

Liu, Lian; Beirne, John; Azhgaliyeva, Dina; Rahut, Dil Bahadur

**Working Paper**

## Climate change and corporate financial performance

ADB Working Paper, No. 1457

**Provided in Cooperation with:**

Asian Development Bank Institute (ADBI), Tokyo

*Suggested Citation:* Liu, Lian; Beirne, John; Azhgaliyeva, Dina; Rahut, Dil Bahadur (2024) : Climate change and corporate financial performance, ADB Working Paper, No. 1457, Asian Development Bank Institute (ADBI), Tokyo,  
<https://doi.org/10.56506/DVFD7780>

This Version is available at:

<https://hdl.handle.net/10419/301962>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**Terms of use:**

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*



<https://creativecommons.org/licenses/by-nc-nd/3.0/igo/>



## **ADBI Working Paper Series**

### **CLIMATE CHANGE AND CORPORATE FINANCIAL PERFORMANCE**

---

Lian Liu, John Beirne, Dina Azhgaliyeva,  
and Dil Rahut

No. 1457  
June 2024

**Asian Development Bank Institute**

Lian Liu is a Lecturer, both at the Faculty of Global Studies, Musashino University and the Faculty of International Studies, Meiji Gakuin University, Tokyo, Japan. John Beirne is a Principal Economist at the Asian Development Bank, Manila, Philippines. Dina Azhgaliyeva is a Senior Research Fellow, and Dil Rahut is Vice-Chair of Research and Senior Research Fellow, both at the Asian Development Bank Institute, Tokyo, Japan.

The views expressed in this paper are the views of the author and do not necessarily reflect the views or policies of ADBI, ADB, its Board of Directors, or the governments they represent. ADBI does not guarantee the accuracy of the data included in this paper and accepts no responsibility for any consequences of their use. Terminology used may not necessarily be consistent with ADB official terms.

Discussion papers are subject to formal revision and correction before they are finalized and considered published.

The Working Paper series is a continuation of the formerly named Discussion Paper series; the numbering of the papers continued without interruption or change. ADBI's working papers reflect initial ideas on a topic and are posted online for discussion. Some working papers may develop into other forms of publication.

The Asian Development Bank refers to "China" as the People's Republic of China.

Suggested citation:

Liu, L., J. Beirne, D. Azhgaliyeva, and D. Rahut. 2024. Climate Change and Corporate Financial Performance. ADBI Working Paper 1457. Tokyo: Asian Development Bank Institute. Available: <https://doi.org/10.56506/DVFD7780>

Please contact the authors for information about this paper.

Email: [h082523@ptf.musashino-u.ac.jp](mailto:h082523@ptf.musashino-u.ac.jp)

Asian Development Bank Institute  
Kasumigaseki Building, 8th Floor  
3-2-5 Kasumigaseki, Chiyoda-ku  
Tokyo 100-6008, Japan

Tel: +81-3-3593-5500  
Fax: +81-3-3593-5571  
URL: [www.adbi.org](http://www.adbi.org)  
E-mail: [info@adbi.org](mailto:info@adbi.org)

© 2024 Asian Development Bank Institute

**Abstract**

Climate change impacts will continue to worsen with rising greenhouse gas (GHG) emissions and global temperatures, underscoring the growing necessity to foresee and comprehend the impact of climate change risks on economic activity. Using quarterly firm-level data of 173 firms from the People's Republic of China (PRC) over the period Q1 2018–Q2 2022, this study estimates the impact of firms' exposure to climate-related risks on their financial performance. The results indicate a notable adverse effect of climate change exposure on firms' rate of return, with a lag of around two years. Firms located in more climate-vulnerable coastal areas and high-income provinces experience relatively greater negative impacts on their financial returns. Our findings have important policy implications for firms aiming to maximize their returns through enhanced climate change mitigation and adaptation efforts.

**Keywords:** climate change, climate change exposure, corporate financial performance, PRC

**JEL Classification:** Q56, F61, Q54

## Contents

1.	INTRODUCTION.....	1
2.	DATA AND METHODOLOGY.....	3
2.1	Key Variables.....	3
2.2	Methodology.....	5
3.	EMPIRICAL ANALYSIS AND DISCUSSION .....	6
4.	CONCLUSION AND POLICY IMPLICATIONS .....	9
	REFERENCES .....	11
	APPENDIX.....	13

# 1. INTRODUCTION

Climate change and global warming have led to extreme weather events, such as an increase in temperature, floods, droughts, and sea level rises, severely affecting human health, food security, livelihoods, and economic activities. The negative repercussions for affected economies are substantial, with output losses affecting longer-term growth potential, causing a decline in investment and employment and hindering the progress toward the achievement of the Sustainable Development Goals. Without appropriate climate action and reducing GHG emissions, the economic effects of climate change on economies will continue to worsen, underscoring the growing importance of comprehending and anticipating the impact of climate change risks (Dell, Jones, and Olken 2014; Mihaylova and Blumer 2022). This paper examines the impact of corporate climate vulnerability and climate change management on firm performance, with a particular focus on firms located in climate-vulnerable coastal areas and more affluent Chinese provinces.

