

The Impact of Climate Risk on Firm Value: Evidence from China's A-share Market

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Abstract

With the increasing severity of global climate change, climate risk has a wide range of impacts on corporate operations. This paper constructs firm-level climate risk indicators to explore the impact of climate risk on firm value using textual analysis. Based on a sample of Chinese A-share listed companies, we find that increased climate risk significantly reduces firm value. We further confirmed this conclusion through a series of robustness tests. Furthermore, we find that climate risk primarily reduces firm value by increasing financing costs of companies.

Keywords

Climate Risk; Firm Value; Textual Analysis.

1. Introduction

Many parts of the globe have experienced extreme weather events in various forms in recent years. Since the middle of the twentieth century, the global average surface temperature has risen by 1.2 °C, and extreme natural events have more than doubled. To address the risk of climate change, the Paris Agreement proposes to limit global average warming to less than 2 °C in the twenty-first century and to strive to limit it to less than 1.5 °C, with a view to achieving the goal of zero greenhouse gas emissions in the second half of the century. Several countries around the world have made carbon-neutral commitments. China has proposed in 2020 that it will strive to achieve carbon peak by 2030 and carbon neutrality by 2060. Responding to the multiple risks posed by climate change and actively carrying out environmental governance has become an important topic related to national economy and people's livelihood, the significance of which lies not only in the climate governance itself, but also in the fundamental transformation of China's economic development mode and the realization of high-quality development.

Climate risk refers to the uncertainty that climate change brings to the economic and financial activities of human societies. In 2017, the Task Force on Climate-Related Financial Disclosure (TCFD) published the Task Force on Climate-Related Financial Disclosure Policy Recommendations Report, which provides a more comprehensive framework for analyzing climate risk. The Task Force divided climate-related risks into two major categories: (1) risks related to the physical impacts of climate change and (2) risks related to the transition to a lower-carbon economy. Specifically, physical risk refers to the potential economic costs and financial losses resulting from an increase in the intensity and frequency of events associated with extreme climate change, as well as long-term gradual changes in climate. Transition risk mainly refers to the risk caused by uncertainties such as policy changes, technological improvements, and shifts in market preferences during the low-carbon transition process [1]. Based on the growing recognition of the potential impact of weather events and climate change on the business sector, there is increasing literature exploring the impact of climate risk on companies, stemming from both physical and transition risks [2]. However, measuring climate

risk has been challenging. A few scholars are now measuring climate risk through keyword-based textual analysis, such as Sautner et al. (2023) [3] and Li et al. (2023) [4], but there are not many studies based on the Chinese market. Moreover, current research does not provide sufficiently strong evidence on the relationship between climate risk and firm value. Therefore, based on the Chinese context, this paper introduces climate risk to the micro level to further investigate the impact of climate risk on firm value.

We conduct regression analysis using annual data on Chinese A-share listed companies for the period 2007–2022. The results reveal that increased firm-level climate risk reduces firm value. A series of robustness checks confirm this conclusion. According to the mechanism analysis, climate risk reduces firm value by increasing financing costs.

2. Methods

2.1. Firm-level Climate Risk

Following Sautner et al. (2023) [3], Du et al. (2023) [5], and Lin & Wu (2023) [6], we take the annual reports of Chinese A-share listed companies from 2007 to 2022 as the research object, and determine the Chinese “climate risk” lexicon through textual analysis and machine learning methods, to construct firm-level climate risk indicators based on the Chinese background and language habits. This paper calculates the ratio of the total word frequency of the extended word set of “climate risk” to the total word frequency of the annual report, and then multiplies it by 100 to obtain the total index of firm-level climate risk. The larger the value of the above indicator, the greater the exposure of the enterprise to climate risk.

2.2. Additional Variables

2.2.1. Dependent Variable

Based on the prior literature [7, 9], we use Tobin’s Q as a measure of firm value. Tobin’s Q is measured as the firm’s market capitalization scaled by total assets.

