

Transition Finance Policy and Financing Constraints of High-Carbon Enterprises: Evidence from Ownership Heterogeneity

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Abstract

Transition finance aims to direct capital towards the decarbonisation of high-carbon sectors, but its effectiveness depends on whether policy signals reshape credit allocation. Based on Chinese A-share listed firms from 2015 to 2025, this paper manually codes local transition-finance policies and constructs measures of policy adoption and policy intensity. Using a staggered difference-in-differences design based on industry exposure, the analysis finds that transition-finance policies produce an initial financing-support signal for high-carbon firms, but this effect is not robust to stricter fixed effects, alternative policy and industry definitions, or additional tests on debt maturity and debt costs. Policy intensity also fails to generate stable financing improvement, and state-owned enterprises' conventional financing advantage does not reliably extend to high-carbon transition finance. The evidence suggests that transition finance cannot rely on policy issuance alone. Its effectiveness depends on whether transition standards, verification mechanisms and risk-sharing arrangements are incorporated into banks' credit screening, pricing and monitoring.

Keywords

Transition finance, high-carbon firms, financing constraints, ownership heterogeneity, policy intensity.

1. Introduction

Under China's dual-carbon targets, high-carbon industries face a pronounced transition-finance dilemma. Sectors such as steel, chemicals, building materials, power, non-ferrous metals and transport are central to emissions reduction, and their technological retrofits, equipment renewal and energy substitution require sustained and large-scale capital investment. Yet their higher carbon intensity and environmental risk may also induce financial institutions to adopt a more cautious stance in credit and investment decisions. Capital markets have begun to price corporate carbon risk, with high-emission firms required to provide higher risk compensation [1]. Institutional investors also treat climate risk as financially material and incorporate it into portfolio management and corporate governance [2]. Financing for high-carbon firms is therefore not merely a conventional corporate-finance problem; it is a question of how financial resources are allocated during low-carbon transition.

Traditional green finance primarily supports green industries, green projects and low-carbon technologies. Although this framework helps channel capital towards environmentally friendly activities, it may insufficiently cover firms that remain in high-emission stages but possess credible decarbonisation potential and transition needs. Climate finance research shows that climate risk is priced across equities, bonds, real estate and other asset classes [3]. Green assets may benefit from investor preferences and lower capital costs, whereas high-carbon or brown assets are more exposed to climate risk, regulatory expectations and shifts in investor demand

[4, 5]. If financial resources flow primarily to already-green firms and projects, high-carbon industries may lack the financing required for substantive transition.

Transition finance has emerged in response to this gap. Unlike green finance, which mainly supports activities that are already green, transition finance aims to support the decarbonisation of high-carbon sectors under conditions of identifiability, verifiability and accountability. Its function is not to expand credit unconditionally, but to use transition catalogues, sectoral standards, technical pathways, disclosure requirements and financial instruments to help financial institutions identify borrowers with genuine transition capacity. In this sense, transition finance converts an undifferentiated high-carbon risk into a transition activity that can be identified, constrained and financed.

A substantial literature now links green finance, climate risk and corporate financing. Green credit policy affects debt costs and maturity structures [6], and may shape the green transformation of high-polluting firms through financing constraints, debt costs and market attention [7]. Green bonds, too, have been associated with broader financing channels, stronger market reactions and green innovation [8–10]. Yet the evidence still leaves an important blind spot. Much of it is built around broad green-finance instruments, whereas transition finance is a narrower institutional response to the decarbonisation of high-carbon sectors. Many studies also rely on aggregate green-finance indices or bond issuance, rather than on the local policy texts through which transition finance is actually operationalised. The ownership dimension is especially unresolved: it remains unclear whether these new policy tools loosen the old pattern of ownership-based credit rationing, or quietly reproduce it.

This article studies that question using Chinese A-share listed firms over 2015–2025. I manually code local transition-finance policy documents and build region-year measures of policy adoption (TFPolicy) and policy intensity (TFIntensity). By matching these measures with firms' high-carbon industry exposure and ownership status, the analysis estimates a staggered difference-in-differences model based on industry exposure. The design asks a simple empirical question: once a local transition-finance policy is introduced, do high-carbon firms experience a sharper easing of financing constraints than comparable non-high-carbon firms in the same local setting? The paper then examines whether policy intensity matters, and whether the allocation of transition-finance resources differs between state-owned and non-state firms.

2. Theory and Research Hypotheses

2.1. Transition-finance Policy And Financing Constraints of High-Carbon Firms

High-carbon firms usually require large and long-term investment to complete low-carbon transition, including equipment renewal, process upgrading, clean-energy substitution and emissions-monitoring systems. These investments are capital-intensive, slow to pay back and subject to technological uncertainty. For lenders, the central difficulty is not only whether a firm can repay its debt, but also whether its transition activities are credible, whether proceeds are used for genuine decarbonisation, and whether future carbon regulation will raise default risk. Existing studies show that green credit and green finance policies can affect firms' debt costs, debt maturity and green transformation incentives [6, 7].

Transition-finance policies may ease these constraints by reducing information frictions between banks and high-carbon firms. Sectoral standards, transition catalogues, disclosure requirements and third-party verification make transition projects easier to screen, monitor and price. In markets with information asymmetry, banks may ration credit when they cannot accurately evaluate borrower quality or project risk [11, 12]. By improving the credibility and observability of transition activities, local transition-finance policies may therefore reduce credit rationing for high-carbon firms. If the policy is effective, financing constraints should fall more for high-carbon firms than for non-high-carbon firms after policy implementation.

