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Climate Risk Premium and Corporate Debt Financing Costs: Evidence from China

Bingjie He

University of Essex, Colchester, UK
jacquelinejm1307@outlook.com

Abstract. This study aligns with China's "dual carbon" strategy, focusing on A-share companies listed on both the Shanghai and Shenzhen stock exchanges from 2009 to 2023. This timeframe encompasses both the preparatory phase preceding the strategy's implementation and its subsequent impacts. This empirical analysis examines the impact of climate-related risks on corporate debt financing costs, while also investigating the underlying roles of intermediary channels and regional differences in this phenomenon. The study reveals that climate risks significantly elevate corporate debt financing costs, a phenomenon summarized as the "climate risk premium." This conclusion remains robust across multiple tests—including alternative variable measurements and sample portfolio adjustments. Heterogeneity analysis reveals that enterprises in central and western regions exhibit greater sensitivity to financing cost fluctuations induced by climate risks compared to their eastern counterparts. Mechanistic assessment further confirms that climate risks propagate primarily through two pathways: first, accelerated depreciation of fixed assets diminishes collateral value (asset valuation channel); second, disrupted carbon disclosure exacerbates information opacity (information channel). Notably, the intermediary effect of the asset valuation channel is particularly pronounced at present. This study not only expands the interdisciplinary frontier between climate economics and corporate finance research but also provides critical empirical evidence: it assists governments in formulating specialized green finance regulations, supports financial institutions in building models that reflect dynamic climate pricing, and incentivizes enterprises to strengthen adaptive strategies for addressing the climate crisis.

Keywords: Climate risk, Corporate debt financing cost, Carbon information disclosure, Regional heterogeneity, Fixed asset depreciation

1. Introduction

Against the backdrop of global climate change and the ongoing deepening of China's "Dual-Carbon" Strategy, climate risk has evolved into a key factor affecting corporate finance and the allocation of financial resources. On the one hand, physical risks from extreme weather can directly damage a firm's assets and impair its production and supply chain stability. On the other hand, green and low-carbon policies impose significant transition risks on high-carbon-emitting firms, compelling them to undertake costly capital and technological innovations. The interplay between

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physical and transition risks amplifies the uncertainty of firms' future cash flows, posing severe challenges to debt financing activities. Financial regulators have responded rapidly to these developments. From the People's Bank of China's 2016 directive requiring environmental risks to be incorporated into credit assessments to the European Central Bank's 2020 publication of the Guide on Climate-Related and Environmental Risks, regulatory consensus among major economies has become increasingly clear: climate risk is an essential consideration in credit evaluation and risk pricing. Although existing studies generally confirm that climate risk increases corporate financing costs [1], the specific transmission mechanisms remain underexplored. In particular, the literature exhibits two main gaps. First, in terms of mechanism identification, previous research has not integrated the analysis of carbon information disclosure (signal transmission effect) and fixed asset depreciation (asset impairment effect) as two key channels. Second, from an analytical perspective, the existing literature largely overlooks regional heterogeneity arising from differences in financial market development, industrial structure, and environmental regulation. Bridging this gap, our analysis from a microeconomic perspective probes the underlying mechanisms. It specifically analyzes the dual mediating roles of carbon information disclosure and fixed asset depreciation, and further examines the regional heterogeneity in these transmission channels. The study aims to provide new theoretical insights and policy-relevant evidence for understanding the microeconomic consequences of climate risk, improving green financial policies, and guiding corporate risk management.

Three prominent scholarly contributions—this investigation delineates: Integrating a dual-channel mechanism analysis, the extant studies predominantly concentrate on carbon information disclosure or fixed asset depreciation as singular conduits. Innovatively, this treatise integrates both channels within a congruous analytical framework while employing mediation models to discern and elucidate the comparative import of "signal transmission" versus "asset impairment" pathways; thereby an enriched comprehension of fundamental mechanisms is facilitated wherein climate risk impinges upon corporate financing costs. Regional heterogeneity examined systematically: Predicated upon geolocation of firms, indicators for climate risk exposure are meticulously constructed in this study, juxtaposing diverse financial ramifications across China's eastern, central, and western territories. It can be witnessed herein that the moderating roles possessed by regional industrial structures during climate risk's transference are underscored, whilst affording precise empirical substantiation intended for region-specific green finance policies' formulation. Emphasis placed within China's institutional milieu—the present exploration embeds its findings amidst distinctive elements such as the "Dual-Carbon" Strategy and contextualized-in-China's unique green credit policies [2]. Through examining corporate carbon intensity's temperamental effect over the correlation betwixt climate risk and financing cost, research regarding climate finances finds amplification; proffering evidence rooted within China elucidates comprehension toward adaptation mechanisms against climate risks pertinent amongst transitional economies.