The channels through which climate change affects corporate financial performance are well documented in the literature. Climate change could shift the economic growth pattern of regions and comparative advantages (Moyo and Wingard 2015). Sun et al. (2020) observe that the risks associated with climate change influence corporate financial performance through a dual pathway, encompassing both direct (physical) impacts and indirect channels. Direct impacts include a wide array of consequences, including implications for core operations, such as damage to production materials and infrastructure. Additionally, disruptions in the value chain, such as an interrupted supply of raw materials, and infrastructural effects, such as damage to transportation, communication, and energy supply networks, further compound the challenges faced by corporations. Additionally, Cevik and Miryugin (2023) highlight the challenge that non-financial firms in climate-exposed countries face in accessing debt financing. They also observe that these firms tend to be less productive and less profitable than those in countries with lower vulnerability to climate change.

The indirect impacts of climate change on corporate financial performance are equally significant. These include climate-related financing constraints, such as carbon pricing and other climate-related policies, which can impose additional costs and financial burdens on companies. Furthermore, reputational considerations play a crucial role, with an increasing proportion of investors focusing on environmental, social, and governance (ESG) factors. Companies with poor environmental records or inadequate climate change mitigation strategies may face reputational damage and diminished investor confidence.

Legal matters also contribute to the indirect impacts of climate change on corporate financial performance. Changes in laws or regulations related to climate change, such as stricter environmental standards or emissions regulations, can result in increased compliance costs and legal liabilities for corporations. For instance, Fang, Tan, and Wirjanto (2019) show how climate change issues can trigger stricter environmental regulations and social norms, leading to higher costs of emissions or lower costs of green technologies for companies. These changes subsequently affect corporate operational costs and financial performance, highlighting the complex interplay between environmental regulations, technological innovation, and financial outcomes for corporations (Secinaro et al. 2020).

Most of the empirical literature underscores the adverse effect of climate change exposure on corporate financial performance. Using a sample dataset of Chinese listed firms from 2009 to 2021, Wu et al. (2021) investigate the impact of climate risks on the stock market. Their results indicate that greater corporate climate risks lead to negative market reactions in the PRC. Cooper, Raman, and Yin (2018) describe the impact of GHG emissions on company valuation, revealing a dual cost scenario. They note that GHG emissions lead to a reduction in company value due to both the anticipated negative cash flow associated with emissions in the future and the diminishing reputation regarding corporate social responsibility.

With increasing awareness of the Sustainable Development Goals (SDGs), more companies are taking proactive measures to address climate change issues. The empirical literature consistently finds a positive relationship between climate change management and corporate financial performance (Qian, Suryani, and Xing 2020). For instance, Sun et al. (2020) advocate for the adoption of low-carbon strategies and proactive disclosure of emission information to enhance corporate brand value and create new competitive advantages for long-term development. Similarly, Ziegler, Busch, and Hoffmann (2011) discover a positive correlation between disclosed corporate responses to climate change and stock performance among energy firms in the United States. Additionally, Perlin et al.'s (2022) study on Brazilian industrial companies concludes that firms with a high degree of climate change mitigation and adaptation practices demonstrate better market performance.

The literature examining the potential economic impacts of climate change is large and growing rapidly. However, empirical research investigating the firm-level impacts of climate change in the PRC remains relatively scarce. In addition, the existing empirical literature based on firm-level data often uses a country-level climate vulnerability measure (Acevedo et al. 2020).<sup>1</sup> Such a measure may not be sufficiently accurate to assess firms' climate exposure, especially in large countries like the PRC. While difficulties in gathering data on firm-level climate exposure remain, it needs to be borne in mind that firm-based analyses using country-level climate exposure measures should be interpreted with caution (Bernstein, Gustafson, and Lewis 2019; Hong, Li, and Xu 2019; Choi, Gao, and Jiang 2020).

Focusing on the PRC, this paper empirically investigates the impact of firms' climate change exposure on corporate financial performance using a firm-level panel dataset of 173 firms over the period Q1 2018 to Q2 2022. In particular, it exploits a climate change exposure and management score measured at the firm level, which is a more comprehensive measure than that used by Wu et al. (2022). More specifically, this study utilizes two measures of firms' climate change risks: (i) the Financial Times Stock Exchange (FTSE) climate change exposure score and (ii) the FTSE climate change management score. Our results show a significant negative impact of firms' climate change exposure on their rate of return, especially in the long term. The effect is more substantial for firms in coastal areas and high-income provinces. The empirical results imply that activities to reduce climate change exposure (such as integrating climate risk considerations into business models and implementing emission reduction initiatives) could improve firm performance.

The study makes two contributions to the existing literature. First, it adds to the limited body of empirical literature in the PRC concerning the impact of climate change exposure and management on firm corporate financial performance. Given the scarcity

---

<sup>1</sup> Some studies use firm-specific climate exposure measures, such as Ziegler et al. (2011) in the case of the EU and the US and Wu et al. (2022), who employ a firm-specific measure for the PRC based on transcripts of firms' performance briefings using a word count of climate-related keywords.

of such studies conducted in the PRC, this research fills an important gap in the existing literature. Secondly, prior research primarily focuses on the effect of GHG emission-related risks or policies on corporate financial performance. By extending the investigation beyond these areas, this study broadens the scope to include climate change exposure and management, thereby providing a more comprehensive understanding of the factors influencing financial outcomes for firms. This holistic approach offers deeper insights into the multifaceted relationship between climate change and corporate financial performance. The remainder of this paper is structured as follows. Section 2 provides the data and methodology. Section 3 discusses the results. Section 4 concludes and provides policy recommendations.