H1: After the implementation of transition-finance policies, financing constraints decline significantly for high-carbon firms relative to non-high-carbon firms.

2.2. Policy Intensity And Financing Constraints of High-Carbon Firms

Identifying whether a region has issued a transition-finance policy is only the first step; it does not capture the substantive force of the policy. Local policies differ markedly in specificity and implementation tools. Some merely state broad support for transition finance, whereas others specify transition catalogues, sectoral technical pathways, disclosure requirements, third-party verification, project pipelines and financial instruments. The former mainly signals policy intent, while the latter is more likely to enter project screening, risk pricing and post-loan management.

A stronger policy intensity implies a more complete institutional chain from project identification to risk sharing. Clear catalogues and technical standards reduce screening costs; disclosure and verification requirements reduce monitoring costs; and interest subsidies, risk compensation and financing-matching mechanisms may improve financial institutions' assessment of the risk-return profile of transition lending. Existing evidence also suggests that green-finance policies depend not only on formal adoption but also on implementation environments and complementary arrangements [13]. Financial markets' repricing of green preferences and climate risk also shapes the relative performance of green and high-carbon assets [5]. More specific, complete and enforceable transition-finance policies should therefore be more likely to ease financing constraints for high-carbon firms.

H2: The higher the intensity of transition-finance policy, the stronger the reduction in financing constraints for high-carbon firms.

2.3. Ownership Heterogeneity And Policy Resource Allocation

Ownership has long shaped corporate financing capacity in China. State-owned enterprises often benefit from implicit government backing, stronger policy absorption capacity and more stable bank-firm relationships, which make them more likely to obtain formal financial support. China's formal financial system has historically served the state sector disproportionately [14], while credit discrimination against non-state firms in transition economies has also been discussed through the lenses of information, incentives and institutions [15]. In the context of transition finance, ownership heterogeneity is therefore not merely a grouping variable; it is a window into the allocation of policy resources.

One plausible channel runs through state ownership. State-owned firms are often larger, more visible to local governments, and easier for banks to evaluate through established government-bank-firm relationships. If financial institutions continue to rely on government backing and existing credit channels during policy implementation, transition finance may operate through conventional resource-allocation mechanisms and generate stronger financing improvements for state-owned high-carbon firms.

H3a: Under a resource-bias mechanism, transition-finance policies reduce financing constraints more strongly for state-owned high-carbon firms, thereby extending existing ownership-based allocation advantages.

The opposite prediction is also credible. Non-state high-carbon firms start from a more constrained financing position, so a credible transition catalogue, disclosure rule or project certification system may have a larger marginal effect on their bankability. By reducing banks' screening costs and improving the credibility of transition projects, these policies may partly neutralise long-standing ownership discrimination in credit markets. Financing constraints have been shown to weaken firms' green innovation capacity, with private firms being more vulnerable to such constraints [16]. Non-state high-carbon firms may therefore have more to gain if transition finance works as intended.

H3b: Under a marginal-improvement mechanism, transition-finance policies reduce financing constraints more strongly for non-state high-carbon firms, thereby mitigating ownership-based discrimination in credit markets.

3. Research Design

3.1. Sample Selection And Data Sources

The sample consists of Chinese A-share listed firms from 2015 to 2025. Firm financial data, basic company information, financial indicators, Special Treatment status and ownership attributes are obtained from the CSMAR database. Local transition-finance policy data are manually collected from publicly available policy texts issued by local governments, financial regulatory authorities and local branches of the People's Bank of China.

Standard screening rules are applied to the initial panel. Financial institutions are removed because their balance sheets are not comparable with those of industrial firms; distressed observations marked as ST, *ST, PT or subject to delisting risk are also removed to reduce noise from abnormal financial or trading conditions. I further drop firm-years before listing and observations with missing core variables. Continuous variables are winsorised at the 1st and 99th percentiles.

Policy exposure is matched to firms by location. City-level transition-finance policies are matched to firm city, while provincial catalogues, standards and guidelines are matched to firm province. For policies issued late in a year and unlikely to affect financing decisions within that same year, a conservative effective-year rule is applied: policy exposure is counted from the following year. Robustness tests further assess whether the results depend on the timing of policy exposure, including by excluding observations from 2025.

3.2. Identification of Transition-Finance Policies And Construction of Policy Intensity

The core explanatory variable is the transition-finance policy indicator, $TFPolicy_{ct}$, where c denotes firm location and t denotes year. Drawing on the G20 Transition Finance Framework, OECD transition-finance guidance and Chinese local transition-finance catalogues, implementation guidelines and working instructions [17–19], local policies are identified as transition-finance policies when they explicitly include a transition-finance catalogue, supported-project catalogue, sectoral implementation guideline, working instruction or relevant transition-finance standard. If region c has issued a policy document that meets this definition by year t , $TFPolicy_{ct}$ equals 1; otherwise it equals 0.

Policy intensity is captured by $TFIntensity$. The index is intended to measure how complete and operational a local policy text is. Seven dimensions are coded: dedicated policy document, catalogue or standard, sector coverage, technical pathway, transition plan, disclosure or verification requirement, and financial instrument or incentive mechanism. Each dimension receives a value of 1 when satisfied and 0 otherwise; the sum yields an intensity index ranging from 0 to 7.