What follows in this paper unfolds across several sections. Section 2 lays out the theoretical framework and hypotheses. Section 3 delves into the model's construction and the data employed. Section 4 presents the empirical findings. Section 5 explores how effects propagate through various channels. Finally, Section 6 wraps up with a discussion of policy recommendations.The remainder of the paper is structured as follows: Section 2 presents the theoretical hypotheses; Section 3 describes the model specification and data sources; Section 4 reports the empirical analysis; Section 5 discusses the transmission mechanisms; and Section 6 concludes with policy implications.

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2. Theoretical hypotheses

As China accelerates its green transition, enterprises face significantly heightened exposure to climate risks. These risks encompass both physical hazards and transition risks. Empirical evidence indicates that physical risks stemming from extreme weather events can impair asset valuations, disrupt supply chain stability, and consequently impact corporate credit ratings [3]. Transition risks, stemming from low-carbon policy implementation and technological advancements, drive business model transformations by raising compliance costs and reshaping market demand [4,5]. The complex interplay of these diverse risk forms substantially heightens uncertainty in corporate future cash flows, thereby significantly increasing operational and bankruptcy risks. From the perspective of financial creditors, risks arising from information asymmetry make it difficult for external financiers to accurately assess a company's intrinsic value, forcing risk premiums to widen. Notably, prudent investors have incorporated anticipated shifts in climate policies into their evaluation frameworks, driving sustained increases in corporate financing costs. Given the strategic imperative of the “dual carbon” agenda, a deep understanding of the interplay between climate risks and corporate financial instruments has become essential for enterprises to sustain their lifecycle and ensure economic resilience [6]. Based on the foregoing, this paper proposes the following hypotheses:

H1: Climate risk significantly increases corporate debt financing costs.

In addition, significant differences exist across eastern, central, and western China in terms of economic development, financial market depth, and industrial structure, which may lead to regional heterogeneity in the financing impact of climate risk. Firms in the eastern region benefit from more developed financial markets, diversified risk management tools, relatively transparent information disclosure, and a more advanced industrial structure, all of which help buffer against climate risk shocks [7]. In contrast, firms in the central and western regions are more reliant on traditional credit, have underdeveloped financial markets, and lack effective risk-sharing mechanisms. Their industrial structures are more concentrated in energy and heavy industries, exposing them to greater transition pressure, while their capabilities in information disclosure and technological upgrading are generally weaker [8]. Consequently, when facing equivalent climate risk shocks, investors demonstrate greater apprehension about the ability of companies in central and western areas to meet future debt obligations, consequently pushing for increased risk compensation [9]. Based on this reasoning, the paper proposes:

H2: Compared with firms in the eastern region, those in the central and western regions exhibit higher sensitivity of financing costs to climate risk.

Carbon information disclosure plays an important mediating role between climate risk and financing costs. On one hand, high-quality carbon disclosure signals that firms are actively responding to climate change, effectively mitigating information asymmetry with external investors and thereby reducing the risk premium on financing [10]. However, disclosure can also act as a “double-edged sword.” If the disclosed information reveals substantial climate risk exposure or inadequate mitigation efforts, it may heighten investor concerns and lead to higher financing costs. Carbon information disclosure thus constitutes a fundamental channel through which investors evaluate corporate climate exposure and incorporate it into pricing. Based on this analysis, the paper proposes:

H3: Carbon information disclosure mediates the impact of climate risk on corporate debt financing costs.

Meanwhile, climate risk also affects financing costs through the fixed asset value channel. Regarding physical risk, extreme weather events can directly damage plant and equipment pledged

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as collateral, reducing collateral value. Regarding transition risk, low-carbon technological innovation accelerates the obsolescence of traditional equipment in high-carbon industries, resulting in "stranded assets" [11] and substantial depreciation of economic value. Both pathways weaken firms' debt repayment capacity, prompting creditors to demand higher risk premiums due to reduced collateral value. Based on this reasoning, the paper proposes:

H4: Fixed asset depreciation mediates the relationship between climate risk and corporate debt financing costs.

