

CLIMATE RISK AND BANK STABILITY: EVIDENCE FROM EMERGING COUNTRIES

Kim Thanh Duong^{1,*}, Mai Quynh Ha²

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ABSTRACT

This study examines the impact of climate risks on banking stability across international emerging countries using a dataset of 1,857 bank-year observations from 18 countries. The Global Climate Risk Index (CRI) developed by Germanwatch is used to quantify economic damage and fatalities from extreme weather events while bank Z-score is employed to measure bank stability. Using fixed-effect and feasible generalized least squared (FGLS) regressions, we find that increased climate risk generally diminishes bank stability. We also find that GDP growth and inflation positively influence stability. Conversely, factors like bank size have a negative impact on stability. These findings suggest a proactive approach from policymakers and financial institutions to mitigate the detrimental impact of climate risks on banking stability.

Keywords: *Climate risk, bank stability, emerging countries.*

¹East Asia University of Technology, Vietnam

²University of Economics and Business, Vietnam National University, Hanoi, Vietnam

*Email: thanhdh@eaut.edu.vn

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1. INTRODUCTION

In the 21st century, climate change has become an increasingly pressing issue, marked by rising temperatures, more frequent and severe weather events, and record levels of greenhouse gases. Since the industrial revolution, global climate change has been a major concern, with unprecedented changes evident since the 1950s [40]. Despite international efforts like the Paris Climate Agreement aiming to limit global warming to 1.5°C by 2050, temperatures have already risen by 1.1°C since pre-industrial times, and the period from 2015 - 2019 was the warmest on record (WMO).

Emerging economies near the equator are particularly vulnerable to the impacts of climate change, despite contributing less to global warming. Regions such as Sub-Saharan Africa, South Asia, and Latin America face severe environmental changes, including rising sea levels and extreme weather events, which affect agriculture, energy production, and water supply. These changes pose significant socio-economic and environmental challenges, necessitating global cooperation [33, 39]. The Paris Agreement, established at the Paris Climate Conference, aims to create a new framework for global climate governance.

Climate risk, as defined by the IPCC's Sixth Assessment Report, arises from the interaction of hazards, vulnerability, and exposure, posing threats to financial stability by causing systemic risks and financial losses. Past calculations indicate significant economic losses in industries like agriculture, forestry, and fisheries due to land use changes and degradation. Projections suggest that rising sea levels could result in over \$14 trillion in annual losses by 2100 if the 2°C target is not met. Climate change has also been linked to an increased frequency of banking crises [29].

Financial systems face serious challenges from climate risk, identified as the most significant emerging risk for the next five years in a global banking risk management survey. Climate risks, through both physical and transition risks, can affect the safety and soundness of banks by reducing the value of collateral and increasing borrower defaults, thereby exacerbating financial market volatility. As climate change intensifies, financial institutions will face increased risks from extreme weather and rising sea levels, heightening systemic financial risk (EY/IIF).

This study aims to evaluate the impact of climate risks on the stability of banking systems in emerging countries. It seeks to analyze the relationship between banking

stability and climate risk across various emerging economies and provide evidence to policymakers, regulators, and financial institutions on the adverse effects of climate risk on banking stability. Using a sample of 1,857 observations from 264 banks in 18 emerging countries between 2012 and 2019, the study employs climate risk index data from the Germanwatch Global Climate Risk Index and Z-score data to measure banking stability. Data were sourced from reputable organizations such as the World Bank, Germanwatch, and the International Monetary Fund, and the methodologies include quantitative analysis and regression analysis. Unlike previous studies that focused solely on bank-level determinants, this paper introduces a country-level perspective to assess the impact of climate risks on financial stability. It also explores the economic impacts of climate risks on banking stability in emerging countries, an area not extensively covered in existing literature.

2. LITERATURE REVIEW

2.1. Theoretical framework

Bank stability

The banking industry in emerging economies is undergoing significant changes due to the development of financial markets and the aftermath of the 2007/2008 financial crisis, leading to extensive economic restructuring. Central banks and monetary authorities are increasingly focused on financial stability and the safety of the financial system, which are crucial for global economic and social development [1]. Bank stability is vital for maintaining public confidence, referring to a bank's ability to withstand adverse shocks and maintain financial health, ensuring resilience to losses and overall system health [3].

Research on bank stability explores various determinants, including financial indicators like equity capital ratio, non-interest-bearing debt ratio, and profit, as well as market and business environment factors. Effective capital management and appropriate ownership structures contribute significantly to bank stability. Banking risk theory emphasizes effective risk management to ensure stability, focusing on managing credit, liquidity, market, and operational risks to prevent financial crises. Climate risks further pressure banks to improve service quality, reduce costs, and enhance risk management measures, ensuring the safety and resilience of the banking system. This additional layer of risk necessitates that banks not only manage traditional

financial risks but also incorporate climate risk into their strategic planning and operational frameworks to maintain stability and public trust.

