

How Climate Resilience Shapes Sovereign Credit Risk: A Cross-Country Comparative Study

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Abstract

This article aims to identify the impact of a country's climate risk resilience on its sovereign credit rating, and to answer whether a country's vulnerability can be mitigated by its readiness. The analysis also examines the robustness of the identified relationships, assessing their relevance to both investment-grade and speculative-grade countries. The study is based on a cross-country sample of 67 countries. It examines the relationship between sovereign credit ratings issued by Standard & Poor's and Moody's and the ND-GAIN climate risk index, including the effects of its vulnerability and readiness components. To examine the link between sovereign credit ratings and climate resilience, we employ a cluster analysis based on climate vulnerability, adaptive capacity, and sovereign credit ratings, complemented by a linear regression model. The results indicate a positive relationship between climate resilience and sovereign credit rating. Vulnerability to climate risk negatively affects the rating, whereas the positive impact of climate readiness is more pronounced in countries with higher credit ratings than in those with lower ratings. The conclusions offer new insights into the determinants of sovereign credit ratings and the impact of climate risk on a country's credibility, providing important implications for climate policy and for the methodologies used by credit rating agencies to assess sovereign ratings.

Keywords: climate risk, sovereign rating, vulnerability, readiness, ND-GAIN index

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Introduction

One of the most fundamental questions in economics concerns the reasons behind the wealth and stability of some countries and the poverty of others. In classical economic thought (Kuznets 1966; Kaldor 1967; Chenery, Robinson, and Syrquin 1986), development and prosperity are seen as a function of the availability of production factors and the ability to use them efficiently. The range of goods produced and the structure of export baskets also play a significant role (Felipe, Kumar, and Abdon 2014).

Contemporary growth theories emphasize the importance of research and development investment, innovation, education, institutional quality, and natural resources (Oikawa 2023). Climate change, on the one hand, depletes and reduces the economic efficiency of resources such as arable land and forests. On the other hand, it has a negative impact on human well-being. Climate risks significantly impact global financial markets, influencing asset pricing, diversification, and stability (Karkowska and Urjasz 2025). According to the International Monetary Fund, between 1970 and 2018, natural disasters caused damage amounting to 3–10% of GDP in emerging markets and 1–3% in advanced economies (International Monetary Fund 2020). These findings are consistent with empirical stress tests on the materialization of physical risk, which show GDP contractions of up to 5%, comparable to major recessions (Financial Times 2025).

S&P Global Ratings estimates that in the absence of adaptation measures, under a slow transition scenario where global temperatures rise by 3.6°C by the end of the 21st century, annual losses could reach up to 4.4% of global GDP (Feng et al. 2025). This leads to the conclusion that sovereign creditworthiness is increasingly exposed to physical and transition-related climate shocks. The result is strained fiscal profiles, which increase sovereign spreads and default risk, particularly in emerging markets (Li, Li, and Lu 2024).

The existing literature focuses either on microeconomic channels and mechanisms through which climate risk affects economic agents or on macroeconomic parameters. However, there is a distinct research gap regarding the impact of climate risk on sovereign creditworthiness, specifically when measured by long-term, stable sovereign ratings. Other measures of sovereign risk – both CDS premiums and premiums embedded directly in government bond yields – are highly volatile (especially default spreads), and their levels are determined not only by fundamental factors but also by speculative capital activity. Ratings assigned by rating agencies are much more stable and are assigned in accordance with the “through the cycle” and “forward-looking” philosophy, i.e., they take into account changes in the economic situation in the medium term. The nature of sovereign ratings corresponds to the nature of climate indices, which, due to slow changes in climate risk exposure and limited opportunities to adapt to climate change in the short term, are also characterised by relative stability. Therefore, sovereign ratings seem to be appropriate measures of sovereign risk to be confronted with climate resilience measures.

Previous research has focused on the relationships between climate risk and sovereign bond yields, risk premiums (Boitan and Marchewka-Bartkowiak 2022), and default probabilities (Cevik and Jalles 2022) – that is, parameters characterized by high volatility compared to sovereign

ratings. In contrast, studies that do use sovereign ratings as the dependent variable tend to focus on specific climate risk components (Bernhofen et al. 2024) or their decomposition into physical and transition risk (Cappiello et al. 2025). However, there is a lack of research aimed at integrating the static dimension of climate risk (exposure, sensitivity, and capacities to adapt) with its dynamic dimension. This latter dimension encompasses the ability to leverage investments into adaptation actions, as well as the quality and effectiveness of climate risk management. Therefore, our goal is to assess how climate risk resilience ultimately impacts sovereign risk.

This approach raises several important research questions: (i) To what extent does a country's climate resilience affect its sovereign credit rating, and does the strength of this effect differ across rating categories (investment-grade vs. speculative-grade)? (ii) Does higher climate vulnerability translate into lower sovereign credit ratings, indicating that vulnerability constitutes a material long-term credit risk? (iii) Can stronger adaptive capacity and climate readiness mitigate climate-related risks and contribute to higher sovereign credit ratings?

Accordingly, this article assesses the impact of a synthetic measure of climate risk resilience on sovereign ratings, as well as two key dimensions: vulnerability and readiness. We also examine the robustness of these relationships across countries with high (investment grade) and low (speculative grade) creditworthiness.

The ND-GAIN (Notre Dame Global Adaptation Initiative) Country Index is used as a comprehensive measure that integrates these two dimensions. The index combines vulnerability (reflecting exposure, sensitivity, and adaptive capacity) with readiness (encompassing economic, governance, and social components). We chose the ND-GAIN index for several reasons. First, it covers 180 of the 195 countries recognized by the United Nations and provides consistent time-series data dating back to 1995. Second, the index integrates both the passive (exposure) and active (capacities and conditions for its mitigation) dimensions of climate risk. Third, S&P used the tool to capture facets of potential vulnerability when ranking sovereigns for its report *Climate Change Is A Global Mega-Trend For Sovereign Risk* (Standard and Poor's 2014). Therefore, due to its stability and multidimensionality, it is highly suitable for comparison with sovereign ratings.

To investigate the impact of climate risk on sovereign creditworthiness, we analyse a cross-country sample of 67 countries over the period 2012–2023, exploring the relationship between S&P sovereign credit ratings and the ND-GAIN index. To estimate these relationships, we employed five models: (1) Pooled OLS as the baseline; (2) a model with additional macroeconomic variables; (3) a model with interaction terms to test for differing effect between investment-grade and speculative-grade countries; (4) a fixed-effects panel model controlling for unobservable, time-invariant characteristics (e.g., institutions, geography); and (5) a dynamic model that incorporates a lagged dependent variable to capture the persistence of ratings.

Although high correlation among ratings issued by all three entities is confirmed by Korzeb, Kulpaka, and Niedziółka (2019), we verified our results through robustness tests using Moody's ratings as an alternative.

Our findings suggest that, in general, a country's climate resilience has a positive influence on its sovereign credit rating. While high climate vulnerability and exposure to climate risk

correlate with lower ratings, this impact can be mitigated by readiness, which contributes positively to the rating. The strength of this readiness-driven effect diminishes as sovereign ratings decline.

This study presents a novel perspective on the credibility and stability of rating agency assessments and the determinants of rating changes – factors that are crucial for financing availability and cost, as well as the intensity and direction of international capital flows. By aligning with widely accepted climate risk transmission mechanisms used in stress testing, our findings offer predictive value for future rating agency methodologies and the ratings they assign.

The remainder of the paper is structured as follows: Section 2 reviews the relevant literature and develops the hypotheses. Section 3 outlines the methodology and data. Section 4 presents the empirical results, and Section 5 discusses them and provides a conclusion.