2.2.2. Control variables

Table 1. Variable definitions

Variable	Definition
Dependent variable	
TobinQ	market capitalization / total assets
Independent variables	
ClimateRisk	Proportion of total word frequency of climate risk terms to total word frequency of annual reports × 100
Control variables	
size	Natural logarithm of firm’s total assets
lev	total debt / total assets
age	Natural logarithm of firm’s listed years
ROE	net profit / average balance of shareholders’ equity
growth	(Current year’s operating revenue - previous year’s operating revenue) / previous year’s operating revenue
capex	capital expenditure / total assets
top1	shareholding ratio of the largest shareholder
dual	dual is 1 if the chairman and the general manager are the same person, otherwise it is 0

Based on the literature, we control eight variables at the firm level thought to affect firm value, including firm size (Ln of total assets), lev (the ratio of total debt to total assets), age (Ln of listed years), ROE (the ratio of net profit to average balance of shareholders' equity), growth (annual growth rate of the company's operating revenue), capex (the ratio of capital expenditure to total assets), top1 (shareholding ratio of the largest shareholder), and dual (dual is 1 if the chairman and the general manager are the same person, otherwise it is 0). Detailed information on the variables included in the present study is provided in Table 1.

2.3. Empirical Model

We investigate the effect of firm-level climate risk on firm value by estimating the following regression analysis:

$$TobinQ_{i,t} = \beta_0 + \beta_1 ClimateRisk_{i,t} + \gamma_k \sum Controls_{i,t}^k + Year_t + Industry_i + \varepsilon_{i,t}, \quad (1)$$

where i and t denote the firm and the year, respectively. *TobinQ_{i,t}* presents firm value. *ClimateRisk_{i,t}* is the firm-level climate risk. *Controls_{i,t}* is a vector of control variables, namely firm size (*size_{i,t}*), leverage ratio (*lev_{i,t}*), firm age (*age_{i,t}*), return on equity (*ROE_{i,t}*), growth rate of revenue (*growth_{i,t}*), capital expenditure (*capex_{i,t}*), shareholding ratio of the largest shareholder (*top1_{i,t}*), and duality (*dual_{i,t}*). *Year_t* is the time-fixed effect, *Industry_i* is the industry-fixed effect, and $\varepsilon_{i,t}$ is the unobserved error term.

3. Empirical Results

3.1. Descriptive Statistics

Table 2 reports summary statistics for the variables. The maximum value of TobinQ is 8.511, the mean value is 2.051, and the standard deviation is greater than 1. These values align with those reported in related studies by Shu et al. (2023) [10] and Du et al. (2023) [5]. The mean value of ClimateRisk is 0.204, with a standard deviation of 0.229, indicating that there are large differences in climate risk indicators between enterprises. The control variables also align with prior literature. For instance, the mean value of size is 22.290 with a standard deviation of 1.286, which is comparable to Ren et al. (2022) [11].

Table 2. Descriptive statistics

variable	Observations	Mean	Std. dev.	Min	Median	Max
TobinQ	32545	2.051	1.316	0.841	1.629	8.511
ClimateRisk	32545	0.204	0.229	0.008	0.134	1.399
size	32545	22.290	1.286	19.880	22.110	26.260
age	32545	2.165	0.751	0.693	2.303	3.332
lev	32545	0.445	0.200	0.064	0.442	0.887
growth	32545	0.165	0.402	-0.564	0.104	2.499
top1	32545	0.344	0.147	0.091	0.322	0.741
ROE	32545	0.051	0.150	-0.860	0.066	0.322
dual	32545	0.252	0.434	0.000	0.000	1.000
capex	32545	0.049	0.046	0.000	0.035	0.223

This table provides the descriptive statistics for the main variables included in the empirical models. All continuous variables are winsorized at 1st and 99th percentiles.

3.2. Baseline Results

We use model (1) to explore the effect of climate risk on firm value. The benchmark regression results are shown in Table 3. From the results in the second column, the coefficient of ClimateRisk on the TobinQ is significantly negative at the level of 1%. These results indicate that the higher the level of ClimateRisk, the lower the level of TobinQ. The results of the baseline regression model confirm that increased climate risk will impede improvements in firm value.