Climate risk

According to the IPCC, climate change involves long-term changes in the climate system, including rising Earth's surface temperatures and sea levels. Since industrialization, climate change and natural disasters have become more frequent and severe, posing significant global risks. Climate risk refers to the adverse consequences of climate change on humans and ecosystems, affecting financial decision-making and performance. While climate risks can offer some benefits, such as better income management [8] and tax avoidance [9], they generally increase loan costs [10], reduce market efficiency, and impact firm performance and financing. Climate-related risks arise from hazards like droughts and storms.

Banks classify climate-related risks into two categories. Physical risks impact facilities, operations, and customers through extreme weather events and long-term climate changes, affecting creditworthiness and asset prices. Transition risks affect products and services due to shifts towards a low-carbon economy, including regulatory changes and evolving stakeholder expectations. UNEP highlights that future climate change scenarios focus on temperature changes, precipitation, and sea level rise, impacting infrastructure, agriculture, ecosystems, and human health. These changes can lead to economic impacts such as reduced productivity, resource conflicts, and migration.

The financial impacts of climate change on the banking sector are still emerging, with the transition to a low-carbon economy potentially increasing systemic risk [41]. The increasing severity of climate change necessitates immediate action to address ecological degradation, as emphasized by initiatives like the 2015 Paris Agreement and COP26, which aim to reduce greenhouse emissions and support sustainable business models [18, 19, 20, 22].

2.2. Empirical studies about climate risk and bank stability

Banks and banking systems can be affected by climate change through macroeconomic and microeconomic channels, arising from two types of climate risk drivers. First, physical climate risks involve economic costs and financial losses due to the increased severity and

frequency of climate events. Second, transition risks emerge as economies strive to reduce carbon dioxide emissions, resulting from changes in government policy, technological developments, or shifts in investor and consumer sentiment. These risks can lead to significant costs and losses for banks [21]. Climate risks also impact banks' liquidity through their loan portfolios. Banks that have invested in sectors vulnerable to climate change, such as agriculture, tourism, and energy, may face defaults and growing losses due to climate-related events like droughts, storms, and sea level rise, reducing their liquidity and making it difficult to meet short-term obligations [21].

Several factors contribute to the destabilizing effect of climate risks on the financial sector. Physical risks, such as forest fires and floods, can lead to unexpected large capital outflows and off-balance sheet commitments requiring immediate financing. Transition risks can limit available market-based funding or external aid, causing regulatory pressure and potential downturns for the banking industry. In emerging markets, banks play a crucial role in addressing climate risks. These regions are more vulnerable to climate impacts due to poverty, limited infrastructure, and weak governance. A major climate-related crisis could reduce access to credit, increase loan defaults, and lead to a liquidity crisis for banks, with severe consequences for the broader economy. Emerging markets also have significant roles in global climate efforts as major emitters of greenhouse gases. Banks in these markets can finance low-carbon and climate-resilient development, reducing vulnerability and supporting global mitigation and adaptation efforts [22].

Climate change and environmental disasters result in substantial human, material, economic, and financial losses, affecting countries' development goals. Specifically, loan losses and revaluation of financial instruments can severely impact the solvency and profitability of financial institutions. Environmental disasters and extreme climate events increase the bad debt ratio, a key measure of banking asset quality. Nikola Fabris [28] shows a negative relationship between climate risk and financial stability, emphasizing that climate change increases financial risks and creates instability in financial entities. Climate change reduces the value of assets dependent on natural resources, causes asset losses, and weakens financial stability. New policy measures like emissions reduction and environmental regulation add to this instability. Battiston

explores the multifaceted impacts of climate change on financial stability, noting that climate risks decrease the value of environmentally related assets, increase environmental risks, and create long-term financial uncertainties. These changes affect business conditions and future prospects, adding to the challenges for financial stability.

3. VARIABLE DESCRIPTIONS

From a theoretical foundation and research framework, the hypothesis of this research is that there is a negative relationship between climate risk and banking stability. The proposed research model includes six factors affecting banking stability: banking stability as the dependent variable, the Climate Risk Index as the independent variable, and control variables such as bank size, inflation, GDP growth, financial freedom, and the unemployment rate.