Literature review and hypotheses development

Climate risk is linked to the increasing frequency of extreme weather events and long-term climate changes that adversely affect ecosystems (Sheedy, Griffin, and Barbour 2017). These phenomena pose significant threats to human health, life, and overall well-being. Floods, rising sea levels, droughts, ozone layer depletion, wildfires, hurricanes, earthquakes, changes in seawater chemistry, and biodiversity loss cause substantial material damage, reduce access to drinking water, degrade formerly arable land, and lead to asset and income losses.

The growing frequency of extreme weather events and persistent climate change is classified as a physical risk. Individual extreme events represent acute physical risk, while long-term climate changes correspond to chronic physical risk (European Banking Authority 2020; Korzeb et al. 2024). Conversely, the economic and social consequences of climate mitigation efforts constitute the second component of climate risk, transition risk. This type of risk arises from additional costs associated with the energy transition, including regulatory changes (e.g., carbon taxes), shifting social preferences, and changes in market sentiment. These factors can weaken the financial position of high-emission companies by restricting access to capital or increasing its cost, reducing profitability, and impairing debt-servicing capacity (Monasterolo and Raberto 2018; NGFS 2025). Physical and transition risks are interconnected and may amplify each other (IPCC 2021).

Climate risk leads to reduced economic activity, disrupted supply chains, poverty, and unemployment. Beyond purely economic consequences, these effects also trigger social tensions, political polarization, migration, and international conflicts. The materialization of climate risk weakens the economy, which is why climate risk influences sovereign credit risk, measured by sovereign ratings (Korzeb, Kulpaka, and Niedziółka 2019). Two main transmission channels can be distinguished: climate risk's impact on the banking sector's condition and the resulting financial stability (Stawasz-Grabowska 2020), as well as its effect on the economy's macroeconomic parameters (Mitra et al. 2025).

Climate shocks worsen the quality of bank loan portfolios by weakening borrowers' financial standing and straining macro-financial conditions (Bank for International Settlements 2023),

which in turn affects the broader economy. Overall, rising climate risk leads to a deterioration in bank creditworthiness, as highlighted by Graff Zivin and Neidell (2014) and Dafermos, Nikolaidi, and Galanis (2018). However, Chalabi-Jabado and Ziane (2024) find that transition risks may positively influence both bank performance and lending growth, whereas physical risks exert a negative impact.

The deteriorating financial position of businesses and households, combined with the declining value of collateral (which negatively affects loan-to-value ratios), reduces borrowers' ability to service debt (Muzuva and Muzuva 2024). This ultimately impacts the financial sector, causing instability (Garmaise and Moskowitz 2009; Nieto 2019; Zhai et al. 2024; Ma et al. 2025), particularly within the banking system (Noth and Schüwer 2018; Zhang, Chang, and Xuan 2022). Financial instability resulting from worsening bank solvency and liquidity negatively affects sovereign ratings (Hu et al. 2020).

The performance of non-financial corporations, financial institutions, and households also influences the overall economy. Li, Li, and Lu (2024) suggest that climate risk significantly reduces credit supply to the private sector. A typical response to rising climate risk is a contraction in lending (Faiella and Natoli 2018). This weakening of credit activity negatively affects consumption and investment, which are key drivers of GDP (Barauskaitė Griškevičienė et al. 2021). Climate risk deteriorates key macroeconomic indicators (Bank for International Settlements 2021). Changes in these indicators, such as GDP growth, inflation, unemployment, fiscal imbalances, and external debt-to-GDP ratios, are among the primary determinants of sovereign ratings (Cantor and Packer 1996; Mellios and Paget-Blanc 2006; Afonso and Gomes 2010; Sehgal et al. 2018; Proença et al. 2022; Takawira and Mwamba 2022; Ben Mim, Nourira, and Mabrouk 2023; Overes and van der We 2023).

Among studies that examine the direct relationship between climate risk and sovereign ratings, Cappiello et al. (2025) stand out. Analyzing a sample of 124 countries, they suggest that higher physical risk – approximated by temperature anomalies and the frequency of natural disasters – is associated with lower sovereign ratings. In contrast, transition risk measures are not systematically incorporated into credit ratings. More ambitious CO₂ reduction targets and actual emission cuts have been linked to higher ratings following the Paris Agreement. Countries that have benefited from the green transition have also received better ratings since 2015.

Sovereign rating methodologies (Fitch Ratings 2020; S&P 2025; Moody's 2026) and empirical research findings increasingly integrate climate risk into their assessments. Furthermore, Lim, Goh, and Kwek (2023) suggest that for speculative-grade countries, institutional factors like government effectiveness and the ability to generate domestic resources to meet public obligations outweigh factors such as GDP growth and other macroeconomic variables – which are themselves influenced by climate risk. Based on these transmission channels, we formulate the following hypothesis:

H1: A country's climate resilience positively affects its sovereign credit rating; however, the climate-resilience premium is substantially weaker for speculative-grade countries.

Some research on the impact of climate risk on sovereign creditworthiness has focused on variables reflecting investor perceptions or country credit risk, such as sovereign bond yields and risk premiums (Boitan and Marchewka-Bartkowiak 2022) or default probabilities (Cevik and Jalles 2022). These studies incorporate the two key dimensions of climate risk: vulnerability and readiness.

A relatively new research area examines the impact of climate risk on sovereign ratings, i.e., rating agencies' assessments of a country's debt-servicing capacity. Using ratings from "the Big Three" agencies (S&P, Moody's, and Fitch) for 117 countries between 1995 and 2020 and the ND-GAIN index, Sun et al. (2023) found that after controlling for traditional sovereign rating determinants, vulnerability has a significant negative effect on sovereign ratings, while readiness positively influences creditworthiness. The impact is relatively stronger for developing and highly climate-affected countries.

Conversely, Ali, Usman, and Ahmad (2025) find that climate vulnerability and resilience indices do not strongly predict sovereign credit ratings in 15 countries (2020–2024) across developed or developing economies. This suggests that current sovereign rating methodologies may not fully incorporate climate-related risks, particularly in developed countries. Considering these empirical findings and the fact that countries in the Global South are relatively more exposed to climate risk, and that extreme climate events have a significant impact on their economies, we hypothesize:

H2: More climate-vulnerable countries receive lower sovereign ratings, confirming vulnerability as a material source of long-term sovereign credit risk.

Both climate readiness (Notre Dame Global Adaptation Initiative 2025) and sovereign credit ratings (Bissoondoyal-Bheenick 2005; Mutize and Nkhalamba 2021; Proença et al. 2022; Sun et al. 2023; Goel and Singh 2024; 2025) depend on factors, such as economic capacity for investment, governance quality, and social factors (including social inequality, ICT infrastructure, education, and innovation). Building on this overlap, we propose:

H3: A country's climate readiness positively affects its sovereign credit rating, reflecting its capacity to manage climate challenges effectively.

Hypothesis H3 is also consistent with the conclusion drawn by Shang et al. (2024), which states that national wealth and financial stability create the potential for effective climate risk management, for example, through investments in renewable energy.