Table 3. Baseline results

	(1)	(2)
VARIABLES	TobinQ	TobinQ
ClimateRisk	-0.623***	-0.231***
	(-11.44)	(-4.872)
size		-0.397***
		(-20.78)
age		0.197***
		(8.952)
lev		-0.590***
		(-5.924)
growth		0.185***
		(8.264)
top1		0.0353
		(0.381)
roe		0.776***
		(9.008)
dual		0.0537*
		(1.884)
capex		1.242***
		(5.457)
Constant	2.555***	10.68***
	(20.59)	(28.99)
Industry	Yes	Yes
Year	Yes	Yes
Observations	32,545	32,545
Adjusted R-squared	0.148	0.291

This table shows regression results for the effect of climate risk on firm value. Robust t-statistics in parentheses. ***, **, and * denote significance at the 1 %, 5 %, and 10 % levels, respectively.

3.3. Robustness Check

3.3.1. Change Sample Intervals

To avoid the impacts of the financial crisis in 2008 and the COVID-19 pandemic in 2019 (Ren et al., 2022) [11], we change the sample interval in the regression analysis. Table 4 shows the results for the sample subinterval estimates. Sample data for 2019 and beyond are excluded from regression (1), and sample data for 2010 and earlier are excluded from regression (2), to exclude the effects of the financial crisis and COVID-19, respectively. In regression (3), we exclude sample data for 2007 to 2010, and 2019 to 2022 in the regression analysis, to avoid the

impacts of the above two. The results obtained are highly consistent with those of the baseline model.

Table 4. Change sample intervals

	(1)	(2)	(3)
	Sample period from 2007 to 2018	Sample period from 2011 to 2022	Sample period from 2011 to 2018
VARIABLES	TobinQ	TobinQ	TobinQ
ClimateRisk	-0.232*** (-4.720)	-0.242*** (-4.953)	-0.250*** (-4.912)
size	-0.467*** (-21.84)	-0.404*** (-19.79)	-0.501*** (-20.99)
age	0.269*** (10.85)	0.200*** (8.582)	0.282*** (10.53)
lev	-0.559*** (-4.831)	-0.481*** (-4.648)	-0.352*** (-2.852)
growth	0.0872*** (3.352)	0.208*** (8.320)	0.0963*** (3.144)
top1	0.136 (1.321)	0.115 (1.203)	0.285*** (2.686)
roe	0.779*** (7.114)	0.758*** (8.593)	0.727*** (6.266)
dual	0.0319 (0.972)	0.0493* (1.661)	0.0218 (0.637)
capex	0.612** (2.549)	1.369*** (5.378)	0.536* (1.927)
Constant	12.05*** (29.55)	10.34*** (25.77)	12.23*** (26.37)
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
Observations	19,842	28,392	15,689
Adjusted R-squared	0.373	0.285	0.383

This table reports the results of robustness check with changing sample intervals. Robust t-statistics in parentheses. ***, **, and * denote significance at the 1 %, 5 %, and 10 % levels, respectively.

3.3.2. High-degree Fixed Effects

Table 5 includes the industry-year fixed effect to control for variables omitted from the time-variant industry level. Our estimation results show that our main findings are valid and reliable.

Table 5. High-degree fixed effects

	(1)	(2)
VARIABLES	TobinQ	TobinQ
ClimateRisk	-0.234***	-0.234***
	(-4.806)	(-4.805)
size	-0.395***	-0.395***
	(-20.57)	(-20.57)
age	0.197***	0.197***
	(8.895)	(8.893)
lev	-0.578***	-0.578***
	(-5.728)	(-5.727)
growth	0.179***	0.179***
	(7.991)	(7.989)
top1	0.0360	0.0360
	(0.387)	(0.387)
roe	0.737***	0.737***
	(8.555)	(8.553)
dual	0.0516*	0.0516*
	(1.809)	(1.808)
capex	1.207***	1.207***
	(5.260)	(5.258)
Constant	10.58***	10.58***
	(27.93)	(27.92)
Industry	No	Yes
Year	No	Yes
Industry*Year	Yes	Yes
Observations	32,533	32,533
Adjusted R-squared	0.301	0.301

This table shows regression results for the effect of climate risk on firm value under controlling high-degree fixed effects. Robust t-statistics in parentheses. ***, **, and * denote significance at the 1 %, 5 %, and 10 % levels, respectively.