Climate risks are increasingly prevalent globally, characterized by more frequent and severe climate-related disasters. Defined by the IPCC, climate risk encompasses potential adverse impacts on societies and ecosystems due to climate change, influenced by hazards, vulnerabilities, and exposures. The Global Climate Risk Index (CRI) developed by Germanwatch quantifies economic damage and fatalities from extreme weather events such as storms and floods. It evaluates countries based on indicators like total deaths, damage in US dollars at purchasing power parity (PPP), and damage relative to GDP. Higher CRI scores indicate greater climate risk [34].

Bank size, measured by total assets, signifies a bank's influence and stability in the financial system. Larger banks have a significant impact on the economy, influencing interest rates and financing conditions. They expand through additional branches and services to enhance revenue and sustainability, diversifying assets to maintain safer capital. This capitalization reduces credit, interest, and non-interest income risks, bolstering stability against adverse events.

Inflation, the rise in prices over time, initially benefits banks by increasing profits but can erode them in the long term. It escalates bad debts, diminishes asset quality, and complicates monetary policies, influencing interest rates and economic confidence. Central banks respond by raising rates to control inflation, increasing borrowing costs and reducing loan demand, further impacting bank profitability and stability.

Real GDP growth rate reflects economic health, positively impacting banking stability by creating more business opportunities and lowering bad debt risks. Economic expansion enhances loan repayment capabilities, improves loan portfolio quality, and boosts credit demand, increasing banks' lending activities and profitability. Rising asset values fortify banks' balance sheets, while economic optimism spurs borrowing, spending, and investment, thereby mitigating financial instability. Regulators adapt policies to sustain stable banking conditions amid economic fluctuations.

Economic freedom, which includes private property rights and minimal government intervention, is assessed through indices like the Index of Economic Freedom and the Financial Freedom Index (FFI). Higher FFI scores indicate greater bank autonomy and performance. While enhanced financial freedom correlates positively with bank stability by incentivizing risk-taking, excessive freedom may heighten sector risks, necessitating a balanced regulatory approach for stability.

Unemployment rates, a critical macroeconomic indicator, can adversely affect bank stability. Higher unemployment increases credit risk as borrowers' repayment capacity declines, challenging banks' ability to assess borrowers effectively amidst competitive pressures. Though not directly causing instability, elevated unemployment rates create an economic environment that impacts overall banking stability.

4. RESEARCH METHODOLOGY

Empirically, the study employs quantitative analysis to measure and analyze data related to bank stability (Z-score) and climate risk. This includes employing statistical methods such as linear regression and multivariate analysis. Additionally, document analysis is utilized to gather and analyze information from various sources such as research reports, market analyses, technical articles, and relevant documents within the banking and climate risk domains.

Statistical data from credible sources such as international financial institutions, banks, climate regulators, and market reports are utilized in this study. The dataset comprises 1,857 annual observations spanning from 2012 to 2019. Based on the article's criteria, 18 countries were selected for analysis due to their suitability and availability of sufficient data. Key variables include the Z-score, sourced from The World Bank, and the Climate Risk Index (CRI) from Germanwatch

(forecasted over two years), supplemented by additional factors obtained from The World Bank, Macrotrends, and the IMF. The Z-score, a critical indicator of banking stability, is used to approximate a bank's probability of default.

$$Z\text{-score} = (\text{Return on Assets} + \text{Capital Ratio}) / \text{Standard Deviation of Return on Assets}$$

Z-score is a financial measure that evaluates the likelihood of a bank experiencing financial difficulty or bankruptcy. It combines several financial ratios, such as profitability, leverage, liquidity and asset quality, to provide an overall measure of a bank's financial health and stability.

5. RESULTS AND FINDINGS

Descriptive statistics

The statistics presented in Table 1 include variable names, number of observations, mean value, standard deviation, minimum value and maximum value. Detailed information is provided below. The summary statistics of our dataset provide key insights into the variables under study. The ZSCORE, representing bank stability, has an average of -15.48, indicating overall instability, with values ranging from -26.32 to 0. The Climate Risk Index (CRI) averages -57.35, with a wide range from -115.17 to -7.76, reflecting significant variation in climate risk exposure among the observations. GDP growth (GDPG) shows a healthy average of 5.02%, but with some negative growth instances as low as -3.55% and highs up to 8.74%. Inflation (INF) averages 4.40%, though it varies greatly, from -2.27% to an extreme of 50.92%, indicating some periods of deflation and high inflation spikes. The Financial Freedom Index (FFI) has a mean value of 48.56, suggesting moderate financial freedom, with a range from 20 to 70. Unemployment rate (UER) averages 6.28%, with values between 2.24% and 25.54%, pointing to diverse labor market conditions. Firm size (SIZE), averaging 10.20, shows significant variation, with values spanning from 3.91 to 24.63, highlighting the inclusion of both small and large firms in the study. These statistics underline the diversity and variability in economic and financial conditions across the observations.

