.0755***(0.0032)	0.0574***(0.0026)
ROA	0.0662***(0.0152)	0.0001(0.0048)	0.0073*(0.0044)
Growth	0.0000(0.0014)	0.0024***(0.0004)	0.0025***(0.0004)
Tangibility	-0.2450***(0.0122)	0.0547***(0.0037)	0.0281***(0.0034)
Age	-0.0987***(0.0045)	0.0313***(0.0014)	0.0205***(0.0012)
Cash	—	—	-0.1088***(0.0045)
Firm fixed effect	yes	yes	yes
Fixed year effect	yes	yes	yes
Observed value	26,661	26,661	26,661
Number of enterprises	3,715	3,715	3,715
Within R^2	0.2609	0.2634	0.3530

Column (1) takes cash as the explained variable; Columns (2) - (3) take fincost as the explained variable.

In column (1), the policy coefficient is -0.0262, which is significant at the 1% level, indicating that the carbon trading pilot has significantly reduced corporate cash holdings. Column (2) when cash is not added, the policy coefficient is 0.0100; Column (3) after adding cash, the policy coefficient decreases to 0.0071, and the cash coefficient is -0.1088, which is highly significant. The policy coefficient decreased by about 29%, which is consistent with the mechanism of "cash occupied by compliance expenditure - increased liquidity risk - increased debt financing costs", supporting H2.

4.3. Enterprise heterogeneity

Table 3. Ownership and heterogeneity of enterprise life cycle

Variable	State owned enterprises	Non state owned enterprises	Young enterprise	Mature enterprise
Policy	0.0008(0.0011)	0.0128***(0.0021)	0.0109***(0.0022)	0.0015(0.0011)
Size	0.0002(0.0008)	-0.0007(0.0010)	-0.0016(0.0012)	0.0014*(0.0008)
Lev	0.0436***(0.0034)	0.0629***(0.0034)	0.0740***(0.0045)	0.0349***(0.0029)
ROA	0.0052(0.0057)	0.0065(0.0055)	0.0122(0.0076)	-0.0080(0.0050)
Growth	0.0012**(0.0006)	0.0030***(0.0006)	0.0037***(0.0008)	0.0008(0.0005)
Cash	-0.0634***(0.0056)	-0.1209***(0.0056)	-0.1546***(0.0074)	-0.0495***(0.0045)
Tangibility	0.0333***(0.0041)	0.0298***(0.0049)	0.0244***(0.0062)	0.0323***(0.0038)
Age	0.0103***(0.0022)	0.0179***(0.0014)	0.0227***(0.0029)	-0.0030(0.0093)
Firm fixed effect	yes	yes	yes	yes
Fixed year effect	yes	yes	yes	yes
Observed value	9,701	16,960	10,828	9,780
Number of enterprises	1,249	2,682	1,149	1,057
Within R^2	0.2447	0.3859	0.4648	0.1999

In the ownership grouping, the policy coefficient of state-owned enterprises is not significant, and the coefficient of non-state-owned enterprises is 0.0128, which is significant at the 1% level, supporting h3a. The more stable financing channels and credit support of state-owned enterprises weaken the transmission of short-term liquidity shocks to debt prices; Non state owned enterprises

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are more sensitive to their own cash flow and risk changes. In the life cycle grouping, the policy coefficient of young enterprises is 0.0109 and significantly positive, while the coefficient of mature enterprises is not significant, and H3B is supported. Young enterprises have limited internal capital accumulation and stronger external financing constraints, so it is more difficult to absorb the new compliance expenditure brought by the carbon market.

4.4. Robustness and identification test

Table 4. Robustness test

Vatiable	Unified 2014	Eliminate negative values	Liabilities at the end of the year	More stringent tailing	Eliminate 2020
Policy/Policy_2014	0.0082*** (0.0015)	0.0016***(0.0006)	0.0062***(0.0012)	0.0043***(0.0010)	0.0067*** (0.0013)
2013过渡期	0.0049*** (0.0012)	—	—	—	—
Size	-0.0004(0.0007)	0.0002(0.0004)	-0.0011*(0.0006)	0.0005(0.0006)	-0.0003(0.0007)
Lev	0.0573*** (0.0026)	0.0183***(0.0017)	0.0519***(0.0026)	0.0534***(0.0022)	0.0583*** (0.0028)
ROA	0.0075*(0.0044)	-0.0169***(0.0023)	0.0050(0.0045)	0.0034(0.0038)	0.0071(0.0046)
Growth	0.0025*** (0.0004)	0.0009***(0.0003)	0.0013***(0.0004)	0.0015***(0.0004)	0.0024*** (0.0004)
Cash	-0.1086*** (0.0045)	-0.0093***(0.0021)	-0.1036***(0.0042)	-0.0815*** (0.0033)	-0.1122*** (0.0047)
Tangibility	0.0282*** (0.0034)	0.0228***(0.0021)	0.0300***(0.0033)	0.0285***(0.0028)	0.0287*** (0.0036)
Age	0.0205*** (0.0012)	0.0026***(0.0007)	0.0197***(0.0011)	0.0173***(0.0010)	0.0193*** (0.0013)
Firm fixed effect	yes	yes	yes	yes	yes
Fixed year effect	yes	yes	yes	yes	yes
Observed value	26,661	19,167	26,661	26,127	23,312
Number of enterprises	3,715	3,285	3,715	3,704	3,515
Within R^2	0.3535	0.1232	0.3409	0.3188	0.3611

Table 4 unifies the policy time point and controls the transition period in 2013, eliminates the negative financing cost sample, adopts the year-end debt caliber, implements stricter tail reduction and eliminates 2020 in turn. The core policy coefficient under each setting is significantly positive, indicating that the benchmark conclusion does not depend on a single variable caliber or sample processing.