## **2. DATA AND METHODOLOGY**

### **2.1 Key Variables**

To investigate the effect of climate change on corporate financial performance in the PRC, this research utilizes a firm-level fixed-effect panel model across a dataset comprising 173 Chinese listed firms from 14 provinces. Studying the impact of climate change on firm financial performance in the Chinese market holds academic importance due to the PRC's high economic significance, geographical diversity, and global influence. The PRC, as one of the world's largest economies, offers a diverse economic landscape spanning various industries and regions. Its geographical diversity encompasses climate-vulnerable coastal areas and affluent inland provinces, providing a unique opportunity to examine the differential impacts of climate vulnerability on firms. Our dataset spans the period from 2018 to 2022 with a quarterly frequency.

Given the considerable heterogeneity in economic development levels and environmental susceptibility among Chinese provinces, this study further includes three sub-panels in the analysis: coastal provinces, the top 25% GDP per capita provinces, and the top 50% GDP per capita provinces. Such disaggregation allows for a more granular examination of the way in which varying degrees of exposure to climate-related risks intersect with differing economic conditions.

Coastal provinces, for instance, are often characterized by heightened vulnerability to climate change due to their reliance on maritime activities and exposure to extreme weather events, whereas regions within the top percentiles of GDP per capita may exhibit varying levels of economic resilience and adaptive capacity to climate impacts. By delineating our analysis into these sub-panels, this study aims to discern differential effects of climate change on corporate financial performance, thereby enriching our understanding of the complex interplay between climate dynamics, regional economics, and corporate outcomes within the Chinese context. This approach not only enhances the robustness of our findings but also facilitates the identification of targeted policy interventions and adaptation strategies tailored to specific regional needs, fostering more effective climate risk management and sustainable economic development pathways in the PRC.

The primary dependent variable of interest is the return on assets (ROA), which is calculated as the ratio of a firm's net income to its total assets' book value. The ROA is a widely accepted financial performance metric that reflects a firm's profitability and efficiency in generating returns from its assets (Peters and Mullen 2009; Gallego-Álvarez, García-Sánchez, and da Silva Vieira 2014; Sun et al. 2020; Cevik and Miryugin 2023). It provides valuable insights into how effectively a company is deploying its resources to generate earnings, irrespective of its size or industry.



To capture the impact of climate change on firms' financial performance, this study employs two firm-level variables: (i) the climate change exposure score and (ii) the climate change management score data extracted from the FTSE database. The FTSE climate change exposure score measures a company's relevance to climate change-related risk and is largely determined by industrial activity and operational presence.<sup>2</sup> The FTSE climate change exposure score evaluates various factors, including food security, sustainable agriculture, GHG emissions, and access to affordable, reliable, sustainable, and modern energy.<sup>3</sup> FTSE climate change exposure scores typically range from 0 to 3, where 3 is the highest exposure and 0 indicates that climate change does not affect the company. Companies with higher exposure scores are deemed to be more susceptible to climate risks.

The FTSE climate change management score evaluates a company's efforts and strategies for managing climate-related risks and opportunities. This score assesses the company's commitment to climate change mitigation, adaptation, and disclosure practices. It considers factors such as the existence of a climate change policy, the integration of climate considerations into business strategies, the implementation of emission reduction initiatives, and the level of transparency in reporting climate-related information. FTSE climate change management scores range from 0 to 5. A higher climate change management score indicates that a company is taking proactive measures to address climate risks, incorporating sustainability practices into its operations, and aligning its business with the goals of the Paris Agreement and other international climate frameworks. This score provides investors and stakeholders with valuable insights into a company's environmental stewardship and long-term sustainability.

The details of the variable definitions, descriptive summary statistics, and correlation matrix are provided in Appendix A (Tables A1, A2, and A3). The descriptive statistics reveal noteworthy patterns among the selected variables of interest. The mean GDP per capita of 31069.41, coupled with a substantial standard deviation of 11762.57, underscores the considerable economic heterogeneity prevalent across provinces within the PRC. The average exposure variable of 2.13, accompanied by a relatively small standard deviation of 0.79, suggests an overall high level of climate change vulnerability among firms operating within the Chinese market. Similarly, the average management score of 1.25, combined with a standard deviation of 0.94, signifies a spectrum of managerial quality among the sampled firms and a low level of climate change management. These observations collectively underscore the multifaceted nature of the economic and operational landscape within the PRC. Based on the correlation matrix, the independent variables generally exhibit low correlations, suggesting the absence of multicollinearity issues. While awareness of climate change is rising among Chinese firms, corresponding measures to address the climate risk are still not in place.

---

<sup>2</sup> For more details, please refer to *Guide to FTSE and Third Party Sustainable Investment Data used in FTSE Indices*, which is available at [https://research.ftserussell.com/products/downloads/Guide\\_to\\_FTSE\\_and\\_Third\\_Party\\_Sustainable\\_Investment\\_Data\\_used\\_in\\_FTSE\\_Russell\\_Indices.pdf](https://research.ftserussell.com/products/downloads/Guide_to_FTSE_and_Third_Party_Sustainable_Investment_Data_used_in_FTSE_Russell_Indices.pdf).

