Climate Risk and Corporate Performance

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Abstract. Climate risk has garnered significant attention due to its profound impact on corporate sustainability and financial performance. Climate-related risks, such as environmental regulations, climate change, and extreme weather, present challenges to businesses by increasing operational costs and influencing strategic decisions. This study investigates the relationship between climate risk, especially about transition risk, and corporate performance by analyzing the extent of climate risk disclosure of Chinese A-share listed companies from 2010-2020. Our findings indicate a notable negative correlation between climate risk and corporate performance. Regression analyses confirm that climate risk adversely affects business outcomes, suggesting that higher climate risk diminishes firm value. The results suggest that increased climate risk leads to a decrease in firm value. This study contributes to the growing literature on climate risk by focusing on its effect on non-financial firms, particularly in China's A-share market. Additionally, it provides practical insights for business leaders and policymakers, highlighting the need for climate risk mitigation strategies to minimize potential value loss. This study serves as a resource for companies seeking to incorporate climate risk considerations into their operations.

Keywords: Climate Risk, Corporate Performance, TobinQ.

1 Introduction

In the last few years, climate risk has garnered significant attention from academics, regulators, and business leaders due to its extensive and enduring effects on corporate sustainability and financial performance. Climate-related risks—such as environmental regulations, climate change, and extreme weather events—present substantial challenges for businesses across various industries. These risks, which are divided into physical risk and transition risk, not only increase operational costs, but also impact long-term strategic decisions.[1] Understanding the relationship between climate risk and business performance is essential for evaluating its overall impact on enterprise value, particularly for Chinese A-share listed companies. Consequently, climate risk becomes an important factor affecting firm value and has the potential to become both a risk and an opportunity in corporate governance and long-term growth strategies.

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The research investigates the annual reports of Chinese A-share listed companies from 2010 to 2020, calculates the ratio of the total word frequency of climate risk to the total word frequency of the annual reports, obtains an indicator of climate risk, and explores the impacts of climate risk, especially transition risk, on the performance of companies. By using the TobinQ ratio as a measure of firm performance, we find a negative association between climate risk and firm value. Specifically, in the univariate model controlling for firm and year fixed effects, climate risk has a significant negative impact on TobinQ ratio, the coefficient for climate risk is -16.922, significant at the 5% level. In the multivariate model, the coefficient remains negative at -13.313 with a t-value of -2.09, figuring out significance at the 1% level. These findings suggest that the TobinQ of corporations decreases as climate risk increases, highlighting the adverse impact of climate risk on corporate value.

This study makes several important contributions. First, from a theoretical perspective, it addresses the challenge of measuring climate risk and donates to the growing literature by focusing on the effect of climate risk on firm value. While much of the previous literature has centered on the impact of climate risk on financial institutions, our empirical analysis deepens the understanding of how climate risk affects non-financial firms, particularly those in the A-share market in China, and fills a gap in the climate finance literature. Second, from a practical perspective, our findings provide important insights for business leaders and policymakers. By demonstrating the negative impact of climate risk on firm performance, this study provides strategic guidance for firms to better manage climate risk. Firms can integrate climate risk mitigation strategies into their business models to minimize potential value loss and enhance long-term sustainability. Thus, this study provides a basis for further investigation of corporate adaptation to climate risk, particularly about how to cope with transition risk, and provides actionable recommendations for policymakers to develop climate-related financial regulations.

In the subsequent part, the paper will firstly conduct a literature review of previous related studies and put forward a hypothesis based on the factual cases, which will be analyzed by regression analyses using the annual reports of the A-share market in China in the CSMAR database from 2010 to 2020 as samples to derive the connection between climate risk and corporate performance. Finally, a conclusion is drawn for the development and prospective of nearing research.

2 Literature Review

2.1 Climate Risk

Climate risk refers to the uncertainty arising from climate factors—such as extreme weather, natural disasters, global warming, and societal transitions toward sustainable development—that affect economic and financial activities. Not only does climate risk directly affect the natural environment, but it also further transmits to the financial system through channels such as affecting the financial position of enterprises, asset values, and market demand, creating complex financial risks.

