Proceedings of Business and Economic Studies, 2026, Volume 9, Issue 7
http://ojs.bbwpublisher.com/index.php/PBES
Online ISSN: 2209-265X
Print ISSN: 2209-2641

How Extreme Climate Risks Affect Economic Resilience: A Case Study of 280 Cities in China

Siwen Wang
Nanjing Audit University, Nanjing 210000, Jiangsu, China

Abstract: As global climate change intensifies, extreme weather events occur with increasing frequency, posing severe challenges to the stability and sustainable development of urban economic systems. This paper employs Chinese city panel data from 2011 to 2020 as its research sample to systematically assess the impact of extreme climate risks on urban economic resilience. First, an urban economic resilience index was constructed using the entropy method, alongside a climate risk index incorporating indicators such as extreme heat, extreme cold, extreme drought, and extreme precipitation. Second, empirical analysis employing the two-way fixed effects model examined the impact of climate risk on economic resilience, with mediating effects and heterogeneity analysis revealing the underlying mechanisms. Findings indicate: (1) extreme climate risks significantly undermine urban economic resilience, with high temperatures exerting the most pronounced negative effect; (2) agricultural dependency partially mediates the relationship between climate risks and economic resilience, indicating that climate risks further diminish the recovery capacity of economic systems by impacting agricultural output; (3) the impact of climate risks on economic resilience exhibits regional heterogeneity, with high-risk areas experiencing stronger shocks while low-risk areas demonstrate relative robustness. Robustness tests further validate the reliability of these conclusions. Based on this, the following policy recommendations are proposed: strengthen urban climate adaptation and disaster prevention and mitigation capacity building; promote industrial structure optimization and non-agricultural industrial development; enhance agricultural climate adaptability; and implement differentiated resilience enhancement strategies according to regional risk levels. This study not only enriches the literature on climate risk and economic resilience but also provides empirical support and policy insights for urban sustainable development in the context of climate change.

Keywords: Extreme climate risks; Economic resilience; Mediating effects; Heterogeneity analysis

Online publication: July 28, 2026

1. Introduction

Climate change has increased the frequency and intensity of extreme weather events, such as floods, droughts, heatwaves, and heavy rainfall, posing growing risks to agriculture, infrastructure, energy supply, public health, and financial markets. These risks have become important external shocks affecting the stability and adaptability of regional economies.

In this context, economic resilience has gained increasing attention. It refers to an economy's ability to withstand, absorb, recover from, and adapt to external shocks. Compared with traditional growth-oriented perspectives, resilience places greater emphasis on system stability, adaptive capacity, and long-term transformation under uncertainty.

China provides an important case for studying this issue. Due to its vast territory, diverse climate conditions, frequent meteorological disasters, and uneven regional development, different cities show clear differences in fiscal capacity, infrastructure, governance quality, and disaster response ability. Therefore, China is well suited for examining how extreme climate risks affect regional economic resilience.

Although existing studies have discussed climate risks, disaster losses, vulnerability, and adaptation strategies, most focus on post-disaster impacts. Relatively few studies examine climate risk from a forward-looking and probabilistic perspective, especially how the probability of extreme weather events influences regional economic resilience through institutional, financial, and infrastructural channels.

To fill this gap, this study uses city-level panel data in China to construct a Climate Risk Probability Index and applies two-way fixed effects and spatial heterogeneity models. It aims to examine the long-term impact of extreme climate risks on regional economic resilience and provide empirical evidence for climate adaptation and resilience-building policies.

In this study, "climate risk" mainly refers to the increasing frequency and intensity of extreme weather events, which is closely related to the concept of "extreme weather risk."

2. Literature review

2.1. A review of international research

International studies generally show that extreme weather shocks weaken economic resilience through both direct and indirect channels. At the macro level, hurricanes, cyclones, heatwaves, and rising temperatures can cause immediate economic losses and long-term growth decline [1]. At the regional and urban levels, scholars increasingly use nighttime lights, electricity data, and other high-frequency indicators to measure post-disaster disturbance and recovery, revealing clear spatial differences in resilience. In addition, supply chains and production networks can amplify local climate shocks into broader systemic risks through upstream and downstream linkages [2,3]. Overall, international research emphasizes the dynamic process of "shock–recovery–adaptation" and provides useful methodological references for studying climate risks and economic resilience.

2.2. A review of domestic research

Chinese scholars have examined urban economic resilience mainly from the perspectives of urban development, industrial structure, finance, infrastructure, energy systems, and digital transformation. Existing studies suggest that urban sprawl may weaken resilience, while urban–rural integration, factor mobility, digital innovation, and industrial upgrading can enhance cities' adaptive capacity [4]. Industrial diversification and service-oriented structures are also found to reduce vulnerability to climate shocks [5]. Meanwhile, extreme precipitation and other climate risks may increase regional financial risks, credit default risks, and market volatility, while insurance and green finance can help mitigate these impacts [6]. Infrastructure and energy resilience are also key foundations of urban resilience. However, existing domestic studies are still relatively fragmented, and comprehensive analyses of how multiple extreme climate risks affect urban economic resilience remain insufficient.