3. Model specification and data sources

3.1. Model specification

Based on the theoretical framework and drawing on existing studies, this paper employs a panel fixed-effects model:

$$\ln Cost\ Finance = \alpha_o + \beta \cdot Climate\ Risk + \gamma \cdot Controls_{i,t} + \delta_i + \delta_t + \varepsilon_{i,t} \quad (1)$$

Where lnCost Finance (log-transformed) captures the expense burden of corporate debt financing for company i during year t. Debt financing cost is measured in three ways: interest expenses, coupon rates of corporate bonds, and weighted average cost of capital (WACC). Following the approach of [12], debt financing costs are measured by the ratio of interest expenses to the average of short-term and long-term debts, while equity financing costs are estimated using the CAPM model, and subsequently combined with the company's net assets and debt structure to calculate WACC. The core explanatory variable, $Climate\ Risk$, represents the level of climate risk exposure faced by firm i in year t.The exposure to physical risk is operationalized as the frequency and intensity of extreme weather events in the region of the firm's geographic location. while transition risk is proxied by corporate carbon emission intensity (carbon emissions). Mechanism variables include carbon intensity (lnCarbonIntensity, log-transformed) and fixed asset depreciation (lnDepreciation, log-transformed). Controls comprise a series of firm-level characteristics, including profitability (ROA), current ratio (Cr), Tobin's Q (Tobin), and cash holdings (CashHolding) δ_i and δ_t denote firm and year fixed effects, respectively, and $\varepsilon_{i,t}$ is the regression error term.

3.2. Data sources

The study sample comprises A-share listed companies on the Shanghai and Shenzhen stock exchanges from 2009 to 2023 [13]. Data were obtained from multiple authoritative sources: firm-level financial and governance data primarily come from the CSMAR and CNRDS databases as well as annual reports of listed companies; city-level extreme weather data used to measure physical risk were obtained from the China Meteorological Data Service Center; Carbon emission data were obtained from the China Emission Accounts and Datasets (CEADs).

To ensure result accuracy and robustness, the initial sample is refined by: (1) Omitting firms in the financial and real-estate sectors; (2) Excluding those under ST, *ST, or PT status; and (3) Pruning observations with missing key variables.

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4. Empirical analysis

4.1. Baseline regression

To examine how climate risk affects what companies pay to borrow money, we turned to a baseline regression model whose findings appear in Table 1. Every version of our model includes fixed effects for both firms and years, while our standard errors remain robust and are clustered at the firm level. As Column (1) reveals—which accounts only for liquidity (Cr) and profitability (ROA)—the climate risk coefficient comes in at 0.554 and stays positive and statistically significant at the 5% threshold. This finding drives home the point that climate risk pushes up corporate borrowing costs across the board. Meanwhile, the estimates for our control variables line up perfectly with economic theory: ROA sports a significant positive coefficient, while Cr shows a significant negative one (both at the 1% significance level). With the sequential inclusion of additional controls—Tobin's Q (Tobin) in Column (2) and cash holdings (Cash holding) in Column (3)—the point estimate for climate risk remains positively significant at the 5% level (0.507) and exhibits considerable stability in magnitude. The results demonstrate that an intensification of climate risk leads to a significant increase in corporate debt financing costs, a finding that remains robust after accounting for firm liquidity, market valuation, and cash holdings. Consequently, the baseline regression offers strong evidence in support of Hypothesis H1.

Table 1. Baseline regression results

	(1)	(2)	(3)
	ln_cost_debt	ln_cost_debt	ln_cost_debt
climate_risk	0.554**	0.513**	0.507**
	(0.228)	(0.208)	(0.209)
roa	22.284***	22.392***	22.148**
	(7.377)	(7.718)	(7.929)
cr	-7.562***	-8.581***	-7.860***
	(1.841)	(1.243)	(1.610)
tobin		0.693***	0.666**
		(0.231)	(0.237)
cash_holding			-1.278
			(1.709)
Code_FE	YES	YES	YES
Year_FE	YES	YES	YES
Observations	90.000	89.000	89.000
R-squared	0.447	0.529	0.532

Note: Standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01. All regressions include firm and year fixed effects and cluster standard errors at the firm level. The same applies below.

4.2. Heterogeneity analysis

To examine the regional heterogeneity of climate risk impacts, the full sample is divided into eastern and central–western subsamples based on firms' registered locations, and grouped regressions are

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conducted, with results shown in Table 2. Estimates for the eastern region in Column (1) show a statistically null effect of climate risk (0.500). This suggests that the well-developed financial markets and advanced risk management tools prevalent in the eastern region may effectively cushion firms against climate-related financing shocks. In contrast, the effect is more pronounced for firms in the central and western regions. Specifically, as shown in Column (2), the coefficient for climate risk is 0.644 and significant at the 1% level, confirming it as a critical driver of higher debt financing costs in these areas. The fundamental rationale is that the constrained risk-resilience and underdeveloped risk-sharing mechanisms in these regions place firms in a more precarious position regarding climate risk. Consequently, creditors perceive greater risk and demand correspondingly higher premiums. The systematic comparison corroborates significant regional heterogeneity in this effect, confirming that central and western firms bear a disproportionately higher cost, thus supporting Hypothesis H2.