Data and Methodology

To investigate the impact of climate risk on sovereign credit risk, we conduct an empirical study that integrates sovereign credit ratings with climate risk indicators. The analysis uses Standard & Poor's and Moody's country credit ratings, as well as climate risk measures derived from the ND-GAIN indices (Notre Dame Global Adaptation Initiative n.d.). Our study focuses on the period 2012–2023 and a sample of 67 countries (see Appendix), reflecting data availability

and the need to optimise the number of observations in the final dataset. It comprises two key dimensions of climate adaptation: vulnerability and readiness, calculated as follows:

$$NDG = (RI - VI + 1) \cdot 50, \quad (1)$$

where:

NDG – ND-GAIN Country Index ranges from 0 to 1; higher values indicate better climate resilience,

RI – Readiness Indicator ranges from 0 to 1; higher values indicate better preparation to adapt to climate change,

VI – Vulnerability Indicator ranges from 0 to 1; the lower the value, the less vulnerable the country is to climate-related risks.

For the estimations, alphanumeric sovereign credit ratings were transformed into a continuous numerical scale. The primary transformation follows the 21–0 scale applied by Korzebm Niedziółka, and Nistor (2023), where 21 corresponds to the highest creditworthiness (AAA) and 0 to default (D). To verify robustness, we employed the alternative 17–1 numerical conversion proposed by Afonso (2011) and re-estimated the models to assess the stability of the findings. This mapping ensures consistency across rating agencies and enables econometric analysis using a single numerical variable.

Our primary explanatory variables, climate indices (gain, vulnerability, and readiness), are derived from the ND-GAIN index. The vulnerability component captures exposure, sensitivity, and adaptive capacity across six critical sectors: food, water, health, ecosystem services, human habitat, and infrastructure. The readiness component reflects a country's ability to convert adaptation needs into actions by evaluating three domains: economic readiness, governance readiness, and social readiness. Together, these indices provide a comprehensive measure of both the challenges posed by climate hazards and the institutional and socioeconomic conditions that enable effective responses. Sourcing these indices from ND-GAIN ensures a transparent, standardized methodology for cross-country comparisons.

To investigate the relationship between climate risk and sovereign creditworthiness, we first conducted a cluster analysis based on countries' climate vulnerability, adaptive capacity, and sovereign credit ratings. This approach allowed us to group countries with similar climate risk profiles and examine patterns in credit ratings across these clusters. Subsequently, we performed panel regression analyses to verify the impact of climate risk indicators on sovereign credit ratings and to test the statistical significance of the observed relationships.

To validate the relationship between sovereign credit ratings and climate resilience, we estimated a set of regression models using the transformed S&P and Moody's Sovereign Credit Ratings (*SCR_rating*) as the dependent variable. In addition to the ND-GAIN measures (overall index, Vulnerability, and Readiness), the regressions include macroeconomic and institutional controls identified in the literature: GDP growth, inflation, government consumption (% of GDP), a speculative-grade dummy, and an interaction term (*ND-GAIN* × speculative-grade). Incorporating this dummy variable – defined as ratings below BB+, the standard S&P threshold separating investment-grade from speculative-grade credit quality – allows us to formally test

whether the impact of climate resilience differs across rating categories. This unified approach offers a more straightforward interpretation of cross-country heterogeneity.

The extended model specification takes the following form:

$$SCR_rating_i = \alpha + \beta_1 ClimateRisk_i + \beta_2 Macro_i + \beta_3 Institutional_i + \varepsilon_i, \quad (2)$$

where SCR denotes the sovereign rating for country i , $ClimateRisk$ represents the ND-GAIN indices (*Gain Index*, *Vulnerability*, *Readiness*), $Macro_i$ denotes the macroeconomic controls, and $Institutional_i$ includes the speculative-grade dummy and interaction term, and ε_i is the error term.

To test the robustness of the results, we estimated four types of models: a baseline OLS model, an OLS model with interaction terms, a fixed-effects (FE) panel model, and a dynamic panel model including the lagged dependent variable. These complementary specifications allow us to assess the stability and persistence of the relationship between climate resilience and sovereign ratings.

The descriptive statistics presented in Table 1 show that both S&P and Moody's sovereign credit ratings cluster around the middle-upper end of their respective scales, with mean values near 14 on the 0–21 scale and around 10 on the 1–17 scale. This indicates that the sample consists largely of countries with moderate to strong credit quality. The climate-related indices show relatively low average vulnerability (mean 0.36) and moderate readiness (0.50), suggesting that while countries generally face some exposure to climate risks, they possess a varying but overall moderate capacity to adapt. The ND-GAIN index exhibits substantial variation, with (mean ≈ 57), highlighting significant heterogeneity in potential climate-related benefits or adaptive opportunities across countries. Macroeconomic variables including GDP growth, inflation, and government consumption display wide ranges that reflect diverse economic conditions without appearing extreme on average.

Table 1. Descriptive statistics

	N	Mean	Median	SD	Min	Max
S&P rating (0–21 scale)	795	14.48	14.00	4.82	0	21
Moody's rating (0–21 scale)	803	14.13	14.00	5.18	0	21
S&P rating (1–17 scale)	803	10.25	10.00	4.93	1	17
Moody's rating (1–17 scale)	801	10.44	10.00	4.79	1	17
NC-GAIN	804	56.81	56.58	10.64	32.86	78.32
VULNERABILITY	804	.36	0.36	.06	.25	.57
READINESS	804	.5	0.48	.16	.15	.82
GDPgrowth	795	2.57	2.66	3.8	-17.67	24.48
Inflation	778	3.79	2.32	6.34	-2.1	72.31
Gov consum exp gdp	753	17.19	17.84	4.45	5.04	26.47

Sources: own study.

Results

To examine the relationship between climate risk and sovereign creditworthiness, we conducted a cluster analysis based on vulnerability, adaptive capacity, and credit ratings, followed by regression estimations assessing the impact of these factors on sovereign ratings. The results from both methods provide complementary insights, highlighting how variations in climate vulnerability and adaptive capacity are associated with differences in sovereign credit risk.

Cluster analysis

To explore patterns in climate risk and sovereign creditworthiness, we performed a cluster analysis using four variables: GAIN, Vulnerability, Readiness, and S&P sovereign credit ratings. A three-cluster solution was selected based on hierarchical and k-means clustering methods. Table 2 presents the summary statistics for each group.

Table 2. Summary statistics by climate-based clusters

	Mean	SD	N
Cluster 1			
ND-GAIN	47.96	5.69	388
VULNERABILITY	0.41	0.05	388
READINESS	0.37	0.08	388
S&P rating (0-21 scale)	10.52	3.03	388
Cluster 2			
ND-GAIN	70.35	3.02	216
VULNERABILITY	0.31	0.04	216
READINESS	0.72	0.05	216
S&P rating (0-21 scale)	20.2	1.13	216
Cluster 3			
ND-GAIN	60.24	3.06	191
VULNERABILITY	0.33	0.03	191
READINESS	0.53	0.05	191
S&P rating (0-21 scale)	16.07	2.22	191

Sources: own study based on credit rating agencies and Notre Dame Global Adaptation Initiative n.d., databases.

The clustering reveals three distinct groups that differ systematically in both climate characteristics and credit ratings.

- Cluster 1: Countries with the lowest climate readiness and the highest vulnerability. This group has the weakest average S&P rating, suggesting limited adaptive capacity and greater exposure to climate risks.
- Cluster 2: The most climate-resilient group. It combines exceptionally high readiness, low vulnerability, and the highest gain potential. This group also exhibits the strongest

credit ratings, indicating that climate resilience and sovereign creditworthiness tend to align.

- Cluster 3: An intermediate group. These countries have moderate readiness and vulnerability, as well as mid-range credit ratings.

Overall, the results show a transparent gradient: as climate resilience improves, sovereign ratings tend to rise. This supports the idea that climate risk factors are reflected in sovereign credit assessments.