General green-finance, carbon-finance, carbon-peaking pilot or low-carbon industrial-support policies are not automatically treated as transition-finance policies. A policy is included only when its text contains substantive transition-finance content such as catalogues, sectoral standards, technical pathways, disclosure and verification requirements, or complementary financial instruments. Detailed scoring rules may be reported in an appendix.

3.3. Identification of High-Carbon Firms

High-carbon firms are identified by industry affiliation. Based on the People's Bank of China's transition-finance standards for key sectors, industries covered by local transition-finance

catalogues and listed-company industry classifications, this study defines coal, petroleum processing, chemicals, steel, non-ferrous metals, non-metallic mineral products, electricity and heat, paper-making, air transport and water transport as core high-carbon industries. A firm in a core high-carbon industry is assigned $\text{HighCarbon}_i^{\text{Core}}=1$; otherwise, $\text{HighCarbon}_i^{\text{Core}}=0$.

Because the boundary of high-carbon industries may vary across policy documents and classification systems, a broader high-carbon industry definition, $\text{HighCarbon}_i^{\text{Broad}}$, is also constructed for robustness tests. Firm-level carbon-emissions data are not used for the main classification because disclosure remains incomplete, inconsistent and difficult to compare over the sample period. Industry-based classification ensures replicability and aligns with the policy practice of targeting key high-carbon sectors.

3.4. Variable Definitions

Table 1 defines the main variables. The dependent variable is corporate financing constraints, measured using the SA index proposed by Hadlock and Pierce [20]. The study defines $\text{FC} = -\text{SA}$ so that a larger value indicates stronger financing constraints. The core explanatory variables are TFPolicy and TFIntensity . TFPolicy is manually coded from local transition-finance policy texts, while TFIntensity is constructed from seven policy-design dimensions. The treatment-group variable is $\text{HighCarbon}^{\text{Core}}$, and the ownership variable is SOE . Control variables include firm size, leverage, profitability, growth, operating cash flow, asset tangibility and growth opportunities.

Table 1. Variable definitions

Category	Symbol	Variable	Definition / calculation	Source / note
Dependent variable	(FC)	Financing constraints	(FC=-SA); larger values indicate stronger financing constraints	Calculated from firm size and firm age
Dependent variable	(SA)	SA index	(SA=-0.737Size+0.043Size ² -0.040Age)	Hadlock and Pierce (2010)
Core explanatory variable	(TFPolicy)	Transition-finance policy	Equals 1 if region (c) has implemented a strict transition-finance policy by year (t), and 0 otherwise	Manually coded local policy texts
Core explanatory variable	(TFIntensity)	Policy intensity	Sum of seven policy-intensity dimensions; range 0–7	Policy scoring rules
Treatment variable	($HighCarbon_i^{Core}$)	Core high-carbon firm	Equals 1 if the firm belongs to a core high-carbon industry, and 0 otherwise	Industry-based classification
Robustness variable	($HighCarbon_i^{broad}$)	Broad high-carbon firm	Equals 1 if the firm belongs to a broad high-carbon industry, and 0 otherwise	Robustness tests
Ownership variable	(SOE)	State-owned enterprise	Equals 1 for central, local or state-controlled firms, and 0 otherwise	CSMAR ownership data
Control variable	(Size)	Firm size	Natural logarithm of total assets	CSMAR financial statements
Control variable	(Lev)	Leverage	Total liabilities / total assets	CSMAR financial indicators
Control variable	(ROA)	Profitability	Net profit / total assets	CSMAR financial indicators
Control variable	(Growth)	Growth	Revenue growth rate	CSMAR financial indicators
Control variable	(CFO)	Operating cash flow	Net operating cash flow / total assets	CSMAR cash-flow statement
Control variable	(Tangibility)	Asset tangibility	Net fixed assets / total assets	CSMAR balance sheet
Control variable	(TobinQ)	Growth opportunities	Tobin's Q	CSMAR relative valuation data
Additional financing outcome	(LongDebtRatio)	Long-term debt ratio	Long-term debt / interest-bearing liabilities	Constructed from balance sheet
Additional financing outcome	(DebtCost)	Cost of debt	Interest expense / average interest-bearing liabilities	Constructed from income statement and balance sheet
Interaction	(TFPolicy _{ct} × HighCarbon _i)	Policy × high-carbon firm	Core explanatory variable in the baseline model	Identifies industry-targeted policy effects
Interaction	(TFIntensity _{ct} × HighCarbon _i)	Intensity × high-carbon firm	Core variable in policy-intensity tests	Identifies effects of institutional policy intensity
Interaction	(TFPolicy _{ct} × HighCarbon _i × SOE _{it})	Policy × high-carbon × ownership	Core variable in ownership-heterogeneity tests	Identifies additional ownership-specific policy effects

Note. FC = -SA, so larger values represent stronger financing constraints. A negative coefficient on the core interaction indicates a relative decline in financing constraints.

3.5. Model Specification And Identification Strategy

To identify the effect of transition-finance policies on the financing constraints of high-carbon firms, this study does not rely on a simple before-after comparison. Instead, it exploits regional and temporal variation in local policy rollout, combined with firm-level high-carbon industry exposure, to estimate a staggered difference-in-differences model based on industry exposure. The core logic is straightforward. If transition-finance policies target the low-carbon financing of high-carbon sectors, financing constraints should decline more for high-carbon firms than for non-high-carbon firms in the same region and year.