2.3. Construction and measurement of urban economic resilience indicators

This study constructs an urban economic resilience indicator system from three dimensions: resistance and recovery capacity, adaptation and adjustment capacity, and transformation and development capacity.

Resistance and recovery capacity reflects a city's short-term ability to withstand and recover from shocks, including indicators such as income, savings, employment, and imports and exports. Adaptation and adjustment capacity measures medium-term flexibility, mainly through fiscal revenue, consumption, industrial structure, finance, and investment. Transformation and development capacity captures long-term resilience potential, including innovation, education, and public expenditure on science and technology.

Overall, this framework covers short-term resistance, medium-term adaptation, and long-term transformation. It is consistent with the resilience logic of "resistance–recovery–adaptation–transformation" and provides a comprehensive basis for evaluating China's urban economic resilience under extreme climate risks.

3. Theoretical hypothesis

Hypothesis 1: The increase in the extreme climate index reduces the economic resilience of cities.

Extreme weather events weaken urban economic resilience mainly through infrastructure damage and economic instability. Disasters such as floods and hurricanes can disrupt transportation, energy supply, medical services, water systems, and other critical infrastructure, thereby reducing cities' ability to resist and recover from shocks. In addition, extreme weather may increase regional financial risks and generate spatial spillover effects through interregional economic and financial linkages, further weakening urban adaptability and recovery capacity. Therefore, this study proposes Hypothesis 1.

Hypothesis 2: Extreme climate risks impact economic resilience by affecting agriculture.

Agriculture is highly sensitive to climate conditions and is often the first sector affected by extreme weather. Events such as heatwaves, floods, and droughts can reduce agricultural output, raise food prices, and disturb both rural and urban markets. Through supply chains and industrial linkages, agricultural shocks may increase living costs, suppress consumption, and weaken overall economic activity. In less developed regions, agriculture also provides important employment, so climate-induced income losses may further increase labor market instability.

Hypothesis 3: The impact of extreme climate risks on urban economic resilience varies across regions.

The effect of extreme climate risks on urban resilience is regionally heterogeneous. Differences in geographic exposure, climate conditions, industrial structure, and governance capacity lead to different resilience outcomes. Cities with higher exposure to heat, floods, or droughts tend to be more vulnerable, while cities with diversified industries, stronger fiscal capacity, and better disaster management systems are better able to absorb and recover from shocks.

Hypothesis 4: Different types of extreme climate risks exert varying impacts on urban economic resilience.

Different extreme weather events affect urban economic resilience through different channels. Extreme heat mainly reduces labor productivity, increases energy demand, and raises public health risks. Extreme cold disrupts heating, transport, and infrastructure systems. Droughts damage agriculture and water-dependent industries, while extreme precipitation and floods directly destroy infrastructure and critical public services.

4. Methodology and data

4.1. Entropy weight method

The entropy method is an approach for calculating the weightings of various indicators based on information entropy. The greater the information entropy, the less information the indicator provides; conversely, the lower the information entropy, the greater the information provided by the indicator. To enhance the objectivity and comparability of the measurement results, this paper adopts the entropy method for weighting. This effectively mitigates subjective bias.

4.2. Data

4.2.1. Explained variable: Economic Resilience

Given the significant variations in secondary indicators and their orientations across prefecture-level cities, the range standardization method was employed to eliminate the influence of dimensionality on results. This approach normalizes different indicator values to the interval [0,1], as per the following formula:

Furthermore, drawing upon Zhu's [7] methodology for processing indicator system data, this study employs the entropy weighting method to assign weights. This approach effectively mitigates human bias in the weighting process. An introduction to this method has already been provided in Section 4.1, so it shall not be repeated here.

The specific methodology for constructing urban economic resilience indicators is presented in **Table 1** below.

Table 1. Framework for building economic resilience

First-level indicators	Second-level indicators	Third-level indicators	Weighting of indicators	Indicator properties
Economic resilience	Resilience and recovery capacity	Per capita regional GDP (Yuan)	0.0467	Positive
		Per capita disposable income of urban residents (Yuan)	0.0208	Positive
		Savings balance of urban and rural residents (Yuan)	0.0010	Positive
		Registered urban unemployment (persons)	0.1096	Negative
		Total imports and exports as a share of GDP (%)	0.0022	Negative
	Adaptation and adjustment capacity	Local fiscal revenue as a share (%)	0.0237	Positive
		Total social retail sales (10,000 Yuan)	0.0959	Positive
		Tertiary industry as a share of GDP (%)	0.0072	Positive
		Ratio of loans to deposits of financial institutions at year-end (%)	0.0232	Positive
		Fixed asset investment (10,000 Yuan)	0.0839	Positive
	Transformation and development capability	Number of patent authorizations (items)	0.1826	Positive
		Number of students in regular higher education institutions per 10,000 people	0.0864	Positive
		Government expenditure on science (10,000 Yuan)	0.0812	Positive
		Government expenditure on education (10,000 Yuan)	0.2357	Positive