Table 1. Descriptive Statistics

Variable	Obs	Mean	Std. Dev	Min	Max
ZSCORE	2112	-15.4757	6.6422	-26.3185	0
CRI	2112	-57.3531	28.8495	-115.17	-7.7614
GDPG	2112	5.016	2.335	-3.5457	8.7384

INF	2112	4.4013	5.9073	-2.27	50.9215
FFI	2112	48.5606	16.5702	20	70
UER	2112	6.2814	3.7012	2.24	25.54
SIZE	2112	10.2028	0.9839	3.9119	24.6334

Source: Author's Stata processing results

Linear regression (Pooled OLS)

With the close relationship between the dependent variable and the independent variables in the model, the author conducted a regression model with the dependent variable (Z-score representing banking stability) and 6 variables. independent, shown in the following regression equation:

$$ZSCORE = \beta_0 + \beta_1 * CRI + \beta_2 * GDPG + \beta_3 * INF + \beta_4 * FFI + \beta_5 * UER + \beta_6 * SIZE$$

Table 2. Linear regression (Pooled OLS)

ZSCORE	Coef.	Std. Err.	t	P > t	[95% Conf. Interval]	
CRI	-0.0365	0.0039	-9.14	0.000	-0.0443	-0.0257
GDPG	0.5486	.00556	9.86	0.000	0.4955	0.6578
INF	0.111	0.0196	5.69	0.000	0.0733	0.1504
FFI	0.2779	0.0088	31.53	0.000	0.2606	0.2952
UER	-0.2078	0.0324	-6.40	0.000	-0.2715	-0.1441
SIZE	-0.5517	0.1286	-4.29	0.000	-0.8040	-0.2995
_cons	-27.4610	1.6248	-16.90	0.000	-30.6477	-24.2744

Source: Author's Stata processing results

The adjusted R-squared value of 0.4889 implies that the independent variable included in the regression model explains 48.89% of the variation in the dependent variable. The remaining 51.11% of the variation is due to factors outside the model and random errors. This shows that the model explains nearly half of the variation in the dependent variable.

Fixed-effects regression (FEM)

Table 3. Fixed-effects regression (FEM)

ZSCORE	Coef.	Std. Err.	t	P > t	[95% Conf. Interval]	
CRI	0.0073	0.0056	1.29	0.197	-0.0037	0.0184
GDPG	0.1512	0.0287	5.26	0.000	0.0948	0.2075
INF	0.0288	0.0131	2.20	0.028	0.0031	0.0546
UER	-0.078	0.0326	-2.41	0.016	-0.1425	-0.0144
SIZE	-0.689	0.1789	-3.85	0.000	-1.0403	-0.3383
Const	-8.129	1.9121	-4.25	0.000	-11.8802	-4.3790

Source: Author's Stata processing results

In the above regression equation, the regression coefficient for the constant (Const) is -27.461 and has

high statistical significance (p value < 0.01), showing its importance in the model. The variables CRI and SIZE have positive regression coefficients (β) showing a positive correlation with the variable ZSCORE. The variables GDPG, INF, FFI, UER show a significant relationship with the stability of the variable, indicated by their p-value (p_value= 0) less than 0.05. This shows that these variables are all statistically significant predictors of bank stability in the regression model. Variance inflation factor (VIF) was used to check for multicollinearity. In the study, all VIF coefficients are less than 2, showing that there is no multicollinearity phenomenon in the regression model. This implies that the independent variables included in the analysis do not show strong correlations with each other and the regression coefficients can be reliably interpreted. The absence of multicollinearity enhances the stability and accuracy of the regression model, allowing for a better understanding of the relationship between the independent and dependent variables.

The variables UER and SIZE have a significant negative impact on the dependent variable with estimated coefficients of -0.0785 and -0.6893, respectively. In contrast, the variables GDPG and INF have positive estimated coefficients of 0.15122 and 0.02887, respectively, indicating that they are both statistically significant and have a positive impact on the dependent variable. In addition to the FFI variable being removed from the model because of multicollinearity, the CRI variable also does not have a statistically significant impact on the dependent variable (p > 5%). This means that changes in these variables do not have a significant impact on the dependent variable when other factors are held.

Feasible Generalized Least Squares (FGLS) model

After analyzing and testing the Hausman specification, we selected the FEM model as the appropriate model for the research data. However, after checking the defects in the FEM model, the results show that the FEM model has both autocorrelation and heteroscedasticity defects. Based on the above evidence, we conduct the FGLS model to overcome the defects in the above model.