<sup>3</sup> For more details, please refer to *FTSE Russell ESG Rating のご紹介*, which is available at [https://www.jp.x.co.jp/corporate/sustainability/esgknowledgehub/esg-rating/nlsgeu0000053wrj-att/FTSE\\_ESG\\_Rating\\_j.pdf](https://www.jp.x.co.jp/corporate/sustainability/esgknowledgehub/esg-rating/nlsgeu0000053wrj-att/FTSE_ESG_Rating_j.pdf).

## 2.2 Methodology

We estimate the following baseline equation (1) to test the impact of climate change factors on corporate financial performance:

$$ROA_{i,t} = \alpha_0 + \alpha_1 Exposure_{i,t-1} + \alpha_1 Management_{i,t-1} + \alpha_2 X_{i,t-1} + \alpha_3 Macro_{j,t-1} + \delta_i + \mu_{it} \quad (1)$$

where  $i$ ,  $j$ , and  $t$  denote the firms, the provinces where the firms are located, and time indices, respectively.  $Exposure_{i,t-1}$  represents the firms' exposure score to climate change risks.  $Management_{i,t-1}$ , which represents the firms' management score of climate change risks, substitutes the exposure score to assess the effect of climate change management on ROA.  $\delta_i$  represents a firm fixed effect, while  $\mu_{i,t}$  is the error term. We also run regression specifications for coastal areas and high-income groups and examine the delayed effects of climate change using a higher lag level, drawing on the related literature.

Additionally, we incorporate a series of corporate-specific control variables (Vector  $X_{i,t-1}$ ), such as firm size, revenue growth, company age, and financial leverage, to account for other factors that may influence firms' financial performance (Cho and Tsang 2020). The natural logarithm of the total assets serves as a metric for firm size and is widely acknowledged as a pivotal factor influencing corporate financial performance. Larger firms typically benefit from economies of scale and wield greater bargaining power over suppliers and buyers, potentially leading to a positive impact on corporate value. Consequently, we anticipate a positive correlation between firm size and ROA.

Financial leverage, calculated as the ratio of debt to equity, constitutes a crucial instrument for companies in determining suitable financing and investment strategies. Maintaining a stable and optimal capital structure is pivotal for enhancing corporate financial performance. It is anticipated that higher revenue will be associated with higher ROA, reflecting a company's ability to generate greater profits from its assets.

Climate change typically influences corporate financial performance through macroeconomic channels, such as provincial economic development and the impact of events like COVID-19. The literature extensively documents the effects of climate change on economic development, often manifested through increased frequency and severity of natural disasters. These events can disrupt economic activities, damage infrastructure, and hinder business operations, thereby affecting corporate profitability and growth prospects (Volz et al. 2020; Loayza et al. 2012; Raddatz 2009). We include three domestic macroeconomic factors in the regression, as represented in the vector  $Macro_{j,t-1}$ : the COVID-19 exposure, provincial GDP per capita, and urban population ratio in the respective provinces. These variables offer insights into broader economic conditions that may interact with climate change to affect corporate financial outcomes.

The COVID-19 pandemic has had a profound impact on corporate financial performance through various channels, such as disruptions to supply chains, shifts in consumer behaviors, operational challenges, and financial market volatility. The Oxford Stringency Index<sup>4</sup> serves as a proxy for COVID-19 exposure, offering a quantitative

---

<sup>4</sup> The Oxford Stringency Index was developed by the Oxford Coronavirus Government Response Tracker (OxCGRT) project at the University of Oxford. It is available at <https://ourworldindata.org/covid-stringency-index#learn-more-about-the-data-source-the-oxford-coronavirus-government-response-tracker>.

and comprehensive assessment of the stringency of government efforts to tackle the pandemic, such as travel restrictions, lockdown policies, and so on (Hale et al. 2021). COVID-19 data are not available at the firm level because such COVID-related restrictions were implemented at the provincial level.

Due to variations in economic development across different provinces in the PRC, it is important to consider and incorporate specific macroeconomic factors related to each province when analyzing the factors affecting corporate financial performance: the provincial GDP per capita and urban population ratio. A higher provincial GDP per capita indicates a larger consumer market with greater purchasing power. Companies operating in provinces with a higher GDP per capita are likely to benefit from increased consumer demand, leading to higher sales revenues and potential growth opportunities. Besides, the provincial GDP per capita can reflect the overall economic conditions and investment climate. A higher GDP per capita suggests a more developed and prosperous economy, which may attract more domestic and foreign investments. An improved investment climate, including access to capital, infrastructure, and skilled labor, can influence a company's financial performance positively by providing resources for expansion, innovation, and productivity enhancements.

According to the existing literature, the impact of climate change factors on corporate financial performance can exhibit differing dynamics over short- and long-term horizons. Notably, climate change factors may not yield immediate short-term effects on a firm's financial performance. However, these effects on financial performance metrics tend to materialize with a time lag. Specifically, the studies by Hang, Geyer-Klingenberg, and Rathgeber (2019) and Hart and Ahuja (1996), indicate that a period of approximately two years is typically required before the impacts on financial performance become evident.