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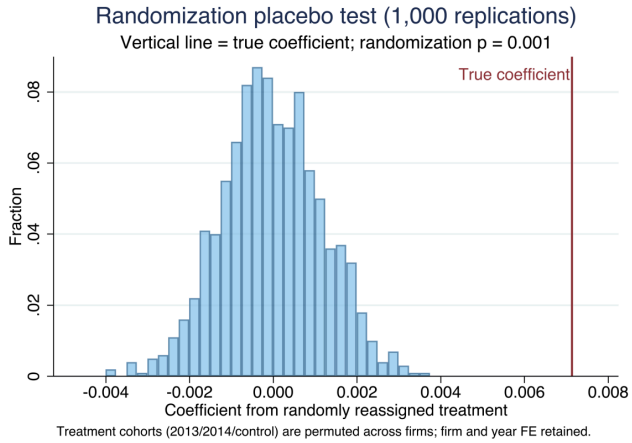


Figure 1. Random placebo test (1000 replicates)

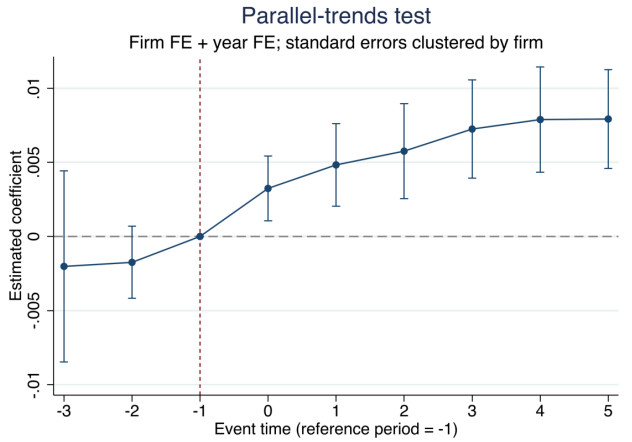


Figure 2. Parallel trend test and policy dynamic effect

The results of the event study showed that the confidence intervals of the estimated coefficients of the -3rd and -2nd periods before the implementation of the policy covered 0, and there was no significant difference between the treatment group and the control group before the implementation of the policy; After the implementation of the policy, the coefficient turned positive and gradually increased, indicating that the rise in financing costs was not a one-time jump, but gradually appeared in the process of continuous implementation and low-carbon transformation. This result supports the parallel trend needed by did to identify, and is consistent with the theoretical mechanism of the continuous entry of compliance costs into corporate cash flow.

5. Conclusions and policy implications

This paper uses the data of A-share listed companies from 2010 to 2020 and local carbon emissions trading pilot to construct a quasi natural experiment to investigate the impact of carbon market on corporate debt financing costs. There are three conclusions. First, the carbon trading pilot has significantly pushed up the cost of corporate debt financing. The benchmark estimate corresponds to an average increase of about 0.71 percentage points, and has passed a variety of robustness and identification tests. Second, the pilot policy significantly reduces the cash holdings of enterprises,

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and the reduction of cash reserves is significantly related to the rise of financing costs, indicating that liquidity contraction is an important channel for the policy to affect debt pricing. Third, the rise in financing costs is mainly concentrated in non-state-owned enterprises and young enterprises, which shows that the financing foundation and internal capital buffer of enterprises determine their ability to bear the cost of low-carbon transformation.

The above results show that the emission reduction incentives of the carbon market and the short-term financing pressure of enterprises can exist at the same time. Policy design should pay more attention to the time distribution of low-carbon transition costs, and mitigate short-term liquidity shocks while maintaining the intensity of carbon constraints. First, improve the transformation financing tools supporting the carbon market. By means of special loans for low-carbon transformation, discount interest support and carbon quota pledge financing, enterprises with real investment demand for emission reduction can be provided with funds with matching terms to avoid the rise of short-term financing prices and the compression of necessary green investment. Second, improve the standardization, comparability and verifiability of MRV and environmental information disclosure, and promote the effective connection between carbon emission information and bank credit, bond pricing and green rating system, so that the improvement of environmental information can be quickly transformed into the efficiency of risk identification. Third, implement differentiated green financial arrangements, take non-state-owned enterprises and young enterprises as important objects of liquidity support, and fine price them according to their carbon performance, emission reduction investment and solvency, so as to reduce transformation friction while maintaining market constraints.

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