4.2.2. Explanatory variable: Extreme climate risk index

Following other literature, this paper adopts the internationally prevalent percentile method to define extreme climate events. However, when extreme weather occurs, it typically persists for several days. Simply adding up the total number of days during which extreme temperatures—whether heatwaves or cold snaps—are recorded may overlook the cumulative effects of consecutive days of extreme weather events, as well as the intensity of such events themselves.

Therefore, if extreme high temperatures persist for three consecutive days, this constitutes a single prolonged extreme heat event. This methodology captures cumulative effects. Considering the possibility of four consecutive days of extreme heat, comprehensive analysis suggests defining the first three days as one prolonged extreme heat event, with days 2 to 4 constituting a separate extreme heat persistence event. This approach, identifying two such events within the four-day period, more accurately reflects the intensity of extreme climate occurrences. The total number of extreme heat persistence events for the year is then calculated by summing these instances.

In the same manner, we can calculate the total number of occurrences of extreme cold spells, extreme droughts, and extreme precipitation events during the year. Finally, the average values for the total number of extreme heat spells, extreme cold spells, extreme droughts, and extreme precipitation events are taken to measure extreme climate conditions, and it is named the Extreme Climate Risk Index.

4.2.3. Control variables

Control variables were incorporated into the model specification to more accurately identify the net effect of extreme climate on economic resilience. This paper incorporates the following four control variables when constructing the regression model to account for other factors potentially influencing economic resilience: infrastructure development; level of government intervention; level of financial development; and level of science and technology. The inclusion of these control variables contributes to more robust and interpretable empirical results.

4.2.4. Sample selection

Due to administrative restructuring within certain prefecture-level cities during the sample period or severe data gaps, this study excludes all prefecture-level cities in the Tibet Autonomous Region and samples from some prefecture-level cities in other provinces. Consequently, considering the availability of variables, the final research sample comprises 280 cities across the decade from 2011 to 2020. Economic resilience data for each city and other municipal-level control variables were sourced from successive editions of the China Urban Statistical Yearbook, provincial and municipal Statistical Yearbooks, and the China Regional Economic Statistical Yearbook. Some data were obtained from annual municipal statistical bulletins, with minor missing values supplemented using linear interpolation. The climate risk index was sourced from the National Centers for Environmental Information (NCEI), a division of the US National Oceanic and Atmospheric Administration (NOAA). Furthermore, to prevent measurement errors arising from differing units of measurement across indicators, all variable values underwent standardization.

4.2.5. Model construction

Below, we construct the two-way fixed effects model as follows:

Based on provincial panel data from 2011 to 2020, we constructed a two-way fixed effects model with fixed years and cities, as shown in the formula below. In this model, represents the dependent variable economic resilience, denotes the explanatory variable probability of extreme weather, and represents various control variables, denotes the parameters of each variable, and represents the residual term.

5. Empirical results and analysis

5.1. Fixed-effects regression results

The table reports the regression results using a two-way fixed effects model. City and year fixed effects are controlled, and the R^2 is about 0.41, indicating that the model explains approximately 41% of the variation in urban economic resilience.

The aggregate climate risk indicator has a significantly negative coefficient of -0.0109 at the 10% level, suggesting that higher extreme climate risk reduces urban economic resilience. Among different types of climate risks, extreme heat has the strongest effect, with a significantly negative coefficient of -0.01 at the 5% level. This indicates that heatwaves weaken resilience by reducing labor productivity, increasing energy demand, and raising public health risks. By contrast, drought, precipitation, and extreme cold show no significant effects in the national sample.

For control variables, infrastructure, government intervention, and financial development all show significantly negative effects, suggesting that excessive infrastructure dependence, government intervention, or financial volatility may weaken resilience under climate shocks. Scientific research investment has a significantly positive effect, indicating that innovation capacity helps improve cities' long-term adaptation and recovery ability.

Overall, the results show that extreme climate risks negatively affect urban economic resilience, with extreme heat being the most important risk type. Therefore, climate adaptation policies should pay greater attention to heatwave prevention while strengthening scientific research and innovation capacity. See **Table 2**.