In light of these findings, our regression analysis incorporates a strategic approach to account for this temporal lag. In the baseline regression model, we introduce a lag of one period for the climate change variables and other variables to mitigate the endogeneity concerns. Furthermore, to account for the lagged impact of climate change on firm performance, we explore a regression wherein the climate change variables are lagged by eight periods (i.e., eight quarters or two years). This dual regression framework allows us to examine comprehensively the potential time-delayed effects of climate change factors on corporate financial performance.

### **3. EMPIRICAL ANALYSIS AND DISCUSSION**

The main results for the impact of climate change exposure and management on corporate financial performance are provided in Table 1. In addition to the baseline estimation across all firms, we test specifications based on sub-panels of firms in coastal areas, the top 25% GDP per capita areas, and the top 50% GDP per capita areas.

From Table 1, it is apparent that the impact of firms' climate change exposure and management on corporate financial performance is not statistically significant, implying that climate change factors do not affect firms' financial performance in the short run, that is, with a lag of one quarter. Drawing on the literature, it is commonly understood that the duration horizon may be longer, with some studies indicating that it could take around two years for financial performance to be affected (Hang, Geyer-Klingenberg, and Rathgeber 2018; Hart and Ahuja 1996). As an alternative approach, we explore a regression wherein the climate change variables are lagged by two years while

other variables are still lagged by one period. The regression results of the alternative specifications of the baseline are presented in Table 2.

**Table 1: Determinants of Corporate Financial Performance  
(Return on Assets—ROA)**

	(1)	(2)	(3)	(4)
	All Firms	Coastal Area	Top 25% GDP per Capita Area	Top 50% GDP per Capita Area
Variable	ROA	ROA	ROA	ROA
<b>Climate change factors</b>				
Exposure(a)	−0.416 (0.705)	−1.132 (1.245)	−2.881** (1.202)	−2.262** (1.084)
Score (b)	−0.244 (0.264)	0.0860 (0.462)	−2.579*** (0.854)	−0.863 (0.562)
Exposure*GDP per capita	0.000 (0.000)	0.000 (0.000)	0.000*** (0.000)	0.000*** (0.000)
Score*GDP per capita	0.000 (0.000)	0.000 (0.000)	0.000*** (0.000)	0.000* (0.000)
<b>Macroeconomic factors</b>				
GDP per capita	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
COVID Contingency Index	0.016*** (0.003)	0.018*** (0.005)	0.015*** (0.005)	0.014*** (0.004)
Urban population ratio (%)	27.800** (12.070)	−9.436 (17.310)	−89.990 (91.540)	−12.870 (20.290)
<b>Firm-specific factors</b>				
Total assets (log)	−0.521 (0.433)	1.184* (0.636)	1.465** (0.603)	1.168** (0.527)
Revenue growth (%)	0.013*** (0.002)	0.013*** (0.002)	0.011*** (0.002)	0.010*** (0.002)
Financial leverage (%)	−1.048*** (0.162)	−1.431*** (0.206)	−1.450*** (0.185)	−1.382*** (0.174)
Firm age	−0.923*** (0.187)	−0.721*** (0.279)	−0.760*** (0.291)	−0.869*** (0.237)
Constant	11.000 (7.421)	22.140** (10.510)	95.990 (77.800)	30.350* (15.490)
Observations	2,515	1,408	1,333	1,584
R-squared	0.064	0.078	0.091	0.082
Number of firms	176	97	96	113

Note: All the independent variables are lagged by one period to mitigate the endogeneity concerns. Standard errors are in parentheses. \*\*\*, \*\*, and \* denote  $p < 0.01$ ,  $p < 0.05$ , and  $p < 0.1$ , respectively. (a) Climate change exposure score and (b) climate change management score data.

**Table 2: Impact of Climate on Firm Performance over a Longer Time Horizon**

	(1)	(2)	(3)	(4)
	All Firms ROA	Coastal Area ROA	Top 25% GDP per Capita Area ROA	Top 50% GDP per Capita Area ROA
<b>Climate change factors</b>				
Exposure (a)	−3.378** (1.504)	−5.453** (2.521)	−8.583*** (2.654)	−7.174*** (2.157)
Score (b)	0.029 (0.400)	−0.175 (0.721)	−2.558 (1.868)	−0.601 (0.970)
Exposure*GDP per capita	0.000*** (0.000)	0.000** (0.000)	0.000*** (0.000)	0.000*** (0.000)
Score*GDP per capita	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
<b>Macroeconomic factors</b>				
GDP per capita	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
COVID Contingency Index	0.015*** (0.004)	0.019*** (0.005)	0.020*** (0.007)	0.013** (0.005)
Urban population ratio (%)	26.440 (23.430)	−15.260 (31.330)	−578.800 (362.900)	−31.130 (46.820)
<b>Firm-specific factors</b>				
Total assets (log)	−0.793 (0.729)	1.875 (1.251)	0.359 (0.922)	0.483 (0.818)
Revenue growth (%)	0.013*** (0.002)	0.015*** (0.003)	0.011*** (0.003)	0.010*** (0.003)
Financial leverage (%)	−0.580*** (0.222)	−0.779*** (0.299)	−0.723*** (0.279)	−0.686*** (0.259)
Firm age	−0.924*** (0.339)	−1.290** (0.533)	−0.831 (0.552)	−0.852* (0.484)
Constant	16.700 (15.710)	37.560* (21.050)	537.600* (319.100)	52.860 (38.250)
Observations	1,517	853	798	952
R-squared	0.054	0.070	0.058	0.053
Number of firms	173	96	94	111

Note: Climate change variables are lagged by two years and other independent variables are lagged by one period to mitigate the endogeneity concerns. Standard errors are in parentheses. \*\*\*, \*\*, and \* denote  $p < 0.01$ ,  $p < 0.05$ , and  $p < 0.1$ , respectively. (a) Climate change exposure score and (b) climate change management score data.