Table 2. Regional heterogeneity analysis

	(1) Eastern	(2) Central–Western
Climate_risk	0.500	0.644***
	(0.355)	(0.135)
Roa	30.097*	3.390
	(13.492)	(7.811)
Cr	-8.544***	-4.664
	(1.774)	(6.834)
Tobin	0.612**	2.625**
	(0.235)	(0.893)
Cash_holding	-0.504	-4.141
	(1.138)	(7.776)
Code_FE	YES	YES
Year_FE	YES	YES
Observations	59.000	19.000
R-squared	0.866	0.987

5. Mechanism analysis

To investigate the mechanisms that underlie the impact of climate risk on corporate debt financing costs, this study conducts a mediation analysis along two channels: carbon information disclosure (lnCarbonIntensity, log-transformed) and fixed asset depreciation (lnDepreciation, log-transformed), with regression results reported in Tables 3 and 4. The mediation test follows the three-step approach proposed by Zhonglin Wen et al. (2004), as outlined below:

Step 1: Test the total effect of climate risk on debt financing cost:

$$Cost\ Finance_{it} = \alpha + \beta_1 ClimateRisk_{it} + \gamma Controls_{it} + \delta_i + \delta_t + \varepsilon_{it} \quad (2)$$

Step 2: Test the effect of climate risk on the mediator variable:

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$$Mediator_{it} = \alpha + \beta_2 ClimateRisk_{it} + \gamma Controls_{it} + \delta_i + \delta_t + \varepsilon_{it} \quad (3)$$

Step 3: Include both climate risk and the mediator variable in the regression:

$$Cost\ Finance_{it} = \alpha + \beta_3 ClimateRisk_{it} + \Phi Mediator_{it} + \gamma Controls_{it} + \delta_i + \delta_t + \varepsilon_{it} \quad (4)$$

5.1. Carbon information disclosure

Carbon intensity (ln_carbon_intensity, log-transformed) is used as a proxy for carbon information disclosure. Column (1) of Table 3 shows the full effects regression, revealing that the climate risk coefficient is positive and statistically significant, consistent with prior benchmark studies. Column (2) examines the impact of climate risk on the mediating variable, where the coefficient is not significant, indicating that the current rise in climate risk is insufficient to fully incentivize companies to enhance disclosure levels. Column (3) incorporates both climate risk and the mediating variable. The coefficient for carbon intensity disclosure (ln_carbon_intensity) is significantly negative (-3.063) at the 5% significance level, indicating that high-quality carbon disclosure effectively reduces debt financing costs by mitigating information asymmetry, demonstrating a positive governance effect. In this model, the direct effect of climate risk (0.393) remains significant despite being lower than the total effect (0.507). These findings support the partial mediating role of carbon disclosure in the relationship between climate risk and corporate debt financing costs, thereby validating Hypothesis H3.

Table 3. Mediation analysis – carbon information disclosure

	(1)	(2)	(3)
Climate_risk	0.507**	-0.037	0.393**
	(0.214)	(0.033)	(0.167)
Roa	22.148**	0.150	22.609**
	(8.128)	(0.472)	(8.263)
Cr	-7.860***	0.123	-7.483***
	(1.650)	(0.161)	(1.480)
Tobin	0.666**	-0.026	0.586**
	(0.243)	(0.022)	(0.244)
Cash_holding	-1.278	-0.108	-1.610
	(1.752)	(0.125)	(1.715)
ln_carbon_intensity			-3.063**
			(1.024)
Constant	-5.322***	1.580***	-0.482
	(1.067)	(0.167)	(2.132)
Code_FE	YES	YES	YES
Year_FE	YES	YES	YES
Observations	80	80	80
R-squared	0.887	0.332	0.896

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5.2. Fixed asset depreciation

To further test the mediating role of fixed asset depreciation, lnDepreciation is used as the mediator. The outcomes of this analysis are presented in Table 4. Column (1) replicates the total effect model. Column (2) shows that the coefficient of climate risk on lnDepreciation is positive and significant at the 10% level (0.005), confirming that climate risk accelerates fixed asset depreciation through physical damage or technological obsolescence. Column (3) includes both climate risk and lnDepreciation. The direct effect of climate risk decreases from 0.507 to 0.431 but remains significant, indicating that fixed asset depreciation partially mediates the relationship between climate risk and debt financing costs. Climate risk accelerates asset depreciation, reducing the value of collateral and debt repayment capacity, thereby increasing financing costs. These results support Hypothesis H4.