The baseline specification is:

$$FC_{ict} = \alpha + \beta_1(TFPolicy_{ct} \times HighCarbon_i) + \gamma Controls_{it} + \mu_i + \lambda_{ct} + \theta_{jt} + \varepsilon_{ict} \quad (1)$$

Where FC_{ict} denotes financing constraints of firm i in region c and year t ; $TFPolicy_{ct}$ indicates whether region c has implemented a transition-finance policy in year t ; $HighCarbon_i$ indicates whether firm i belongs to a high-carbon industry; $Controls_{it}$ denotes firm-level controls; μ_i denotes firm fixed effects; λ_{ct} denotes region-year fixed effects; θ_{jt} denotes industry-year fixed effects; and ε_{ict} is the error term.

To examine whether policy completeness and implementation intensity matter, the policy dummy is replaced with the policy-intensity index:

$$FC_{ict} = \alpha + \beta_2(TFIntensity_{ct} \times HighCarbon_i) + \gamma Controls_{it} + \mu_i + \lambda_{ct} + \theta_{jt} + \varepsilon_{ict} \quad (2)$$

Where $TFIntensity_{ct}$ denotes the transition-finance policy intensity of region c in year t .

To test the ownership-specific allocation of transition-finance resources, the following triple-interaction model is estimated:

$$FC_{ict} = \alpha + \beta_1(TFPolicy_{ct} \times HighCarbon_i) + \beta_2(TFPolicy_{ct} \times SOE_{it}) + \beta_3(HighCarbon_i \times SOE_{it}) + \beta_4(TFPolicy_{ct} \times HighCarbon_i \times SOE_{it}) + \gamma Controls_{it} + \lambda_{ct} + \theta_{jt} + \varepsilon_{ict} \quad (3)$$

Where SOE_{it} equals 1 for state-owned firms and 0 for non-state firms. Lower-order terms are retained to satisfy the hierarchy principle of interaction models; terms that are not separately identifiable are absorbed by fixed effects in estimation.

Finally, to assess whether policy effects are transmitted to concrete financing conditions, the study estimates:

$$Y_{ict} = \alpha + \beta_5(TFPolicy_{ct} \times HighCarbon_i) + \gamma Controls_{it} + \mu_i + \lambda_{ct} + \theta_{jt} + \varepsilon_{ict} \quad (4)$$

Where Y_{ict} denotes additional financing outcomes, including long-term debt ratio and cost of debt.

3.6. Descriptive Statistics

Table 2 reports descriptive statistics for the full baseline sample. Because the main model relies on relative changes between high-carbon and non-high-carbon firms, full-sample descriptive statistics provide the most appropriate overview of the estimating sample.

Table 2. Descriptive statistics for the full baseline sample

Symbol	Variable	N	Mean	Std. dev.	Min	P25	Median	P75	Max
(FC)	Financing constraints	43153	-4.5439	1.5175	-11.3705	-5.2538	-4.2603	-3.5301	-1.4087
(TFPolicy)	Transition-finance policy	43153	0.104	0.3053	0	0	0	0	1
(TFIntensity)	Policy intensity	43153	0.6695	1.9858	0	0	0	0	7
($HighCarbon_i^{Core}$)	Core high-carbon firm	43153	0.1793	0.3836	0	0	0	0	1
($HighCarbon_i^{broad}$)	Broad high-carbon firm	43153	0.3028	0.4595	0	0	0	1	1
(SOE)	State-owned enterprise	40818	0.2952	0.4562	0	0	0	1	1
(Size)	Firm size	43153	22.2804	1.3357	19.2675	21.3439	22.0692	23.0066	27.2933
(Lev)	Leverage	43153	0.4093	0.2056	0.0561	0.2434	0.3977	0.5561	0.9599
(ROA)	Profitability	43153	0.0289	0.0714	-0.3507	0.0093	0.0338	0.0642	0.2056
(Growth)	Growth	43153	0.3142	0.8533	-0.8124	-0.0417	0.1102	0.3703	6.1507
(CFO)	Operating cash flow	43153	0.0479	0.0671	-0.1713	0.0109	0.0472	0.0866	0.2501
(Tangibility)	Asset tangibility	43153	0.1991	0.1509	0.0013	0.0808	0.1675	0.2847	0.6643
(TobinQ)	Growth opportunities	43153	2.0568	1.3486	0.8242	1.2446	1.6256	2.3419	9.0831
(LongDebtRatio)	Long-term debt ratio	25015	0.448	0.3251	0	0.1607	0.3909	0.7245	1

Note. The sample includes non-financial, non-ST firms with complete core variables. DebtCost is not reported in the descriptive statistics because its sample definition differs from the baseline sample.

The table shows substantial dispersion in financing constraints, leverage, profitability, growth and cash-flow conditions. The distributions of TFPolicy and TFIIntensity suggest that local transition-finance policies were still being gradually introduced during the sample period and that the share of observations exposed to strictly defined policies is limited. The high-carbon indicators permit robustness checks under alternative industry definitions, while the distribution of SOE supports subsequent ownership-heterogeneity analysis.

4. Empirical Results and Analysis

4.1. Baseline Regressions: Initial Evidence And Identification Boundaries

As documented in Table 3, the baseline estimates provide some initial evidence of financing relief, although that evidence is not robust to the most demanding specifications. The dependent variable is $FC = -SA$; larger values indicate stronger financing constraints, so a negative coefficient on the core interaction implies a relative easing of financing constraints.