The results from Table 2 show that firms' climate change exposure has a statistically significant (at the 95% level of significance) and negative impact on corporate financial performance, which is in line with the research by Cevik and Miryugin (2023). The estimated coefficients for climate change exposure exhibit a greater magnitude in coastal and higher-income provinces, suggesting a more pronounced adverse effect on firms' financial performance within coastal areas and provinces with a higher income per capita. This implies that firms situated in coastal areas and provinces characterized by a higher income per capita experience a disproportionately larger decline in financial performance attributable to climate change exposure. The observed disparity in the impact of climate change exposure on financial performance, with greater significance discerned in coastal and higher-income provinces, underscores the intricate interplay between regional economic dynamics and environmental vulnerabilities within the

context of climate change. Coastal provinces, characterized by their heightened susceptibility to climate-related risks due to factors such as their economic dependence on maritime trade, urbanization patterns, and exposure to extreme weather events, exhibit more pronounced sensitivity to shifts in climatic conditions. Concurrently, higher-income provinces, typically endowed with greater resources and infrastructure resilience, may nonetheless manifest heightened sensitivities to climate change impacts owing to their complex economic interdependencies and infrastructural dependencies on coastal assets.

However, the impact of climate change management is not significant. The climate change exposure score incorporates the actual environmental performance of firms related to GHG emissions, energy consumption, food security, agricultural sustainability, and access to affordable, reliable, sustainable, and modern energy. The climate change management score, however, measures firms' commitment to climate change mitigation and adaptation and includes the existence of a climate change policy, the integration of climate considerations into business strategies, the implementation of emission reduction initiatives, and the level of transparency in reporting climate-related information. Thus, firms' vulnerability and exposure to climate change negatively affect their financial performance. In contrast, firms' commitment to climate change mitigation and adaptation has no significant impact on their financial performance. The lack of significance in the climate management measure could be related to duration effects, whereby such impacts on firm performance could take longer to materialize. Besides, the effort of one firm may be too small to bring about a reduction in GHG emissions and hence the mitigation effect. For this mitigation, the efforts of all the firms across the world are needed.

The empirical results suggest that activities reducing climate change exposure (such as integrating climate consideration into business strategies and implementing emission reduction initiatives) could improve firm performance, especially for firms located in coastal areas and higher-income provinces.

## 4. CONCLUSION AND POLICY IMPLICATIONS

With increasing GHG gas emissions, climate change will accelerate and worsen, resulting in loss of life and property. Hence, it is imperative to foresee and comprehend the impact of climate change risks on economic activity. Utilizing a quarterly firm-level dataset from the PRC over the period Q1 2018–Q2 2022, this paper estimates the impact of firms' exposure to and management of climate-related risks (such as commitment to climate change mitigation, adaptation, and disclosure practice) on their financial performance.

The current study highlights two findings that have crucial policy implications. First, firms' exposure to climate change has a detrimental impact on their financial performance. However, the effect is statistically significant only over a longer time horizon. Conversely, the impact of climate change management on firm performance is not statistically significant at all. This result could arise because the commitments made by firms to climate change mitigation and adaptation and disclosure practices (such as the corporate climate change policy, the integration of climate considerations into business strategies, the implementation of emission reduction initiatives, and the level of transparency in reporting climate-related information) may be outweighed by the effects of exposure that are negative or not sufficiently material to be reflected in firms' financial performance.

Second, the negative impact of climate change exposure on financial performance is relatively stronger for firms located in coastal areas and higher-income provinces, which are pivotal contributors to the PRC's GDP output. The key message from our findings relates to motivating firms to take climate action, which would boost their financial performance and help contribute to achieving broader global goals in the transition to net zero carbon emissions and sustainable development. Given the significant economic contribution of coastal regions, it is imperative to implement targeted measures to counteract the adverse effects of climate change vulnerability in these areas. Policymakers should prioritize initiatives aimed at enhancing climate resilience, promoting sustainable development practices, and investing in infrastructure to mitigate the economic risks posed by climate change in coastal regions. Additionally, fostering innovation and technology adoption can help to bolster the resilience of coastal economies and facilitate their transition to a low-carbon and climate-resilient future. By overcoming the unique challenges faced by coastal areas, policymakers can safeguard their economic prosperity and promote sustainable development in these critical regions.

The lag with which climate exposure affects firm performance implies that firms must be forward looking and proactive in their efforts to alleviate their exposure to climate change. While climate-related events may not have detrimental impacts on firms' ROA in the short term, complacency in taking affirmative action should be avoided. As climate-related exposure affects firm performance through macroeconomic and related channels, taking time to materialize, a longer-term perspective on incorporating climate risks into business models will be key. This is particularly the case for firms in coastal and more affluent provinces.