3.4. Channels Analysis

We assume that increased climate risk can increase the difficulty and cost of financing for a company, limiting the growth of the business, thereby affecting firm value. Therefore, we use financing costs as the mediating variable, including the cost of debt capital (Cod) and the cost of equity capital (PEG). The cost of debt capital (Cod) is measured as financing expense divided by total liabilities and the cost of equity capital (PEG) is estimated using the PEG model. The results in regression (1) and (3) of Table 6 show that the coefficients of climate risk for the cost of debt capital (Cod) and the cost of equity capital (PEG) are all significantly positive, indicating that climate risk increases financing costs by companies. The results in regression (2) and (4) show that climate risk and financing costs have a significant negative effect on firm value. This finding indicates that the mediating effect of financing costs is significant. The calculation shows that the mediating effect of the cost of debt capital (Cod) in the process of influencing climate risk and firm value is -0.014, and the mediating effect is 6.11% of the total effect. Meanwhile, the mediating effect of the cost of equity capital (PEG) in the process of influencing climate risk and firm value is -0.056, and the mediating effect is 20.45% of the total effect. The impact of

climate risk on the cost of equity capital is greater than that on the cost of debt capital. Further using the Sobel-Goodman test and Bootstrap test for the above mediating mechanisms, the Z-value of the Sobel-Goodman test is significant at the 1% level, and the confidence interval of the Bootstrap test does not contain 0, which indicates that climate risk can reduce firm value by increasing the cost of financing for firms.

Table 6. Channels analysis through financing costs

	(1)	(2)	(3)	(4)
VARIABLES	Cod	TobinQ	PEG	TobinQ
ClimateRisk	0.00418***	-0.217***	0.0103***	-0.205***
	(4.007)	(-4.620)	(5.892)	(-4.268)
Cod		-3.375***		
		(-6.450)		
PEG				-5.408***
				(-18.98)
size	-0.00140***	-0.401***	0.00259***	-0.302***
	(-4.895)	(-21.22)	(6.131)	(-16.70)
age	0.00287***	0.207***	-0.00439***	0.104***
	(6.932)	(9.312)	(-7.793)	(4.532)
lev	0.0759***	-0.334***	0.0338***	-0.826***
	(32.30)	(-3.331)	(14.21)	(-7.397)
growth	0.00006	0.185***	0.00190**	0.130***
	(0.152)	(8.368)	(2.254)	(5.619)
top1	-0.0160***	-0.0188	-0.0232***	-0.0810
	(-7.663)	(-0.203)	(-9.126)	(-0.768)
roe	-0.00935***	0.744***	0.00620	3.033***
	(-6.807)	(8.786)	(1.552)	(15.70)
dual	-0.0001	0.0533*	0.00135*	0.0555*
	(-0.153)	(1.902)	(1.786)	(1.775)
capex	0.0224***	1.318***	0.0642***	1.137***
	(4.462)	(5.812)	(8.689)	(4.887)
Constant	0.0239***	10.77***	0.0300***	9.529***
	(4.033)	(29.54)	(3.351)	(27.03)
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Observations	32,545	32,545	20,382	20,382
Adjusted R-squared	0.310	0.295	0.213	0.356
Sobel-Goodman Z-value	-5.491***		-8.255***	
Bootstrap test	Confidence interval [-0.0188, -0.0096]		Confidence interval [-0.0697, -0.0425]	

This table reports the results of the mediator effects of financing costs on the climate risk's impact on the firm value. Robust t-statistics in parentheses. ***, **, and * denote significance at the 1 %, 5 %, and 10 % levels, respectively.

4. Conclusion

Given that increasing climate risk will affect the profitability and production of companies, this study selects companies in China to explore the relationship between firm-level climate risk and firm value. Based on a sample of Chinese A-share listed companies from 2007 to 2022, we find that climate risk, captured by annual reports of listed Companies via textual analysis, significantly reduces firm value. A series of robustness checks confirm this conclusion. Furthermore, climate risk reduces firm value by increasing financing costs of companies.

Therefore, the government should improve the climate risk information disclosure system, reduce the financing costs of enterprises through policy support and tax incentives, and promote enterprises to increase green innovation and low-carbon transformation, so as to reduce the sensitivity of enterprises to climate risk.

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