Table 3. Baseline regression results

Variable	(1) Firm+Year FE	(2) + Controls	(3) Province × Year FE	(4) Main FE	(5) City × Year FE
TFPolicy _{ct} × HighCarbon _i ^{Core}	-0.0930**	-0.0093***	-0.0116***	0.0028	0.0041
	-0.0393	-0.0032	-0.0041	-0.0058	-0.0051
Controls	No	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	No	No	No
Province × year fixed effects	No	No	Yes	Yes	No
City × year fixed effects	No	No	No	No	Yes
Industry × year fixed effects	No	No	No	Yes	Yes
Clustered standard errors	Province	Province	Province	Province	Province
Observations	43153	43153	43153	43153	43153
Clusters	34	34	34	34	34
Within (R ²)	0.0006	0.9867	0.9866	0.9866	0.9867

Note. Province-clustered robust standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Columns (2) and (3) show that the coefficients on TFPolicy_{ct} × HighCarbon_i^{Core} are -0.0093 and -0.0116, respectively, both significant at the 1% level. Under these relatively basic specifications, transition-finance policies are associated with lower financing constraints for high-carbon firms. The picture changes once the specification becomes stricter. After introducing industry-year fixed effects in column (4), the coefficient turns positive and becomes insignificant; the city-year fixed-effects specification in column (5) is also insignificant.

The implication is deliberately modest. Transition-finance policies appear to generate an initial financing-support signal, but this signal does not survive tighter identification. H1 therefore receives only limited support. The result points to an identification boundary rather than to a stable policy effect.

4.2. Policy Intensity: Whether Institutionalised Text Becomes Financing Improvement

Turning to policy intensity, Table 4 asks whether more complete local transition-finance policies are more likely to reduce financing constraints for high-carbon firms.

Table 4. Policy-intensity tests

Variable	(1) Firm+Year FE	(2) Province × Year FE	(3) Main FE	(4) Broad high-carbon intensity	(5) Broad policy intensity
$TFIntensity_{ct} \times HighCarbon_i^{Core}$	-0.0014*** (-0.0005)	-0.0019*** (-0.0006)	0.0001 (-0.0009)		
$TFIntensity_{ct} \times HighCarbon_i^{Broad}$				-0.0001 (-0.0005)	
$TFIntensity_{ct}^{Broad} \times HighCarbon_i^{Core}$					-0.0002 (-0.0008)
Controls	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	No	No	No	No
Province × year fixed effects	No	Yes	Yes	Yes	Yes
City × year fixed effects	No	No	No	No	No
Industry × year fixed effects	No	No	Yes	Yes	Yes
Clustered standard errors	Province	Province	Province	Province	Province
Observations	43153	43153	43153	43153	43153
Clusters	34	34	34	34	34
Within (R ²)	0.9867	0.9866	0.9866	0.9866	0.9866

Note. Province-clustered robust standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

In columns (1) and (2), the coefficients on $TFIntensity_{ct} \times HighCarbon_i^{Core}$ are -0.0014 and -0.0019, respectively, and are statistically significant. This pattern suggests that, before fully controlling for industry-year shocks, high-carbon firms in regions with more intensive transition-finance policies experience some easing of financing constraints. Once industry-year fixed effects are included in column (3), however, the coefficient is essentially zero. Alternative high-carbon and policy-intensity definitions in columns (4) and (5) do not restore significance. H2 is therefore only weakly supported. The completeness of a policy text is not the same as a change in credit allocation. The bottleneck seems to lie between policy design and financial implementation.

4.3. Ownership Heterogeneity: Whether Ownership Advantages Enter High-Carbon Transition Finance

The results in Table 5 tell a more nuanced story regarding ownership. The core coefficient is the triple interaction $TFPolicy_{ct} \times HighCarbon_i \times SOE_{it}$, which tests whether transition-finance policies have an additional effect for state-owned high-carbon firms.

Table 5. Ownership-heterogeneity tests

Variable	(1) Triple, SOE	(2) Triple, SOE broad	(3) Broad HC triple	(4) Non-SOE sample	(5) SOE sample
$TFPolicy_{ct} \times HighCarbon_i^{Core}$	0.003 (-0.0066)	0.003 (-0.0067)		0.0008 (-0.0075)	0.0102 (-0.0075)
$TFPolicy_{ct} \times HighCarbon_i^{Broad}$			0.001 (-0.0039)		
$TFPolicy_{ct} \times SOE_{it}$	-0.0158*** (-0.0039)		-0.0143*** (-0.003)		
$TFPolicy_{ct} \times SOE_{it}^{Broad}$		-0.0158*** (-0.0039)			
$TFPolicy_{ct} \times HighCarbon_i^{Core} \times SOE_{it}$	0.0104 (-0.0082)				
$TFPolicy_{ct} \times HighCarbon_i^{Core} \times SOE_{it}^{Broad}$		0.0103 (-0.0082)			
$TFPolicy_{ct} \times HighCarbon_i^{Broad} \times SOE_{it}$			0.0022 (-0.0073)		
Total effect for state-owned high-carbon firms ($\beta_1 + \beta_4$)	0.0134 (-0.0084)	0.0134 (-0.0084)	0.0031 (-0.0063)		
Controls	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	No	No	No	No
Province $\times$ year fixed effects	Yes	Yes	Yes	Yes	Yes
City $\times$ year fixed effects	No	No	No	No	No
Industry $\times$ year fixed effects	Yes	Yes	Yes	Yes	Yes
Clustered standard errors	Province	Province	Province	Province	Province
Observations	40818	40842	40818	28767	12051
Clusters	34	34	34	33	33
Within (R^2)	0.9867	0.9867	0.9867	0.987	0.9887

Note. Province-clustered robust standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Column (1) reports the baseline ownership-heterogeneity model; column (2) uses a broader SOE definition; column (3) uses the broad high-carbon definition; columns (4) and (5) report non-SOE and SOE subsample regressions.