Next, we conducted a one-way ANOVA to test whether sovereign credit ratings differ significantly across the three clusters. The analysis reveals a highly significant effect of cluster membership on ratings ($F(2, 792) = 1135.15, p < 0.001$). As Bartlett's test indicates strong evidence of unequal variances across clusters ($\chi^2(2) = 206.55, p < 0.001$), we also performed a Kruskal-Wallis test, which confirms substantial differences between groups ($\chi^2(2) = 616.77, p < 0.001$). Post-hoc Bonferroni comparisons show that all pairwise differences are statistically significant ($p < 0.001$), with Cluster 2 exhibiting the highest ratings and Cluster 1 the lowest. These results reinforce the strong association between climate resilience and sovereign creditworthiness.

Figure 1 illustrates the relationship between climate adaptation capacity and sovereign credit ratings across the three clusters.

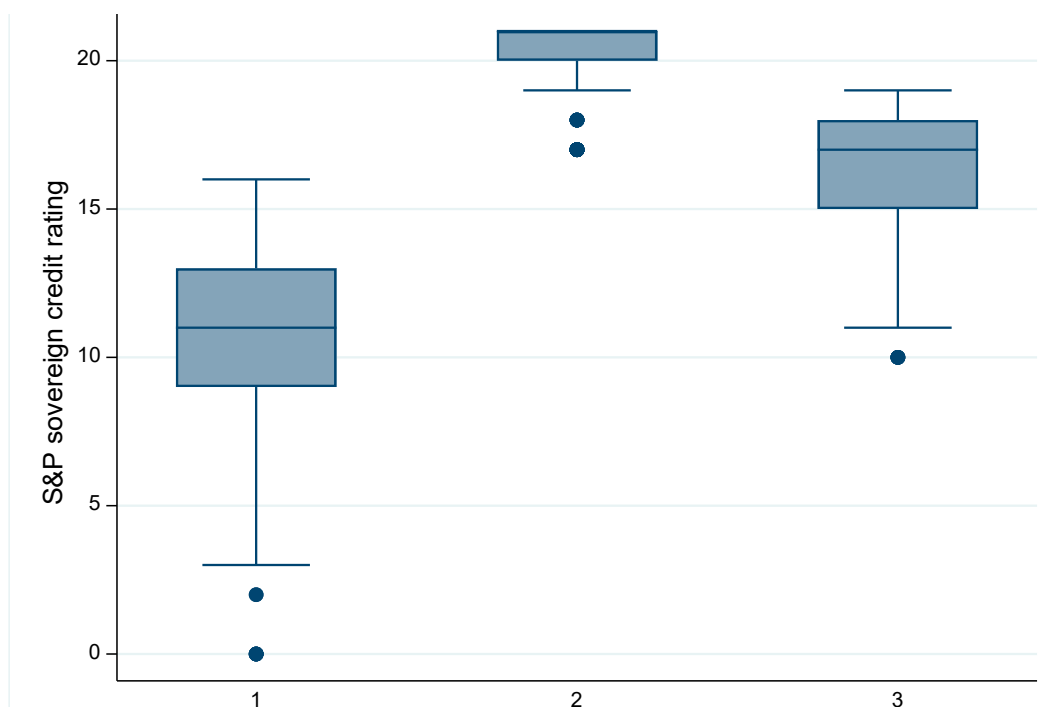


Figure 1. Sovereign Credit Ratings versus Climate Adaptation Capacity by Cluster

Sources: own study based on credit rating agencies and Notre Dame Global Adaptation Initiative n.d., databases.

The boxplot clearly illustrates substantial differences in sovereign credit ratings across the three climate-based clusters.

- Cluster 1 exhibits the lowest and most dispersed ratings, reflecting both weaker creditworthiness and greater heterogeneity among countries with high climate vulnerability and low readiness.
- Cluster 2 shows consistently high ratings with minimal variation, indicating that the most climate-resilient countries also achieve the strongest and most stable credit assessments.
- Cluster 3 occupies an intermediate position; while its ratings are higher than those in Cluster 1, they remain more variable and generally lower than those in Cluster 2.

Overall, the plot visually reinforces the strong relationship between climate resilience and sovereign credit ratings.

Regression analysis

Table 3 presents the regression estimations of the impact of climate resilience indicators on S&P sovereign credit ratings. The results provide robust evidence that climate-related factors significantly affect creditworthiness across multiple model specifications. In the baseline OLS model (1), the ND-GAIN index is strongly and positively associated with ratings (+1.566), indicating that countries better equipped to cope with climate risks tend to receive higher credit assessments. This finding supports Hypothesis 1 (H1) and aligns with prior research demonstrating that greater climate resilience enhances sovereign creditworthiness (e.g., Cevik and Jalles 2023; Naifar 2023; Yang and Hamori 2023).

Model (2), which incorporates an interaction term with speculative-grade status, further reveals that while climate resilience has a positive effect (+1.159), the resilience premium is significantly weaker for speculative-grade sovereigns. This confirms H1 by showing that rating agencies reward climate resilience more strongly in investment-grade countries, whereas resilience gains are discounted for lower-rated economies. This suggests that stronger institutions and greater adaptive capacity enhance the ability of high-rated economies to translate climate readiness into favorable credit outcomes. For lower-rated countries, by contrast, structural vulnerabilities and weaker institutions limit the extent to which climate resilience improves their credit standing.

These findings are consistent with Boehm (2022) who found that rising temperatures and climate anomalies negatively affect the sovereign creditworthiness of emerging economies, increasing borrowing costs. This further supports the view that institutional strength and adaptive capacity play a crucial role in mediating the relationship between climate risks and sovereign credit performance. A deeper interpretation of these findings highlights an important asymmetry in the role of climate factors across different levels of creditworthiness. In high-rated countries, well-developed financial markets, stable macroeconomic fundamentals, and stronger governance frameworks provide a conducive environment in which investments in climate readiness directly translate into measurable improvements in sovereign credit ratings. By contrast, in low-rated countries, fiscal imbalances, weaker governance, and limited adaptive capacity may dilute the observable impact of climate resilience indicators.

Model (8) demonstrates that climate vulnerability exerts a significant negative effect on credit ratings (-1.486), confirming Hypothesis 2 (H2). More climate-vulnerable economies are therefore penalized, likely due to their elevated exposure to climate-induced economic and fiscal stress. This finding is consistent with Sun et al. (2023), who documented that vulnerability to climate change adversely affects sovereign ratings and heightens long-term credit risk, particularly in developing or highly exposed economies.

Conversely, Model (5) demonstrates that climate readiness is positively associated with sovereign credit ratings (+0.889), supporting Hypothesis 3 (H3). This result indicates that countries with stronger institutional capacity and adaptive readiness to address climate-related challenges receive more favourable credit assessments. The significance of this effect across both static and dynamic specifications suggests that adaptive capacity contributes meaningfully to financial stability and investor confidence, consistent with Naifar (2023) and Sun et al. (2023).

Across the dynamic models, the lagged rating variable is large and highly significant, confirming the strong persistence characteristic of sovereign credit evaluations. The explanatory power of the models is substantial, as indicated by the high adjusted R-squared values, underscoring the relevance of climate resilience indicators in explaining variation in S&P's sovereign credit ratings beyond traditional macroeconomic factors.

Importantly, the results for Moody's ratings (Table 4) show a highly consistent pattern. The ND-GAIN index remains strongly positive in the baseline model (+1.824), while the interaction term again indicates a weaker resilience premium for speculative-grade issuers (-0.577), mirroring the S&P findings and reinforcing H1. Similarly, climate vulnerability exhibits a robust negative effect (-1.605), while readiness shows a strong positive association (+1.059), corroborating H2 and H3, respectively, and confirming that both agencies reward countries with greater adaptive capacity. The persistence of ratings is likewise evident in Moody's dynamic models, and the direction and significance of macroeconomic controls remain broadly aligned with the S&P estimations.