In recent time, the intensification of global climate change has highlighted the urgency and complexity of associated risks. In the economic and social fields, the impact of climate risk is multifaceted. Currently, academics categorize climate risks into physical and transition risks. Extreme weather and natural disasters not only directly damage assets, but may also lead to an increase in banks' credit, market, liquidity, and operational risks by affecting debtors' solvency, collateral value and other channels. In this context, physical risk includes the risk of direct damage to productive assets as a result of climate change, while transition risk includes the cash flow risk that may arise from the transition to a low-carbon economy. The former is mainly reflected in the disruption of firms' supply chains due to extreme weather, while the latter is reflected in the increase in firms' environmental compliance costs due to new policies. For example, research by scholars such as Chen Guojin(2024) shows that transition risk raises firms' financing costs.[2]

Currently, international scholars mainly use indicators constructed by text analysis methods (Li et al., 2024), temperature drought, and other physical climate data (Balvers et al., 2017; Hong et al., 2019; Ginglinger and Moreau., 2019), energy consumption data (Noh, 2018; Golosov et al., 2014), etc. as representation variables for measuring climate risk. For Chinese scholars, another research constructed a climate risk indicator for listed companies based on textual analysis of annual reports of listed companies in China (Du Jian et al., 2023); there are also related studies that use temperature, precipitation, and other data to portray China's climate risk (Liu Bo et al., 2021; Pan Min et al., 2022; Shen Yu et al., 2023).[3]

2.2 Corporate Performance

Corporate performance, as a key dimension in measuring the efficiency and effectiven ess of an organization's operations, has always been the focus of attention in both acad emia and practice. The analysis of corporate performance generally includes four core dimensions: profitability, solvency, operational efficiency and growth potential. In pr actice, the evaluation of corporate performance relies on a detailed data base, the use o f statistics and quantitative economics methods, combined with a well-designed indica tor system, to systematically quantitatively assess the operating results of the enterpris e in a specific period of time.

Currently, scholars in China usually select from the following three types of indicators when measuring enterprise performance: (1) financial indicators, including return on total assets (ROA), return on net assets (ROE), etc. By quantitatively analyzing the profitability, asset utilization efficiency and shareholder return level of an enterprise, it provides an intuitive and objective basis of performance evaluation for investors, managers and stakeholders. Many researchers tend to use these indicators when studying corporate performance. (2) Market indicators: such as TobinQ and price-earnings ratio, which focus on assessing the potential of the enterprise to create value in the future and the degree of market recognition of its growth. Although these indicators are to some extent influenced by market sentiment, investor expectations and other subjective factors, they are based on immediate feedback from the capital market on the value of the

enterprise and provide an important reference for predicting the future financial performance of the enterprise. (3)Comprehensive Indicators: Through DuPont Financial Analysis System, Balanced Scorecard and other comprehensive indicator methods, a series of interrelated indicators are set to closely link the strategic objectives, operation process and financial results of an enterprise, so as to realize an all-round and multi-level assessment of the enterprise's performance. However, the implementation threshold of the comprehensive indicator system is high and technically difficult, all of which need to be continuously explored and optimized by enterprises in practical application.[4]

2.3 Climate Risk and Corporate Performance

As global climate change intensifies, climate risk has a wide range of impacts on business operations (Griffin et al., 2017). Literature studies have shown that climate risk not only has a direct impact on production infrastructures, supply chains, infrastructure and so on (Hallegatte et al., 2011; Kousky and Cooke et al., 2012), but also indirectly in terms of policies, markets, consumers, etc.(Aldy and Pollard et al., 2011).[5]In terms of the impact of climate risk on firm performance, it has been noted that climate fluctuations directly affect firm effectiveness by altering physical and human capital inputs. For example, hot weather inhibits firms' productive operations through its impact on investment and capital inputs (Challinor et al., 2014), and the physical risks associated with climate shocks also directly and indirectly lead to a reduction in the quality and quantity of human capital elements (Kettenia et al. 2019). This degree of climate volatility, which is more of a transformation risk, can have a passive impact on business behavior and is not conducive to business performance.[6] through a study of mining firms, showed that different types of climate risks have different impacts on the financial performance of the firms, and these impacts are both positive and negative(Sun et al., 2019).[7] Mining firms are more volatile in the face of physical risks, especially when mineral extraction is dependent on the natural environment, and extreme weather events can have a significant impact on firms' capacity and earnings. In contrast, the technology sector may be more vulnerable to transformation risks. As societal demands for sustainability increase, high-carbon-emitting companies may be forced to increase their R&D investments to develop low- or zero-emission technologies.