The coefficient on $TFPolicy_{ct} \times SOE_{it}$ is significantly negative, indicating a decline in financing constraints for state-owned firms as a whole after policy implementation. But that advantage does not appear to travel cleanly into the high-carbon transition setting. The triple interaction is insignificant, and the total effect for state-owned high-carbon firms ($\beta_1 + \beta_4$) is not statistically significant. In the non-SOE and SOE subsamples, the coefficients on $TFPolicy_{ct} \times HighCarbon_i^{Core}$ are also insignificant.

These results leave little support for either competing hypothesis. The conventional financing advantage of state ownership does not stably extend to state-owned high-carbon firms, while transition-finance policies do not significantly mitigate financing disadvantages among non-state high-carbon firms. In high-carbon transition finance, ownership advantages appear conditional rather than automatic.

4.4. Robustness Checks

The robustness checks in Table 6 probe whether the baseline conclusion depends on the definitions of policy exposure, high-carbon industries, the sample window or regional fixed effects.

Table 6. Robustness checks

Variable	(1) Broad high-carbon	(2) Broad policy	(3) Broad policy × broad HC	(4) Excluding 2025	(5) City × Year FE
$TFPolicy_{ct} \times HighCarbon_i^{Broad}$	0.0007 (-0.0036)				
$TFPolicy_{ct}^{Broad} \times HighCarbon_i^{Core}$		-0.0021 (-0.0043)			
$TFPolicy_{ct}^{Broad} \times HighCarbon_i^{Broad}$			-0.0051 (-0.003)		
$TFPolicy_{ct} \times HighCarbon_i^{Core}$				-0.0001 (-0.0068)	0.0044 (-0.0051)
Controls	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Province × year fixed effects	Yes	Yes	Yes	Yes	No
City × year fixed effects	No	No	No	No	Yes
Industry × year fixed effects	Yes	Yes	Yes	Yes	Yes
Clustered standard errors	Province	Province	Province	Province	Province
Observations	43153	43153	43153	38059	43153
Clusters	34	34	34	33	34
Within (R^2)	0.9866	0.9866	0.9866	0.9866	0.9867

Note. Province-clustered robust standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Column (1) uses the broad high-carbon definition; column (2) uses the broad policy definition; column (3) uses both broad definitions; column (4) excludes 2025; column (5) uses city-year fixed effects.

The results are broadly consistent with the baseline findings. When the broad high-carbon definition is used in column (1), the coefficient on $TFPolicy_{ct} \times HighCarbon_i^{Broad}$ is small and statistically insignificant. Replacing the strict policy definition with a broader policy measure in column (2), and using both broad definitions in column (3), does not generate a stable negative effect. The estimate also remains insignificant after excluding observations from 2025 in column (4) and after replacing province-year fixed effects with city-year fixed effects in column (5).

These robustness checks suggest that the estimated policy effect is not robust to alternative classification rules, sample-window adjustment or a more granular regional fixed-effect structure. This pattern is consistent with the baseline results and reinforces the view that the financing effect of transition-finance policies remains conditional rather than stable.

4.5. Additional Financing Outcomes

The final set of tests moves closer to actual financing terms. While $FC = -SA$ captures a broader financing-constraint condition, the long-term debt ratio and the cost of debt provide more direct evidence on whether transition-finance policies affect debt maturity structure and borrowing prices. Table 7 reports the results.

Table 7. Additional financing-outcome tests

Variable	(1) Long-term debt ratio	(2) Debt cost: interest expense / avg. interest-bearing debt	(3) Debt cost: interest expense / ending interest-bearing debt	(4) Debt cost: broad high-carbon	(5) Debt cost: City × Year FE
$TFPolicy_{ct} \times HighCarbon_i^{Core}$	0.0123 (-0.0163)	0.0001 (-0.0025)	-0.0008 (-0.0051)		0 (-0.0029)
$TFPolicy_{ct} \times HighCarbon_i^{Broad}$				-0.0001 (-0.0017)	
Controls	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Province × year fixed effects	Yes	Yes	Yes	Yes	No
City × year fixed effects	No	No	No	No	Yes
Industry × year fixed effects	Yes	Yes	Yes	Yes	Yes
Clustered standard errors	Province	Province	Province	Province	Province
Observations	25589	32531	33226	32531	31438
Clusters	33	33	33	33	34
Within (R^2)	0.0078	0.0081	0.0237	0.0081	0.0064

Note. Province-clustered robust standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Column (1) uses the broad high-carbon definition; column (2) uses the broad policy definition; column (3) uses both broad definitions; column (4) excludes 2025; column (5) uses city-year fixed effects.