Finally, other specific measures should aim to invest in capacity building and knowledge transfer initiatives that can help firms to understand and address better the implications of climate change for their financial performance, fostering resilience and adaptation within the business sector. These measures collectively aim to mitigate the negative impacts of climate change on corporate financial performance and build resilience against future climate change risks.

## REFERENCES

- Acevedo, S., M. Mrkaic, N. Novta, E. Pugacheva, and P. Topalova. 2020. The Effects of Weather Shocks on Economic Activity: What Are the Channels of Impact? *Journal of Macroeconomics* 65: 103207. <https://doi.org/10.1016/j.jmacro.2020.103207>.
- Bernstein, A., M. T. Gustafson, and R. Lewis. 2019. Disaster on the Horizon: The Price Effect of Sea Level Rise. *Journal of Financial Economics* 134(2): 253–272. <https://doi.org/10.1016/j.jfineco.2019.03.013>.
- Cevik, S., and F. Miryugin. 2023. Rogue Waves: Climate Change and Firm Performance. *Comparative Economic Studies* 65(1): 29–59. <https://doi.org/10.1057/s41294-022-00189-0>.
- Cho, E. and Tsang, A., 2020. Corporate social responsibility, product strategy, and firm value. *Asia-Pacific Journal of Financial Studies* 49(2): 272–298. <https://doi.org/10.1111/ajfs.12291>.
- Choi, D., Z. Gao, and W. Jiang. 2020. Attention to Global Warming. *The Review of Financial Studies* 33(3): 1112–1145. <https://doi.org/10.1093/rfs/hhz086>.
- Cooper, S. A., K. K. Raman, and J. Yin. 2018. Halo Effect or Fallen Angel Effect? Firm Value Consequences of Greenhouse Gas Emissions and Reputation for Corporate Social Responsibility. *Journal of Accounting and Public Policy* 37(3): 226–240. <https://doi.org/10.1016/j.jaccpubpol.2018.04.003>.
- Dell, M., B. F. Jones, and B. A. Olken. 2014. What Do We Learn from the Weather? The New Climate-Economy Literature. *Journal of Economic Literature* 52(3): 740–798. <https://doi.org/10.1257/jel.52.3.740>.
- Fang, M., K. S. Tan, and T. S. Wirjanto. 2019. Sustainable Portfolio Management under Climate Change. *Journal of Sustainable Finance & Investment* 9(1): 45–67. <https://doi.org/10.1080/20430795.2018.1522583>.
- Gallego-Álvarez, I., I. M. García-Sánchez, and C. da Silva Vieira. 2014. Climate Change and Financial Performance in Times of Crisis. *Business Strategy and the Environment* 23(6): 361–374. <https://doi.org/10.1002/bse.1786>.
- Hale, T., N. Angrist, R. Goldszmidt, B. Kira, A. Petherick, T. Phillips, S. Webster, E. Cameron-Blake, L. Hallas, S. Majumdar, and H. Tatlow. 2021. A Global Panel Database of Pandemic Policies (Oxford COVID-19 Government Response Tracker). *Nature Human Behaviour* 5(4): 529–538. <https://doi.org/10.1038/s41562-021-01079-8>.
- Hang, M., J. Geyer-Klingenberg, and A. W. Rathgeber. 2019. It Is Merely a Matter of Time: A Meta-analysis of the Causality between Environmental Performance and Financial Performance. *Business Strategy and the Environment* 28(2): 257–273. <https://doi.org/10.1002/bse.2215>.
- Hart, S. L., and G. Ahuja. 1996. Does It Pay To Be Green? An Empirical Examination of the Relationship between Emission Reduction and Firm Performance. *Business Strategy and the Environment* 5(1): 30–37. [https://doi.org/10.1002/\(SICI\)1099-0836\(199603\)5:1<30::AID-BSE38>3.0.CO;2-Q](https://doi.org/10.1002/(SICI)1099-0836(199603)5:1<30::AID-BSE38>3.0.CO;2-Q).
- Hong, H., F. W. Li, and J. Xu. 2019. Climate Risks and Market Efficiency. *Journal of Econometrics* 208(1): 265–281. <https://doi.org/10.1016/j.jeconom.2018.09.015>.