Among the existing studies, the literature directly linking these is currently vacant. The research on the influence of external factors such as economy, politics and society on enterprise development has been widely concerned in the field of business administration. As a practical issue that cannot be avoided in management, the study on the impact of climate on enterprises is relatively constrained (Muthulingam et al., 2022).[8]

Some scholars point out that climate fluctuations directly affect the efficiency of enterprises by changing the input of material capital and human capital. For example, high temperature weather inhibits the production and operation of enterprises through its impact on investment and capital input (Challinor et al., 2014), the physical risk of climate shocks also directly and indirectly leads to a reduction in the quality and quantity of human capital factors (Kettenia et al., 2019). This degree of climate fluctuation

will have a passive impact on corporate behavior, which is harmful to the improvement of corporate performance.[9]

3 Hypotheses Development

3.1 Impact of Physical Risks on Corporate Performance

Physical risks, as a direct consequence of climate change, often have a significant impact on the day-to-day operations and financial performance of enterprises.[10] Damage to business infrastructure, disruptions to supply chains and reductions in production capacity can have a direct impact on the financial performance of businesses. For example, the 2011 floods in Thailand had a severe impact on global supply chains, particularly in the electronics and automotive industries. Thailand is the world's leading producer of hard disc drives (HDDs), and the floods led to factory closures and a precipitous drop in production capacity, with global HDD supply falling by about 30 per cent. Among them, Western Digital (Western Digital) company was severely affected, production fell sharply, resulting in the global price of hard discs doubled in a short period of time. Meanwhile, the parts supply chain of the automotive industry was even more deeply hit, especially Japanese car companies (such as Toyota and Honda) rely on parts suppliers can not be delivered normally, resulting in production disruptions and delays worldwide.

Meanwhile, agribusinesses are likely to suffer from reduced production due to droughts, fires and other weather-related disasters, with the 2019-2020 ‘Black Summer’ fires in Australia destroying thousands of hectares of farmland and vineyards, leading to agricultural losses of more than AU$1 billion, and the wine industry in particular suffering a major blow, with losses to wineries in the Adelaide Hills region estimated at AU$140 million. The wine industry in particular has been hit hard, with losses to wineries in the Adelaide Hills estimated at AU$140 million. Manufacturing companies, on the other hand, may suffer damage to their production facilities due to flooding or typhoons, resulting in higher production costs and lower profit margins. These natural disasters highlight the significant threat that natural hazards pose to agricultural and manufacturing production, and have prompted these industries to strengthen their resilience measures in reaction to climate change.

Moreover, the indirect impacts of climate change on businesses cannot be ignored. Extreme weather events may affect employee health, productivity and working hours, thus posing a challenge to companies' human resource management. This impact is particularly evident in the context of increasingly complex global supply chains. Therefore, the following hypotheses are proposed in this paper:

Hypothesis 1: The physical risks of climate change negatively affect firm performance through pathways such as infrastructure damage and supply chain disruption.

3.2 Impact of Transition Risk on Corporate Performance

Transition risks, on the other hand, are mainly reflected in the adjustment and adaptation measures undertaken by enterprises to cope with climate change, which usually

include policy changes, technological advances and transition of market demand. Such risks often affect financial performance by increasing operating costs. As governments implement stricter environmental protection policies and hold companies accountable for the environmental impacts of their operations, companies may be subject to higher compliance costs and environmental liabilities, which will have a direct impact on their profitability.[11] For example, China has implemented Cleaner Production Standards (CPSs), which are designed to reduce waste and emissions from production processes and promote more environmentally friendly production practices. Internationally, many policies have also been introduced in the area of environmental protection. The Nationally Determined Contribution (NDC) requires countries to set specific emission reduction targets and measures, and to submit regular updates to demonstrate their progress in reducing emissions; and new rules under the U.S. Climate Disclosure Rule (SEC) require public companies to disclose their climate risks and related financial information, including GHG emissions, emission reduction targets, and plans, etc. The NDC also requires companies to submit regular updates to demonstrate their progress in reducing emissions. These policies and requirements reflect the global expectation for companies to take action on environmental protection and aim to promote environmental sustainability and social responsibility on a global scale.

At the same time, companies may also be under pressure to transform their technologies.[12] For example, in order to meet emission reduction requirements, companies need to invest in new technology development or replace existing production equipment.[13] While these investments increase business costs in the short term, technological innovation may provide a competitive advantage in the long term.[14] Those firms that lead in low-carbon technologies and sustainable development are able to occupy a favourable position in the market with their environmental advantages, enhancing consumer trust and expanding their market share.