Collectively, the consistency between S&P and Moody's strengthens the conclusion that climate resilience, vulnerability, and adaptive readiness constitute meaningful and systematically evaluated components of sovereign credit risk. These findings carry two important policy and financial implications. First, they justify the integration of climate risk assessments into sovereign credit rating methodologies to accurately capture long-term credit risk. Second, they highlight the potential benefits for countries of investing in adaptive capacity, resilience strategies, and institutional readiness, as improved credit ratings reward such efforts. Ultimately, climate resilience is a key determinant of global financial stability, suggesting that credit rating agencies, investors, and policymakers should place greater emphasis on climate-related factors when assessing sovereign risk.

Table 3. Determinants of S&P's Sovereign Credit Ratings: Climate Risk, Macroeconomic Conditions, and Institutional Factors

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Baseline OLS	OLS model with interaction	FE panel model	Dynamic model	Baseline OLS	FE panel model	Dynamic model	Baseline OLS	FE panel model	Dynamic model
L.SCR_rating				0.781***			0.781***			0.781***
				(0.032)			(0.032)			(0.033)
ND-GAIN	1.566***	1.159***	0.239*	0.130*						
	(0.046)	(0.044)	(0.123)	(0.077)						
READINESS					0.889***	0.095*	0.054			
					(0.026)	(0.052)	(0.033)			
VULNERABILITY								-1.486***	-0.464**	-0.164*
								(0.064)	(0.211)	(0.091)
GDP growth (%)		0.005***	0.004***	0.002***		0.004***	0.002***		0.004***	0.002***
		(0.002)	(0.001)	(0.000)		(0.001)	(0.000)		(0.001)	(0.000)
Inflation (%)		-0.003***	-0.003***	-0.003**		-0.003***	-0.003**		-0.003***	-0.003**
		(0.001)	(0.001)	(0.001)		(0.001)	(0.001)		(0.001)	(0.001)
Gov. cons. exp. (% GDP)		-0.005***	0.001	-0.001		0.002	-0.001		0.000	-0.002
		(0.002)	(0.003)	(0.002)		(0.003)	(0.002)		(0.004)	(0.002)
Speculative rating (dummy)		1.674***								
		(0.323)								
ND-GAIN x speculative rating		-0.535***								
		(0.083)								

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Baseline OLS	OLS model with interaction	FE panel model	Dynamic model	Baseline OLS	FE panel model	Dynamic model	Baseline OLS	FE panel model	Dynamic model
Constant	-3.742*** (0.189)	-1.853*** (0.168)	1.652*** (0.502)	0.081 (0.326)	3.268*** (0.021)	2.679*** (0.070)	0.643*** (0.082)	1.091*** (0.066)	2.161*** (0.217)	0.445*** (0.126)
Obs.	739	739	739	675	792	739	675	739	739	675
N, number of groups			64	64		64	64		64	64
Adj. R-squared	0.667	0.838	0.487	0.691	0.604	0.546	0.691	0.484	0.485	0.690

Note: Standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1, speculative rating = 1 for speculative-grade sovereigns (BB+ and below).

Source: own study.

Table 4. Determinants of Moody's Sovereign Credit Ratings: Climate Risk, Macroeconomic Conditions, and Institutional Factors

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Baseline OLS	OLS model with interaction	FE panel model	Dynamic model	Baseline OLS	FE panel model	Dynamic model	Baseline OLS	FE panel model	Dynamic model
L.SCR rating				0.705*** (0.049)			0.706*** (0.049)			0.705*** (0.049)
ND-GAIN	1.824*** (0.068)	1.193*** (0.070)	0.204 (0.200)	0.011 (0.121)						
READINESS					1.059*** (0.035)	0.065 (0.084)	-0.018 (0.059)			
VULNERABILITY								-1.605*** (0.094)	-0.569* (0.343)	-0.305** (0.151)

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	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Baseline OLS	OLS model with interaction	FE panel model	Dynamic model	Baseline OLS	FE panel model	Dynamic model	Baseline OLS	FE panel model	Dynamic model
GDP growth (%)		0.006*** (0.002)	0.005*** (0.002)	0.002 (0.002)		0.005*** (0.002)	0.002 (0.002)		0.005*** (0.002)	0.002 (0.002)
Inflation (%)		-0.003** (0.002)	-0.005*** (0.001)	-0.003** (0.001)		-0.005*** (0.001)	-0.003** (0.001)		-0.005*** (0.001)	-0.003** (0.001)
Gov. cons. exp. (% GDP)		-0.009*** (0.003)	0.001 (0.006)	-0.004 (0.003)		0.001 (0.006)	-0.004 (0.003)		-0.001 (0.006)	-0.004 (0.004)
Speculative rating (dummy)		1.764*** (0.514)								
ND-GAIN x speculative rating		-0.577*** (0.132)								
Constant	-4.784*** (0.273)	-1.941*** (0.267)	1.780** (0.816)	0.800* (0.437)	3.346*** (0.029)	2.649*** (0.113)	0.831*** (0.158)	0.913*** (0.097)	2.044*** (0.353)	0.542*** (0.147)
Obs.	801	738	738	674	801	738	674	801	738	674
N, number of groups			64	64		64	64		64	64
Adj. R-squared	0.476	0.703	0.564	0.568	0.530	0.436	0.568	0.267	0.474	0.569

Note: Standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1, speculative rating = 1 for speculative-grade sovereigns (BB+ and below).

Sources: own study.

Robustness check

To further ensure that our results are not driven by the choice of rating agency or numerical conversion method, we conducted additional robustness estimations using estimations from the Afonso, Gomes, and Rother (2011) 17–1 scale for both S&P and Moody’s ratings. Tables 5 and 6 present these results, which remain highly consistent with our baseline results, confirming the stability and reliability of the estimated effects.

Specifically, climate resilience (ND-GAIN) continues to exert a strong, statistically significant positive effect on S&P’s ratings across specifications. The interaction term again indicates a weaker resilience premium for speculative-grade sovereigns, confirming the stability of H1. Climate readiness also remains positively associated with credit ratings, supporting H3 and demonstrating that adaptive capacity is robust to alternative transformations of credit ratings. Likewise, climate vulnerability retains its expected negative sign, strongly significant in the baseline OLS model, providing further evidence for H2. The persistence of sovereign ratings is reaffirmed in the dynamic models, with macroeconomic controls exhibiting the same direction and significance as in the main estimations. Overall, the robustness checks confirm that the relationships between climate factors and sovereign credit ratings are not sensitive to alternative rating scales, reinforcing the reliability of the core empirical results.