- Loayza, N. V., E. Olaberria, J. Rigolini, and L. Christiaensen. 2012. Natural Disasters and Growth: Going beyond the Averages. *World Development* 40(7): 1317–1336. <https://doi.org/10.1016/j.worlddev.2012.03.002>.
- Mihaylova, I., and A. Blumer. 2022. Analytical Approaches for the Climate-Related Risk Estimation of Commercial Banks' Credit Activities: Challenges, Opportunities, and the Way Ahead. *Journal of Sustainable Finance & Investment* 1–5. <https://doi.org/10.1080/20430795.2019.1704160>.
- Moyo, M., and Wingard, H. C. 2015. An assessment of the impact of climate change on the financial performance of South African companies. *Journal of Governance and Regulation* 4(2-1): 49–62. [https://doi.org/10.22495/jgr\\_v4\\_i2\\_p5](https://doi.org/10.22495/jgr_v4_i2_p5).
- Perlin, A. P., C. M. Gomes, F. D. Motke, I. Kruglianskas, and F. C. Zaluski. 2022. Climate Change Mitigation, Adaptation Practices, and Business Performance in Brazilian Industrial Companies. *Sustainability* 14(18): 11506. <https://doi.org/10.3390/su141811506>.
- Peters, R., and M. R. Mullen. 2009. Some Evidence of the Cumulative Effects of Corporate Social Responsibility on Financial Performance. *Journal of Global Business Issues* 3(1): 1–14.
- Qian, W., A. W. Suryani, and K. Xing. 2020. Does Carbon Performance Matter to Market Returns during Climate Policy Changes? Evidence from Australia. *Journal of Cleaner Production* 259: 121040.
- Raddatz, C. E. 2009. The Wrath of God: Macroeconomic Costs of Natural Disasters. Policy Research Working Paper Series 5039. Washington, DC: The World Bank. <https://elibrary.worldbank.org/doi/abs/10.1596/1813-9450-5039>.
- Secinaro, S., V. Brescia, D. Calandra, and B. Saiti. 2020. Impact of Climate Change Mitigation Policies on Corporate Financial Performance: Evidence-Based on European Publicly Listed Firms. *Corporate Social Responsibility and Environmental Management* 27: 2491–2501. <https://doi.org/10.1002/csr.1971>.
- Sun, Y., Y. Yang, N. Huang, and X. Zou. 2020. The Impacts of Climate Change Risks on Financial Performance of Mining Industry: Evidence from Listed Companies in China. *Resources Policy* 69: 101828. <https://doi.org/10.1016/j.resourpol.2020.101828>.
- Volz, U., J. Beirne, N. Ambrosio Preudhomme, A. Fenton, E. Mazzacurati, N. Renzhi, and J. Stampe. 2020. *Climate Change and Sovereign Risk*. London: SOAS University of London; Tokyo: Asian Development Bank Institute; Singapore: World Wide Fund for Nature Singapore; and Berkeley, CA: Four Twenty Seven. <https://doi.org/10.25501/SOAS.00033524>.
- Wu, N., W. Xiao, W. Liu, and Z. Zhang. 2022. Corporate Climate Risk and Stock Market Reaction to Performance Briefings in China. *Environmental Science and Pollution Research* 29: 53801–53820. <https://doi.org/10.1007/s11356-022-19479-2>.
- Ziegler, A., T. Busch, and V. H. Hoffmann. 2011. Disclosed Corporate Responses to Climate Change and Stock Performance: An International Empirical Analysis. *Energy Economics* 33: 1283–1294. <https://doi.org/10.1016/j.eneco.2011.03.007>.

## APPENDIX

**Table A1: Overview of the Variables Used in the Empirical Analysis**

Variable	Definition	Data Source
ROA	Net income to total assets ratio	S&P Capital IQ
Exposure	Exposure to climate change risks	FTSE Russel
Management	Management of climate change risks	FTSE Russel
Stringency Index	OxCGRT COVID-19 Stringency Index to measure the variation in governments' responses to COVID-19	Hale et al. (2021)
GDP per capita	GDP per capita by province	CEIC
Urban population ratio	Urban population ratio	CEIC
Total assets	Natural logarithm of total assets	S&P Capital IQ
Financial leverage	Total debt as a percentage of shareholders' equity	S&P Capital IQ
Revenue growth	Revenue growth rate	S&P Capital IQ
Age	Firm age	S&P Capital IQ

**Table A2: Summary Statistics**

Variable	Obs.	Mean	Std Dev.	Min.	Max.
ROA	3,553	2.67	4.63	-74.36	32.36
Exposure	3,246	2.13	0.79	1.00	3.00
Management	3,246	1.25	0.94	0.00	3.00
Stringency Index	3,752	31.11	29.67	0.00	97.22
GDP per capita	3,762	31,069.41	11,762.57	9,180.79	48,120.91
Urban population ratio	3,762	0.79	0.11	0.45	0.89
Total assets (log)	3,624	9.90	1.78	6.37	15.59
Financial leverage	3,496	1.01	1.80	-35.49	60.64
Revenue growth	3,636	15.10	34.44	-93.58	288.95
Age	3,294	29.94	22.91	2.75	174.00

**Table A3: Correlation Matrix of All Variables**

	ROA	Exposure	Management	Stringency Index	GDP per Capita	Urban Population Ratio	Total Assets (Log)	Financial Leverage	Revenue Growth	Age
ROA	1									
Exposure	0.050	1								
Management	-0.119	-0.382	1							
Stringency Index	-0.079	-0.031	0.176	1						
GDP per capita	-0.138	-0.225	0.189	0.222	1					
Urban population ratio	-0.192	-0.209	0.132	0.096	0.852	1				
Total assets (log)	-0.232	-0.237	0.436	0.100	0.264	0.288	1			
Financial leverage	-0.243	-0.171	0.199	-0.018	0.105	0.182	0.384	1		
Revenue growth	0.200	-0.032	0.005	-0.088	-0.011	-0.024	-0.003	-0.018	1	
Age	0.000	-0.039	0.061	0.045	0.000	-0.017	0.054	-0.099	-0.078	1