In addition, the impact of increased consumer environmental awareness on market performance is becoming more and more evident. More and more consumers tend to choose environmentally friendly products and services, therefore, enterprises that fail to quickly adapt to this trend may be at a disadvantage in market competition. Based on this, the hypothesis proposed is followed:

Hypothesis 2: Transitional risks of climate change negatively affect business performance through increased compliance costs, pressure for technological transition, and changes in market demand.

Hypothesis 3: Enterprises that proactively address the transitional risks of climate change can improve their enterprise performance in the long run through technological innovation and market competitiveness.

4 Research Design

4.1 Sample and Data Sources

This research investigates the impact of climate risk on corporate performance using a sample of Chinese A-share listed companies from 2010 to 2020. The analysis excludes firms in the financial sector and those under special treatment (ST and *ST firms) due

to regulatory or operational issues. The data used for the analysis is sourced from the CSMAR Database and WIND Database.

4.2 Empirical Model

The core target of this study is to assess whether climate risk has a prominent impact on corporate performance in China. In order to effectively investigate the causal impact of climate risk on firm performance, we used a fixed effects regression model.

$$\text{TobinQ\_Next}_{i,t+1} = \alpha_0 + \beta_1 \text{Climate Risk}_{it} + \gamma X_{it} + \delta + \varphi + \varepsilon_{it} \quad (1)$$

The dependent variable,$\text{TobinQ\_Next}_{i,t+1}$,represents the corporate performance of firm i in the next year t+1, measured by TobinQ. The primary explanatory variable,Climate Risk_{it},represents the level of climate risk disclosure, measured by the proportion of climate-related terms in firm annual reports. In order to further facilitate the quantification of the level of climate risk, our research prefers to use the anthology of transition risk words. $X_{i,t}$ denotes a matrix of control variables including firm size (Size), return on assets (ROA), operating cash flow(Cfo), leverage(Lev), growth, the proportion of independent directors(Indep), board size (Board).The complete variable definitions can be found in Table 1.

Additionally, $\delta_{r,t}$ denotes firm fixed effects while $\varphi_{j,t}$ denotes year fixed effects, and $\varepsilon_{i,,t}$ denotes the standard error of the regression model.

Table 1. Variable Definition.

Variable Type	Variable Name	Variable Value Description
Explained Variables	Corporate Performance	Measured by TobinQ in the next period
Explanatory Variables	Climate Risk	Level of climate risk disclosure (especially about transition risk)
Control Variables	Firm Size	Natural Logarithm of the total assets of the company
	Return on Assets	Net Income / Average Total Assets
	Operating Cash Flow	Cash flow from operating activities/Total assets at end of year
	Leverage	Total liabilities/Total assets
	Growth	Annual growth rate of operating income
	Independent directors	Number of sole directors/number of board of directors
	Board	Size of directors, natural logarithm of the number of board members

5 Empirical Results

From Table 2 about the descriptive statistics: the mean value of the explanatory variable TobinQ is 2.056, which differs from the maximum value of 8.860, indicating that the firm values of listed companies in the sample data of 20,906 companies is low overall, with certain variability and uneven levels of development. The mean value of the explanatory variable Risk is 0.003, and the standard deviation is 0.002, meaning that the information about climate risk mentioned in the corporate annual reports of listed companies in the sample data is generally low.

Among the control variables, the diversity between the minimum and the maximum value of enterprise size is 6.388, which means that the variability of enterprise size in the sample data is small. In terms of financial capability, the median of return on assets is 0.039, with a small difference between the minimum value of -0.262 and the maximum value of 0.221, showing that the there is a lower overall level of profitability among sample enterprises; the variance of operating cash flow is 0.070, which indicates that there is not much difference in short-term survivability, payment ability and solvency among the enterprises of the surface sample data; and the mean value of the financial leverage ratio is 0.424. The difference between the minimum value and the maximum value is 0.859, which demonstrating that the financial risk of the enterprises of the sample data has a large difference. The standard deviation of the proportion of independent directors is 0.073, which indicates that the proportion of independent directors is relatively stable among different companies. The standard deviation of board size is 0.247, indicating that the board size is somewhat different among different companies. The proportion of state-owned enterprises in all firms is 0.349, and the standard deviation is 0.477. This displays that the distribution of state-owned enterprises, as along as state-owned enterprises, is relatively balanced in the sample.