Table 5. Determinants of S&P's Sovereign Credit Ratings: Climate and Macroeconomic Factors. Ratings calculated according to the scale of Afonso, Gomes, and Rother (2011)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Baseline OLS	OLS model with interaction	FE panel model	Dynamic model	Baseline OLS	FE panel model	Dynamic model	Baseline OLS	FE panel model	Dynamic model
L.SCR rating				0.690***			0.690***			0.690***
				(0.036)			(0.036)			(0.037)
ND-GAIN	2.524***	1.601***	0.422*	0.306*						
	(0.087)	(0.084)	(0.255)	(0.174)						
READINESS					1.441***	0.182*	0.133*			
					(0.047)	(0.108)	(0.075)			
VULNERABILITY								-2.323***	-0.663	-0.326
								(0.119)	(0.439)	(0.203)
GDP growth (%)		0.011***	0.008***	0.003***		0.008***	0.003***		0.008***	0.003***
		(0.003)	(0.002)	(0.001)		(0.002)	(0.001)		(0.002)	(0.001)
		(0.002)	(0.002)	(0.003)		(0.002)	(0.003)		(0.002)	(0.003)
Gov. cons. exp. (% GDP)		-0.010***	-0.001	-0.002		-0.001	-0.001		-0.003	-0.003
		(0.003)	(0.007)	(0.004)		(0.007)	(0.004)		(0.007)	(0.004)
Speculative rating (dummy)		0.683								
		(0.620)								
ND-GAIN x speculative rating		-0.357**								
		(0.159)								

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Baseline OLS	OLS model with interaction	FE panel model	Dynamic model	Baseline OLS	FE panel model	Dynamic model	Baseline OLS	FE panel model	Dynamic model
Constant	-7.975*** (0.349)	-3.870*** (0.322)	0.572 (1.042)	-0.489 (0.683)	3.253*** (0.038)	2.399*** (0.144)	0.838*** (0.125)	-0.196 (0.124)	1.627*** (0.451)	0.427* (0.219)
Obs.	801	739	739.000	675.000	801	739.000	675.000	801	739.000	675.000
N, number of groups			64	64		64	64		64	64
Adj. R-squared	0.515	0.778	0.666	0.575	0.542	0.588	0.575	0.321	0.549	0.574

Standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1, speculative rating = 1 for speculative-grade sovereigns (BB+ and below).

Sources: own study.

Table 6. Determinants of Moody's Sovereign Credit Ratings: Climate and Macroeconomic Factors.
Ratings calculated according to the scale of Afonso, Gomes, and Rother (2011)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Baseline OLS	OLS model with interaction	FE panel model	Dynamic model	Baseline OLS	FE panel model	Dynamic model	Baseline OLS	FE panel model	Dynamic model
L.SCR rating				0.819*** (0.058)			0.819*** (0.058)			0.819*** (0.058)
ND-GAIN	2.669*** (0.099)	1.617*** (0.113)	0.220 (0.296)	0.082 (0.203)						
READINESS					1.506*** (0.053)	0.067 (0.125)	0.011 (0.097)			

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	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Baseline OLS	OLS model with interaction	FE panel model	Dynamic model	Baseline OLS	FE panel model	Dynamic model	Baseline OLS	FE panel model	Dynamic model
VULNERABILITY								-2.444***	-0.833	-0.263*
								(0.135)	(0.508)	(0.146)
GDP growth (%)		0.009**	0.006**	0.002		0.006**	0.002		0.006**	0.002
		(0.004)	(0.003)	(0.002)		(0.003)	(0.002)		(0.003)	(0.002)
Inflation (%)		-0.009***	-0.010***	-0.004*		-0.010***	-0.004*		-0.010***	-0.004*
		(0.003)	(0.002)	(0.002)		(0.002)	(0.002)		(0.002)	(0.002)
Gov. cons. exp. (% GDP)		-0.015***	0.002	-0.006		0.002	-0.006		-0.000	-0.007
		(0.004)	(0.008)	(0.005)		(0.008)	(0.005)		(0.008)	(0.005)
Speculative rating (dummy)		0.470								
		(0.830)								
ND-GAIN x speculative rating		-0.328								
		(0.213)								
Constant	-8.604***	-3.859***	1.315	0.186	3.409***	2.251***	0.525***	-0.367***	1.385***	0.258
	(0.398)	(0.431)	(1.209)	(0.833)	(0.125)	(0.168)	(0.165)	(0.140)	(0.522)	(0.164)
Obs.	803	738	738	674	738	738	674	803	738	674
N, number of groups			64	64		64	64		64	64
Adj. R-squared	0.476	0.692	0.492	0.667	0.485	0.384	0.667	0.290	0.477	0.667

Standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1, speculative rating = 1 for speculative-grade sovereigns (BB+ and below).

Sources: own study.

Discussion and Conclusion

This study examines the influence of climate risk on sovereign credit ratings by integrating S&P's and Moody's sovereign credit ratings with climate risk indicators from the ND-GAIN Country Index.

Our results confirm that climate resilience is a significant determinant of sovereign credit ratings, aligning with Boitan and Marchewka-Bartkowiak (2022), Cevik and Jalles (2022), and Capriello et al. (2025), who demonstrate that increasing climate risk is accompanied by rising costs of government borrowing or increasing sovereign risk. Specifically, higher overall resilience and stronger climate readiness are associated with higher credit ratings, whereas greater vulnerability is associated with lower credit ratings. While Ali, Usman, and Ahmad (2025) find limited support for this dependence, our findings provide robust evidence for the negative impact of vulnerability, consistent with Sun et al. (2023).

The subsample analysis further reveals that the positive effect of climate readiness is more pronounced in high-rated countries, where stronger institutions and adaptive capacity enable climate investments to translate more effectively into favorable credit outcomes. In low-rated economies, by contrast, structural weaknesses and limited institutional capacity diminish the impact of climate factors.

Indeed, Şeker and İşgüven (2025) note that while investment-grade countries would receive lower ratings if environmental factors (biodiversity) were taken into account, speculative-grade countries with lower credit ratings could achieve higher ratings by considering environmental factors. Therefore, our results shed new light on the relationship between climate risk and investment and speculative sovereign ratings. The discrepancy suggests that the direction of the relationship between the synthetic measure of climate risk and the sovereign rating may differ from that of individual climate risk composites or dimensions and the ratings assigned by rating agencies.

The novelty of this study mainly lies in providing new insights into the determinants of sovereign ratings. Our results provide important practical implications for governments since the costs of current and planned climate policies (which positively affect climate resilience) may be partially offset by savings resulting from lower risk premiums, provided that such policies help maintain or even improve a country's creditworthiness, as reflected in its sovereign rating. We also demonstrate the heterogeneity in the impact of climate risks across different country clusters. For high-rated countries, continued investment in climate readiness can be viewed as a strategy to preserve and even enhance creditworthiness over time. For low-rated countries, however, strengthening institutional capacity, reducing structural vulnerabilities, and integrating climate resilience into broader economic development strategies are essential for climate factors to have a more substantial impact on credit ratings. This highlights the need for a differentiated approach: while climate readiness is universally beneficial, its effectiveness in improving sovereign credit ratings depends heavily on the broader economic and institutional context.

The conclusions are also important for rating agencies, as they provide a basis for incorporating climate resilience indices into their sovereign rating methodologies – a need recognized as far back as 2014 by S&P, which identified climate change as a megatrend that has a significant impact on sovereign risk.

The main limitation of our study is that while the ND-GAIN indices provide comprehensive measures of climate vulnerability and readiness, they may not fully capture all dimensions of climate-related financial risk, such as sector-specific exposures or extreme weather events. Additionally, the index decomposition does not correspond to the taxonomy of climate risk widely used in regulatory policy and mandatory disclosures, i.e., physical and transition risks. Future research could address these limitations by integrating more granular climate and economic indicators. Furthermore, investigating the role of institutional quality, governance, and macro-economic policies in mediating the impact of climate resilience on credit ratings would provide further valuable insights.