Column (1) shows that the coefficient on $TFPolicy_{ct} \times HighCarbon_i^{Core}$ is positive but statistically insignificant when the dependent variable is the long-term debt ratio. This indicates that transition-finance policies have not yet generated clear evidence of extending the debt maturity structure of high-carbon firms. In other words, even where transition-finance policies are introduced, high-carbon firms do not appear to obtain a significantly larger share of long-term debt.

Columns (2) and (3) turn to debt-financing costs. The coefficients are close to zero and statistically insignificant under both measures of debt costs, suggesting that transition-finance policies have not produced a measurable reduction in borrowing prices for high-carbon firms. The result is unchanged when the broad high-carbon definition is used in column (4) and when city-year fixed effects are introduced in column (5).

Taken together, Table 7 suggests that the limited financing-support signal observed in the baseline regressions has not been clearly transmitted to more direct financing outcomes. Transition-finance policies do not yet appear to significantly lengthen debt maturity or lower debt-financing costs for high-carbon firms. This evidence is therefore best interpreted as a supplementary test of financing transmission rather than as a formal mediation analysis.

5. Conclusions and Outlook

5.1. Main Findings

Using Chinese A-share listed firms from 2015 to 2025, this study manually constructs transition-finance policy and policy-intensity measures from local policy texts and combines

them with firms' high-carbon industry exposure and ownership attributes. The evidence shows that transition-finance policies generate signs of financing relief under relatively basic specifications. After controlling for industry-year fixed effects, replacing policy and high-carbon definitions, and examining long-term debt ratio and debt-financing costs, however, the policy effect no longer forms stable evidence. Local transition-finance policies have therefore released a financing-support signal, but this signal has not yet been robustly translated into improved financing-constraint indicators.

The conditional and bounded nature of the policy effect does not imply that transition-finance policies lack institutional value. Rather, it reveals transmission frictions between policy text and financial execution. Policy-intensity tests show that institutional completeness does not automatically equal effective credit implementation. Ownership-heterogeneity tests show that the traditional financing advantage of state-owned enterprises does not stably extend to state-owned high-carbon firms, while policies do not significantly relieve the credit-rationing difficulties of non-state high-carbon firms. The central conclusion is that the effectiveness of transition finance depends less on whether policy documents are issued than on whether local governments, financial institutions and firms can build transition-financing mechanisms that are identifiable, verifiable, priceable and enforceable.

This conclusion has policy implications. Future transition-finance policy should focus less on expanding the number or coverage of policy documents and more on project identification, corporate disclosure, third-party verification, risk compensation and the integration of transition standards into banks' credit models. Only when policy standards enter due diligence, risk pricing and post-loan monitoring can transition finance move from institutional aspiration to financing improvement perceived by high-carbon firms.

5.2. Limitations and Future Research

Several limits should be noted. The most immediate one is timing. Local transition-finance policies are concentrated toward the end of the sample period, leaving only a short window after policy adoption. Moving from a policy document to bank credit adjustment, and then to financial-statement outcomes, takes time. The estimates should therefore be read as evidence on early-stage effects, not as a final verdict on long-run policy performance.

Measurement is another constraint. The SA index is useful because it is relatively exogenous to short-run financial decisions, but that strength also makes it slow-moving. Since the index is driven by firm size and age, it may not fully capture short-term shifts in credit supply for asset-heavy high-carbon firms. More direct variables—bank loans, credit lines, loan rates, bond spreads or transition-loan project data—would allow future work to identify financing behaviour more precisely.

A deeper limitation lies inside the bank. Public data do not reveal how lenders translate policy standards into credit approval, risk pricing or post-loan monitoring. The additional tests on debt maturity and debt cost offer indirect evidence only. Future research could make progress by linking transition-loan registers, interest-subsidy records, risk-compensation data, project pipelines and bank credit files. That would make it possible to see where the transmission chain breaks—and under what local financial conditions transition finance becomes real credit support.

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Appendix

TFIntensity_{ct} is constructed as the sum of seven binary indicators. Each dimension is assigned a value of 1 when the relevant criterion is explicitly satisfied in the policy text, and 0 otherwise. The total score ranges from 0 to 7.

Appendix Table A1. Coding rules for transition-finance policy intensity

Coding dimension	Variable name	Criterion for value 1	Criterion for value 0	Theoretical meaning / explanation
Dedicated transition-finance policy document	dedicated_TF_doc	The policy title or main text explicitly refers to transition finance, a transition-finance catalogue, transition-finance standard, implementation guideline or working instruction.	The document only refers to general green finance, carbon finance, low-carbon development or industrial transition without explicit transition-finance content.	Prevents general green-finance policies from being misclassified as transition-finance policies.
Catalogue or standard	catalog_or_standard	The policy provides a transition-finance catalogue, supported-project list, eligible activity list, sectoral standard, implementation guideline, group standard or working instruction.	The document only contains general principles, policy objectives or broad encouragement without a catalogue, list or standard.	Determines whether the policy provides an identifiable basis for project screening.
Coverage of high-carbon sectors	highcarbon_sector	The policy explicitly covers high-carbon or hard-to-abate sectors, such as steel, coal power, building materials, chemicals, non-ferrous metals, coking, aluminium, ceramics, aviation or water transport.	The policy does not specify high-carbon sectors or only refers generally to green or low-carbon industries.	Ensures consistency with the high-carbon industry classification used in the empirical sample.
Technical pathway or threshold	technical_path_threshold	The policy specifies technical pathways, energy-efficiency benchmarks, emissions-reduction methods, target values, carbon-intensity requirements or emissions-reduction thresholds.	The policy only expresses general support for transition without technical requirements or measurable thresholds.	Captures whether the policy makes transition activities technically identifiable.
Transition plan or target	transition_plan_or_target	The policy requires or encourages firms/projects to provide transition plans, decarbonisation targets, investment plans, implementation schedules or measurable transition roadmaps.	No transition plan, roadmap, target or implementation schedule is mentioned.	Indicates whether the policy supports an assessment of transition credibility.
Disclosure or verification	disclosure_or_verification	The policy requires information disclosure, third-party verification, carbon monitoring, emissions reporting, graded disclosure, performance tracking or anti-greenwashing arrangements.	No disclosure, verification, monitoring or performance-tracking requirement is mentioned.	Links the policy to the reduction of information asymmetry between firms and financial institutions.
Financial tools, incentives or project pool	financial_tools_incentives_project_pool	The policy includes transition loans, transition bonds, credit support, interest subsidies, risk compensation, guarantees, project pools, entity pools, product matching or financing-matching mechanisms.	No financial instrument, incentive mechanism, risk-sharing arrangement or project-pool arrangement is mentioned.	Links the policy to financing availability and potential reductions in financing costs.
Total policy intensity	TFIntensity	Sum of the seven indicators above. The value ranges from 0 to 7.	—	Used as the policy-intensity variable in the extended regressions.