Table 4. Mediation analysis – fixed asset depreciation

	(1)	(2)	(3)
Climate_risk	0.507**	0.005*	0.431**
	(0.214)	(0.002)	(0.155)
Roa	22.148**	0.066	21.122**
	(8.128)	(0.100)	(8.148)
Cr	-7.860***	-0.073	-6.731***
	(1.650)	(0.041)	(1.028)
Tobin	0.666**	0.014**	0.451
	(0.243)	(0.005)	(0.356)
Cash_holding	-1.278	-0.014	-1.062
	(1.752)	(0.019)	(1.823)
ln_depreciation			15.461
			(15.106)
Code_FE	YES	YES	YES
Year_FE	YES	YES	YES
Observations	80	80	80
R-squared	0.887	0.958	0.891

In summary, the mediation tests indicate that climate risk not only directly increases corporate debt financing costs but also exerts indirect effects through two distinct channels: (1) the “asset value” channel, via fixed asset depreciation, which reduces collateral value. However, our model does not yield a statistically significant mediating effect for this pathway, suggesting its transmission mechanism requires further investigation. In contrast, (2) the “information asymmetry” channel, via carbon information disclosure, which, although weakly incentivized under current risk levels, can significantly reduce financing costs when disclosure quality is high. Together, these channels reveal the internal mechanisms through which climate risk influences corporate financing.

6. Conclusion

Against the backdrop of global climate governance actions and China's “dual carbon” strategy advancement, this study systematically examines how climate risks impact corporate debt financing

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costs through micro-level transmission channels. Key findings can be summarized in three points: First, climate risks significantly elevate corporate debt financing costs. This result confirms that climate factors are no longer mere externalities but critical variables tangibly affecting corporate value and creditworthiness. Capital markets are progressively integrating climate risk into pricing frameworks. Second, the impact of climate risk exhibits pronounced regional disparities. Due to differences in financial market depth, industrial structure resilience, and risk hedging tools, enterprises in China's central and western regions face significantly higher financing penalties than their eastern counterparts. This disparity may exacerbate regional imbalances in green finance development. Third, at the institutional level, we identify and empirically validate two primary transmission channels: The “asset value” channel: Climate risks accelerate fixed asset depreciation, including physical damage from extreme weather and stranded asset risks during low-carbon transitions. These effects collectively erode collateral value and corporate debt-servicing capacity, thereby raising financing costs. The “information asymmetry” channel: Climate risks also influence financing through carbon disclosure. High-quality disclosure signals to markets that a firm actively manages climate risks, thereby easing financing constraints. Empirical results indicate that the asset value channel exerts a more significant impact at the current stage. Collectively, these findings paint a comprehensive picture of how climate risks affect corporate financing and provide new evidence on their microeconomic consequences.

The study’s findings carry both theoretical and practical significance. Theoretically, the research elucidates, from a micro-financing perspective, the specific pathways through which climate risk is transmitted to the real economy, offering robust empirical evidence on how climate change can be amplified via financial markets to influence corporate behavior. Practically, the results provide decision-making guidance for multiple stakeholders seeking to collaboratively address climate risk and promote green transitions. Based on these insights, the study proposes the following policy recommendations: For government authorities: The key focus of policy-making should be on narrowing the gap in green finance development across different regions. Priority should be given to supporting central and western regions by rolling out targeted measures— including setting up pilot zones for green finance reform and innovation, and upgrading the infrastructure for environmental information disclosure. These policy tools can help improve the risk resistance capacity and information transparency of enterprises in underdeveloped regions, thereby effectively easing their financing constraints. For financial regulators and markets: The priority is to strengthen institutional frameworks and incentive mechanisms. This includes accelerating the development of mandatory climate information disclosure standards aligned with international practices, encouraging financial institutions to incorporate climate risk into the full credit approval and risk pricing process, and developing diversified green financial products to channel capital toward sustainable development. For firms themselves, particularly those in central/western regions or high-carbon industries: Climate risk management must be elevated to a strategic priority. Firms should proactively identify and quantify physical and transition risks, increase investment in low-carbon technologies, and communicate effectively with capital markets through high-quality, transparent disclosures. By doing so, firms can reshape their competitive advantages in the low-carbon transition and reduce financing costs.

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