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References

- Afonso, A., Gomes, P. (2010), *Do Fiscal Imbalances Deteriorate Sovereign Debt Ratings?*, “ISEG Economics Working Paper”, 24/2010/DE/UECE, <https://doi.org/10.2139/ssrn.1715850>
- Afonso, A., Gomes, P., Rother, P. (2011), *Short- and long-run determinants of sovereign debt credit ratings*, “International Journal of Finance and Economics”, 16 (1), pp. 1–15, <https://doi.org/10.1002/ijfe.416>
- Ali, A., Usman, M., Ahmad, K. (2025), *Environmental Risks and Sovereign Credit Ratings: Evidence from Developed and Developing Economies*, “Competitive Research Journal Archive”, 3 (01), pp. 356–370, <http://thecrja.com/index.php/Journal/article/view/146> (accessed: 27.07.2025).
- Bank for International Settlements (2021), *Climate-related risk drivers and their transmission channels*, <https://www.bis.org/bcbs/publ/d517.pdf> (accessed: 30.08.2025).
- Bank for International Settlements (2023), *The effects of climate change-related risks on banks: a literature review*, <https://www.bis.org/bcbs/publ/wp40.htm> (accessed: 9.08.2025).
- Barauskaitė Griškevičienė, K., Nguyen, A.D.M., Fache Rousová, L., Cappiello, L. (2021), *The impact of loan and market-based credit supply shocks on euro area GDP growth*, “Financial Stability Review”, November, https://www.ecb.europa.eu/press/financial-stability-publications/fsr/focus/2021/html/ecb.fsrbox202111_07~83888507a6.en.html (accessed: 19.08.2025).
- Ben Mim, S., Nouira, R., Mabrouk, F. (2023), *Non-Linear Determinants of Developing Countries’ Sovereign Ratings: Evidence from a Panel Threshold Regression (PTR) Model*, “Sustainability”, 15 (4), 3390, <https://doi.org/10.3390/su15043390>
- Bernhofen, M.V., Burke, M., Puranasamriddhi, A., Ranger, N., Shrimali, G. (2024), *The Impact of Physical Climate Risks on Sovereign Credit Ratings: Implications for financial resilience and fiscal policy at the sovereign-bank nexus*, Smith School of Enterprise and the Environment and Environmental

- Change Institute, University of Oxford, Oxford, <https://www.eci.ox.ac.uk/sites/default/files/2024-12/Impact%20of%20Physical%20Climate%20Risks%20%28Nov24%29.pdf> (accessed: 2.09.2025).
- Bissoondoyal-Bheenick, E. (2005), *An analysis of the determinants of sovereign ratings*, “Global Finance Journal”, 15 (3), pp. 251–280, <https://doi.org/10.1016/j.gfj.2004.03.004>
- Boehm, H. (2022), *Physical climate change and the sovereign risk of emerging economies*, “Journal of Economic Structures”, 11, 31, <https://doi.org/10.1186/s40008-022-00284-6>
- Boitan, I.A., Marchewka-Bartkowiak, K. (2022), *Climate change and the pricing of sovereign debt: Insights from European markets*, “Research in International Business and Finance”, 62, 101685, <https://doi.org/10.1016/j.ribaf.2022.101685>
- Cantor, R.M., Packer, F. (1996), *Determinants and Impact of Sovereign Credit Ratings*, “Economic Policy Review”, 2 (2), <https://doi.org/10.2139/ssrn.1028774>
- Cappiello, L., Ferrucci, G., Maddaloni, A., Veggente, V. (2025), *Creditworthy: do climate change risks matter for sovereign credit ratings?*, “Working Paper Series”, 3042, ECB, Frankfurt am Main, <https://www.ecb.europa.eu/pub/pdf/scpwps/ecb.wp3042~b5465ef93e.en.pdf?cfid7187b00814e498629541182f20b07> (accessed: 9.09.2025).
- Cevik, S., Jalles, J.T. (2022), *This changes everything: Climate shocks and sovereign bonds*, “Energy Economics”, 107, 105856, <https://doi.org/10.1016/j.eneco.2022.105856>
- Cevik, S., Jalles, J.T. (2023), *Feeling the Heat: Climate Shocks and Credit Ratings*, “Review of Development Finance”, 13 (2), pp. 21–34.
- Chalabi-Jabado, F., Ziane, Y. (2024), *Climate risks, financial performance and lending growth: Evidence from the banking industry*, “Technological Forecasting and Social Change”, 209, 123757, <https://doi.org/10.1016/j.techfore.2024.123757>
- Chenery, H., Robinson, S., Syrquin, M. (1986), *Industrialization and Growth: A Comparative Study*, Oxford University Press, Oxford.
- Dafermos, Y., Nikolaidi, M., Galanis, G. (2018), *Climate Change, Financial Stability and Monetary Policy*, “Ecological Economics”, 152, pp. 219–234, <https://doi.org/10.1016/j.ecolecon.2018.05.011>
- European Banking Authority (2020), *Discussion paper on management and supervision of ESG risks for credit institutions and investment firms*, <https://www.eba.europa.eu/publications-and-media/press-releases/eba-launches-consultation-incorporate-esg-risks-governance> (accessed: 26.08.2025).
- Faiella, I., Natoli, F. (2018), *Natural catastrophes and bank lending: the case of flood risk in Italy*, “Questioni di Economia e Finanza (Occasional Papers)”, 457, https://www.bancaditalia.it/publicazioni/qef/2018-0457/QEF_457_18.pdf (accessed: 14.09.2025).
- Felipe, J., Kumar, U., Abdon, A. (2014), *How rich countries became rich and why poor countries remain poor: It's the economic structure...duh!*, “Japan and the World Economy”, 29, pp. 46–58, <https://doi.org/10.1016/j.japwor.2013.11.004>
- Feng, T., Maher, S., Singh, K., Lord, R. (2025), *Climate risk and portfolio analysis*, <https://www.spglobal.com/sustainable/en/insights/blogs/climate-risk-and-portfolio-analysis> (accessed: 2.10.2025).
- Financial Times (2025), *The ECB's song of fire and flood keeps getting louder*, July 15, <https://www.ft.com/content/79fccf47-7fa7-40e6-8021-630386050e11> (accessed: 3.09.2025).
- Fitch Ratings (2020), *Climate Change Impact on Sovereign Ratings: A Primer*, <https://www.fitchratings.com/research/sovereigns/climate-change-impact-on-sovereign-ratings-a-primer-01-06-2020> (accessed: 4.10.2025).