Table 2. Descriptive Statistics.

Variable	N	Mean	SD	Min	p25	p50	p75	Max
TobinQA_Next	20906	2.056	1.364	0.857	1.231	1.608	2.345	8.860
Risk	20906	0.003	0.002	0.000	0.001	0.002	0.004	0.012
Size	20906	22.13	1.260	19.681	21.219	21.958	22.850	26.019
ROA	20906	0.041	0.064	-0.262	0.015	0.039	0.071	0.221
Cfo	20906	0.044	0.070	-0.172	0.005	0.043	0.084	0.243
Lev	20906	0.424	0.208	0.049	0.255	0.414	0.581	0.908
Growth	20906	0.19	0.419	-0.589	-0.009	0.118	0.284	2.652
Indep	20906	0.381	0.073	0.250	0.333	0.364	0.429	0.600
Board	20906	2.281	0.247	1.609	2.197	2.303	2.398	2.890
SOE	20906	0.349	0.477	0.000	0.000	0.000	1.000	1.000

From Table 3 about the Regression results: controlling for firm fixed effects and year fixed effects, climate risk has a significant effect on TobinQ (next period) in the unidimensional dependent variable (coefficient of - 16.922 at the 5% level of significance),

showing a negative correlation, while in the multivariate model the coefficient of climate risk is -13.313, with a t-value of -2.09, which has a significant effect on TobinQ at the 1% level of significance. The data shows that there is a critical correlation between climate risk and TobinQ in both models, and climate risk can crucially affect the TobinQ value of enterprises, and as the climate risk increases, the TobinQ of enterprises shows a decreasing trend.

Table 3. Regression Results.

	(1)	(2)
	TobinQA_Next	TobinQA_Next
Risk	-16.922**	-13.313**
	(-2.42)	(-2.09)
Size		-0.451***
		(-14.95)
ROA		0.749***
		(3.64)
Cfo		0.930***
		(6.98)
Lev		0.580***
		(4.99)
Indep		-0.158
		(-1.26)
Board		0.003
		(0.06)
SOE		-0.149**
		(-2.32)
_cons	2.105***	11.864***
	(103.71)	(18.12)
Firm FE	YES	YES
Year FE	YES	YES
N	20906	20906
R2	0.612	0.629

Note: ***, ** and * are significant at the 1 per cent, 5 per cent and 10 per cent levels, respectively; values in parentheses are t-values.

6 Conclusion

This paper provides an in-depth study on the relationship between climate risk, mainly about transition risk, and business performance, and has achieved corresponding results. However, there are still many issues to be further explored:

(1) Insufficient refinement of the types of corporate climate risk: the text analysis and machine learning methods to capture the word frequency ratio of the word set in the annual report to determine the climate change risk can not deeply refine the climate change risk into multiple specific dimensions, and ignore the different impact of various types of risk on the operation and financial performance of the enterprise. Future research should aim to build a comprehensive climate change risk classification system and accurately measure the specific path and intensity of each type of risk on the sustainable development of enterprises through algorithmic modelling, so as to provide more accurate coping strategies for enterprises.

(2) Limitations in the scope of sample enterprises: This study focuses on China's A-share listed companies, which ensures the consistency and accessibility of the data, but limits the universality of the study's conclusions. Not only listed companies, but also a large number of other enterprises also face the challenges posed by climate change. These firms may exhibit different capabilities and strategies in coping with climate change risks due to factors such as size, industry characteristics or geographical location. Therefore, prospective research should expand the scope of the sample to include unlisted companies in order to reveal the differences in climate change risks among different industries and types of enterprises, and to provide empirical evidence for the formulation of more comprehensive and effective policies and management.

(3) Lack of comparative research on climate risk of foreign enterprises: Current research focuses on domestic enterprises, ignoring the differences in risk perception, coping strategies and performance of domestic and foreign enterprises under the circumstance of global climate change. With the deepening of globalization, climate risk has become an important issue for enterprises around the world. Therefore, future research should cross national boundaries, comparatively analyze the similarities and differences between domestic and foreign enterprises in climate risk management and the impact of climate risk on them, explore international best practices, and provide theoretical support and practical guidance to boost the competitiveness and influence of Chinese enterprises in global climate governance. At the same time, this will also help build a fairer and more reasonable international climate governance system and promote the realization of global sustainable development goals.

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