Notes. Each policy document is coded according to its explicit textual content. Ambiguous, rhetorical or purely promotional statements are coded as 0. When multiple transition-finance policy documents are issued in the same region-year, the highest available score is used to represent the policy intensity of that region-year. The baseline model uses $TFPolicy_{ct}$, while the extended specification uses $TFIntensity_{ct}$.

Appendix Table A2. Local transition-finance policy events and coding results

Policy ID	Region	Policy level	Policy document	Event year	Effective year	Policy type	Main definition	Broad definition	Intensity
TF_HUZHOU_2022	Huzhou, Zhejiang	City	Huzhou Transition Finance Development Roadmap and Transition Finance Support Catalogue (2022)	2022	2022	Roadmap / catalogue	1	1	6
TF_HUZHOU_2023	Huzhou, Zhejiang	City	Huzhou Transition Finance Support Activity Catalogue (2023)	2023	2024	Support activity catalogue	1	1	7
TF_CHONGQING_2023	Chongqing	Municipality	Chongqing Transition Finance Supported Project Catalogue (2023)	2023	2023	Supported project catalogue	1	1	6
TF_TIANJIN_2023	Tianjin	Municipality	Tianjin Implementation Guideline for Transition Finance in Key Areas of the Chemical Industry	2023	2024	Sectoral guideline / group standard	1	1	5
TF_SHANGHAI_2023	Shanghai	Municipality	Shanghai Transition Finance Catalogue (Trial) and Application Instructions	2023	2024	Transition finance catalogue	1	1	7
TF_HEBEI_2024	Hebei	Province	Hebei Transition Finance Working Guideline for the Steel Industry (2023–2024)	2024	2024	Sectoral working guideline	1	1	7
TF_ZHEJIANG_TEXTILE_2024	Zhejiang	Province	Zhejiang Textile Industry Transition Finance Supported Economic Activity Catalogue and Related Standards	2024	2024	Sectoral catalogue / group standard	1	1	7
TF_GUIZHOU_2024	Guizhou	Province	Guizhou Technical Catalogue for Transition Finance Support in Chemical, Building Materials and Non-ferrous Industries	2024	2024	Technical catalogue	1	1	6
TF_SHANXI_2024	Shanxi	Province	Shanxi Transition Finance Support Catalogue for Coking and Non-ferrous Industries (Trial)	2024	2024	Sectoral support catalogue	1	1	4
TF_GUANGXI_2024	Guangxi	Autonomous region	Guiding Catalogue for Transition Finance Support in the Aluminium Industry (Trial)	2024	2025	Sectoral guiding catalogue	1	1	5
TF_GUANGDONG_2024	Guangdong	Province	Guangdong Implementation Guideline for Transition Finance in the Ceramic Industry	2024	2025	Sectoral guideline / group standard	1	1	5
TF_YINGTAN_2024	Yingtian, Jiangxi	City	Copper Industry Transition Finance Supported Project Catalogue / Standard	2024	2025	Sectoral project catalogue / standard	1	1	6
TF_JIANGSU_2025	Jiangsu	Province	Notice on Building a Transition Finance Support System and Jiangsu Transition Finance Supported Economic Activity Catalogue	2025	2025	Support system / catalogue	1	1	7
TF_SHANDONG_FRAMEWORK_2023	Shandong	Province	Shandong Three-Year Action Plan for Carbon Finance Development (2023–2025)	2023	2023	Carbon finance framework	0	1	2
TF_BEIJING_FRAMEWORK_2024	Beijing	Municipality	Measures to Support Green and Low-carbon Development through Green Finance	2024	2025	Green finance framework	0	1	2

Notes. The main definition includes only policy documents with explicit transition-finance catalogues, standards, implementation guidelines, working instructions or supported project

lists. The broad definition additionally includes policy frameworks that explicitly mention transition finance or the development of transition-finance standards but do not yet provide a complete catalogue or standard. The effective year is used for annual panel matching. $TFIntensity_{ct}$ is coded according to the seven criteria reported in Appendix Table A1. Source URLs are retained in the original coding file and are available upon request.