Table 4. Feasible Generalized Least Squares (FGLS) regression results

ZSCORE	Coef.	Std. Err.	t	P > t	[95% Conf. Interval]	
CRI	-0.0218	0.0023	-9.25	0.000	-0.0264	-0.0172
GDPG	0.1073	0.0171	6.26	0.000	0.0737	0.1409
INF	0.0544	0.0090	6.02	0.000	0.0367	0.0721

FFI	0.2803	0.0062	45.02	0.000	0.2681	0.0925
UER	-0.1997	0.0203	-9.83	0.000	-0.2396	-0.1599
SIZE	-0.3666	0.0864	-4.24	0.000	-0.5360	-0.1972
_cons	-25.8043	1.010	-25.53	0.000	-27.7850	-23.8236

Source: Author's Stata processing results

Upon analysis, the dataset exhibits first-order autocorrelation and heteroskedasticity issues. However, the FGLS model successfully addresses these concerns. Regression results demonstrate that all independent variables in the model are statistically significant concerning the dependent variable ZSCORE.

Specifically, GDPG, INF, and FFI positively influence banking stability, whereas CRI, UER, and SIZE show negative relationships with ZSCORE. CRI has a coefficient of -0.0218, indicating an inverse relationship with banking stability-the higher the climate risk index (CRI), the lower the banking stability. GDPG has a coefficient of 0.1073, suggesting that GDP growth positively impacts banking stability. Similarly, INF with a coefficient of 0.0544 indicates that inflation enhances banking stability by stimulating lending activities and economic growth.

Furthermore, FFI has a coefficient of 0.2803, illustrating that greater financial freedom correlates with increased banking stability. Conversely, UER shows a coefficient of -0.1997, indicating that higher unemployment rates decrease banking stability. Finally, SIZE has a coefficient of -0.3666, suggesting that larger banks face challenges in managing risks effectively during climate events, potentially impacting their stability in unstable business environments.

6. CONCLUSION AND LIMITATIONS

In this study, we investigate the impact of climate risks on banking stability across international emerging countries using a dataset comprising 1,857 bank-year observations from 18 countries. Our findings indicate that increased climate risk generally diminishes bank stability. Comparing our study with study [14], we observe similarities concerning factors affecting banking stability such as GDP growth and inflation, which both studies find to positively influence stability. Conversely, factors like bank size have a negative impact on stability, consistent across both studies. Similarly, comparing with [34], our research aligns in identifying that heightened climate risk correlates with reduced bank stability. However, discrepancies arise regarding the influence of factors like GDP growth, inflation, and financial freedom on stability, where our study suggests positive impacts while theirs shows mixed results.

Moreover, our research extends beyond specific factors to explore the broader implications of climate risks on banking stability globally. Unlike other studies focusing on competitive dynamics, market structures, and risk provisions, our approach utilizes statistical regression analyses to establish relationships between climate risk and bank stability. Methodologically, our study employs various quantitative methods including correlation tests, linear regression, and FGLS regression to analyze data sourced from Germanwatch for climate risk and Z-score for bank stability. Overall, our findings contribute valuable insights by highlighting the detrimental impact of climate risks on banks, urging policymakers and financial institutions to address climate vulnerabilities to safeguard banking stability globally.

The research faces certain limitations. First, data availability and reliability in different countries can be a challenge. Collecting comprehensive and consistent data can be difficult, hindering thorough cross-national analysis. This limits the ability to analyze and assess the impact of climate risks. Additionally, differences in data collection methods may affect the reliability of the data and the comparability of the findings. There is little research that focuses specifically on the impact of climate risk on banking stability in emerging countries. The amount of existing research on this issue is relatively small, and more research is needed to thoroughly examine the relationship between climate risk and bank stability.

The lack of focused research on this topic may be due to several factors. In emerging countries, there may be a lack of complete and reliable data on both climate risks and financial indicators related to bank stability. Emerging countries may be experiencing policy and regulatory changes, especially in the financial and environmental sectors. These changes could affect the way banks and businesses deal with climate risks. Research on this complex issue requires great time and expense, especially to collect data and analyze figures from many different sources.

Future research on the impacts of climate risks could delve into a number of issues. First, further research would provide valuable insights into the correlation of climate risks between the banking and financial sectors internationally. By proceeding on other econometric methods such as the difference method in the use of endogenous variables and exogenous shocks. Second, further research could look at the role of institutional

quality, banking supervision and regulation in relation to climate risk and national or social norms such as culture or social trust. association in the relationship between banking stability and climate risk. In this direction, future research can increase our understanding of the actual impact of climate risks.

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