Table 2. Fixed-effects regression results

	(1)	**(2)**	**(3)**	**(4)**	**(5)**
Variables	Eco	Eco	Eco	Eco	Eco
Climate risk	-0.0109*				
	(0.00656)				
Dry		-0.00589			
		(0.00359)			
Rain			3.18e-05		
			(0.00389)		
Low				-0.00369	
				(0.00487)	
High					-0.00902**
					(0.00364)
Other control variables	controlled	controlled	Other control variables	controlled	controlled
City FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes

5.2. Heterogeneity analysis

To examine regional heterogeneity, this study divides cities into high-risk and low-risk groups based on the mean value of the Urban Extreme Climate Risk Index and conducts separate regressions.

The results show that in the high-risk group, the coefficient of climate risk is -0.0343 and significant at the 1% level, indicating that extreme climate risks significantly reduce urban economic resilience. In contrast, the coefficient in the low-risk group is insignificant, suggesting that climate risks have no clear impact on resilience in lower-risk cities.

For control variables, infrastructure, government intervention, and financial development show significant negative effects in both groups, while scientific research investment has a significant positive effect. This indicates that innovation capacity helps strengthen long-term resilience, whereas infrastructure dependence, excessive intervention, and financial volatility may weaken resilience under climate shocks.

Overall, the results confirm that the impact of extreme climate risks is regionally heterogeneous. High-risk cities are more vulnerable to climate shocks, while low-risk cities are relatively more resilient. Therefore, climate adaptation policies should be differentiated according to cities' risk levels.

5.3. Mechanism analysis

This part further examines the specific mechanisms through which extreme climate risks impact economic resilience using a mediation effect model.

To examine the mediating role of agricultural dependence, this study uses the share of agricultural value added in GDP as the mediating variable. The results show that climate risk has a significantly negative effect on urban economic resilience. Meanwhile, climate risk also significantly reduces the share of agriculture in GDP. When both climate risk and agricultural share are included in the model, climate risk remains negative, and agricultural share is also significantly negative.

These results indicate that agricultural dependence plays a partial mediating role. In other words, extreme climate risks weaken urban economic resilience both directly and indirectly through their impact on agriculture.

Overall, regions with higher agricultural dependence are more vulnerable to climate shocks. Therefore, policy efforts should focus on reducing excessive reliance on agriculture, promoting industrial diversification, and improving the climate adaptation capacity of the agricultural sector.

6. Discussion and conclusion

Extreme climate risks significantly weaken urban economic resilience, with extreme heat having the strongest negative effect, while the impacts of extreme cold, precipitation, and drought are relatively weaker. High-risk cities are more vulnerable to climate shocks than low-risk cities. Agricultural dependence plays a partial mediating role, meaning climate risks weaken resilience both directly and indirectly by affecting agricultural output. Robustness checks confirm the reliability of these results.

The study still has limitations in the measurement of economic resilience and climate risk. Future research could include nighttime light data, big data, or survey data, and further consider compound climate risks, spatial spillover effects, and stronger causal identification methods such as DID or RDD. Cross-country comparison is also needed to test whether the conclusions apply beyond China.

Policy should focus on improving urban climate adaptation capacity, strengthening disaster prevention and infrastructure resilience, and integrating climate risks into urban planning and fiscal policies. Cities should also reduce excessive agricultural dependence, promote industrial diversification, and develop climate-resilient agriculture. In addition, policies should be differentiated by region and risk type, with high-risk cities receiving stronger support in infrastructure, early warning systems, and risk-sharing mechanisms.

Disclosure statement

The author declares no conflict of interest.

References

[1] Boehm CE, Flaaen A, Pandalai-Nayar N, 2019, Input Linkages and the Transmission of Shocks: Firm-Level Evidence from the 2011 Tōhoku Earthquake. Review of Economics and Statistics, 101(1): 60–75.

[2] Carvalho VM, Nirei M, Saito YU, et al., 2021, Supply Chain Disruptions: Evidence from the Great East Japan Earthquake. The Quarterly Journal of Economics, 136(2): 1255–1321.

[3] Inoue H, Todo Y, 2019, Firm-Level Propagation of Shocks Through Supply-Chain Networks. Nature Sustainability, 2(9): 841–847.

[4] Zhang L, Yao L, 2023, Research on the Impact of Digital Technology Innovation on Urban Economic Resilience—Empirical Evidence from 278 Prefecture-Level and Above Cities in China. Journal of Management Studies, 36(05): 38–59.

[5] Wang J, Qiao H, 2022, Human Capital Level, Industrial Structure Transformation and Upgrading, and Urban Economic Resilience: An Analysis Based on the PVAR Model of Chinese Cities. Journal of Technical Economics Management, (10): 80–86.

[6] Li L, Wu S, Chen Z, 2023, Extreme Climate Risk and Macroeconomic Fluctuations. Journal of Financial Research, (9): 58–75.

[7] Zhu J, Sun H, 2020, Spatiotemporal Evolution and Influencing Factors of Urban Resilience in China's Three Major Urban Agglomerations. Soft Science, 34(2): 72–79.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.