- Garmaise, M.J., Moskowitz, T.J. (2009), *Catastrophic Risk and Credit Markets*, “The Journal of Finance”, 64 (2), pp. 657–707, <https://www.jstor.org/stable/20487982> (accessed: 29.09.2025).
- Goel, A., Singh, A. (2024), *Are sovereign credit ratings impacted by institutional quality?*, “International Journal of Economics and Accounting”, 12 (2), pp. 99–115, <https://doi.org/10.1504/IJEA.2024.144246>
- Goel, A., Singh, A. (2025), *Impact of economic and socio-political risk factors on sovereign credit ratings*, “Information Processing & Management”, 62 (1), 103943, <https://doi.org/10.1016/j.ipm.2024.103943>
- Graff Zivin, J., Neidell, M. (2014), *Temperature and the Allocation of Time: Implications for Climate Change*, “Journal of Labor Economics”, 32 (1), pp. 1–26, <https://doi.org/10.1086/671766>
- Hu, H., Prokop, J., Shi, Y., Trautwein, H.-M. (2020), *The rating spillover from banks to sovereigns: An empirical investigation across the European Union*, “Journal of International Financial Markets, Institutions and Money”, 64, 101161, <https://doi.org/10.1016/j.intfin.2019.101161>
- International Monetary Fund (2020), *Chapter 5: Climate Change: Physical Risk and Equity Prices*, [in:] *Global Financial Stability Report: Markets in the Time of COVID-19*, Washington, <https://www.imf.org/en/Publications/GFSR/Issues/2020/04/14/global-financial-stability-report-april-2020> (accessed: 27.09.2025).
- IPCC (2021), *Climate Change 2021: The Physical Science Basis*, <https://www.ipcc.ch/report/ar6/wg1/> (accessed: 19.09.2025).
- Kaldor, N. (1967), *Strategic Factors in Economic Development*, New York State School of Industrial and Labor Relations, Cornell University, Ithaca.
- Karkowska, R., Urjasz, S. (2025), *How does the volatility of ESG stock indices spillover in times of high geopolitical risk? New insights from emerging and developed markets*, “Journal of Sustainable Finance & Investment”, 15 (3), pp. 577–623, <https://doi.org/10.1080/20430795.2025.2489395>
- Korzeb, Z., Gospodarowicz, M., Niedziółka, P., Torre Gallegos, A. de la (2024), *Climate risk and capital requirements – findings for the Polish banking sector based on empirical research*, “Ekonomista”, 3, pp. 249–274, <https://doi.org/10.52335/ekon/188777>
- Korzeb, Z., Kulpaka, P., Niedziółka, P. (2019), *Deoligopolizacja rynku agencji ratingowych oraz inne inicjatywy na rzecz poprawy jakości ratingów zewnętrznych w kontekście oddziaływania agencji ratingowych na stabilność finansową*, „Materiały i Studia”, 333, NBP, <https://static.nbp.pl/publikacje/materialy-i-studia/ms333.pdf> (accessed: 5.10.2025).
- Korzeb, Z., Niedziółka, P., Nistor, S. (2023), *Sovereign creditworthiness and bank foreign ownership. An empirical investigation of the European banking sector*, “Journal of International Financial Markets, Institutions and Money”, 89, 101857, <https://doi.org/10.1016/j.intfin.2023.101857>
- Kuznets, S. (1966), *Modern Economic Growth: Rate, Structure, and Spread*, Yale University Press, New Haven.
- Li, S., Li, Q., Lu, S. (2024), *The impact of climate risk on credit supply to private and public sectors: an empirical analysis of 174 countries*, “Environment, Development and Sustainability”, 26, pp. 2443–2465, <https://doi.org/10.1007/s10668-022-02827-0>
- Lim, K.T., Goh, K.L., Kwek, K.T. (2023), *A Comparative Analysis of the Investment- and Speculative-Sovereign Credit Ratings*, “International Journal of Business & Economics”, 8 (1), pp. 49–174, <https://doi.org/10.58885/ijbe.v08i1.149.kl>
- Ma, F., Cao, J., Wang, Y., Vigne, S.A., Dong, D. (2025), *Dissecting climate change risk and financial market instability: Implications for ecological risk management*, “Risk Analysis”, 45 (3), pp. 496–522, <https://doi.org/10.1111/risa.14265>

- Mellios, C., Paget-Blanc, E. (2006), *Which factors determine sovereign credit ratings?*, “The European Journal of Finance”, 12 (4), pp. 361–377, <https://doi.org/10.1080/13518470500377406>
- Mitra, P., Raissi, M., Versailles, B., Centorrino, S., Ivanyna, M., Kirabaeva, K., Massetti, E., Montes de Oca Leon, M., Nguyen, H., Oman, W., Rebei, N., Tagklis, F., Tianbo Zhang, A., Ungerer, Ch., Uruñuela López, J., Yu, S. (2025), *Integrating Climate Change into Macroeconomic Analysis: A Review of Impact Channels, Data, Models, and Scenarios*, “IMF Working Paper”, 2025 (170), <https://doi.org/10.5089/9798229021890.001>
- Monasterolo, I., Raberto, M. (2018), *The EIRIN Flow-of-funds Behavioural Model of Green Fiscal Policies and Green Sovereign Bonds*, “Ecological Economics”, 144, pp. 228–243, <https://doi.org/10.1016/j.ecolecon.2017.07.029>
- Moody’s (2026), *Sovereign Methodology overview*, <https://www.moodys.com/web/en/us/solutions/ratings/sovereign-methodology.html#overview-item-f77dcf2958-tab> (accessed: 9.03.2026).
- Mutize, M., Nkhalamba, M.P. (2021), *A comparative study of economic growth as a key determinant of sovereign credit ratings in Africa*, “International Journal of Emerging Markets”, 16 (4), pp. 786–805, <https://doi.org/10.1108/IJOEM-10-2019-0830>
- Muzuva, M., Muzuva, D. (2024), *The impact of climate change on banks loan portfolios and strategies for effective climate risk management*, “International Journal of Research in Business and Social Science”, 13 (6), pp. 148–157, <https://doi.org/10.20525/ijrbs.v13i6.3510>
- Naifar, N. (2023), *Does climate change affect sovereign credit risk? International evidence*, “Borsa Istanbul Review”, 23 (1), pp. S84–S95, <https://doi.org/10.1016/j.bir.2023.10.001>
- NGFS (2025), *Guide to climate scenario analysis for central banks and supervisors – Update*, https://www.ngfs.net/system/files/2025-11/Guide%20to%20climate%20scenario%20analysis%20for%20central%20banks%20and%20supervisors%20-%20Update_0.pdf (accessed: 9.03.2026).
- Nieto, M.J. (2019), *Banks, climate risk and financial stability*, “Journal of Financial Regulation and Compliance”, 27 (2), pp. 243–262, <https://doi.org/10.1108/JFRC-03-2018-0043>
- Noth, F., Schüwer, U. (2018), *Natural Disaster and Bank Stability: Evidence from the US Financial System*, “SAFE Working Paper”, 167, Goethe University Frankfurt, SAFE – Sustainable Architecture for Finance in Europe, Frankfurt am Main, <https://doi.org/10.2139/ssrn.2921000>
- Notre Dame Global Adaptation Initiative (2025), *Methodology*, <https://gain.nd.edu/our-work/country-index/methodology/> (accessed: 15.07.2025).
- Notre Dame Global Adaptation Initiative (n.d.), <https://gain.nd.edu/> (accessed: 20.09.2025).
- Oikawa, K. (2023), *Economic Growth: Why Are There Rich and Poor Countries?*, [in:] S. Urata, K.I. Akao, A. Washizu, (eds.), *Sustainable Development Disciplines for Society. Breaking Down the 5Ps – People, Planet, Prosperity, Peace, and Partnerships*, Springer, Singapore, pp. 141–158, https://doi.org/10.1007/978-981-19-5145-9_9
- Overes, B.H.L., Wel, M. van der (2023), *Modelling Sovereign Credit Ratings: Evaluating the Accuracy and Driving Factors using Machine Learning Techniques*, “Computational Economics”, 61, pp. 1273–1303, <https://doi.org/10.1007/s10614-022-10245-7>
- Proença, C., Neves, M., Dias, J.S., Martins, P. (2022), *Determinants of sovereign debt ratings in clusters of European countries – effects of the crisis*, “Journal of Financial Economics”, 14 (3), pp. 403–427, <https://doi.org/10.1108/JFEP-01-2021-0017>

- S&P (2025), *Climate Physical Risk Exposure Scores and Financial Impact Data. Methodology*, https://portal.s1.spglobal.com/survey/documents/SPG_S1_Physical_Risk_Methodology.pdf (accessed: 2.10.2025).
- Sehgal, S., Mathur, S., Arora, M., Gupta, L. (2018), *Sovereign ratings: Determinants and policy implications for India*, "IIMB Management Review", 30 (2), pp. 140–159, <https://doi.org/10.1016/j.iimb.2018.01.006>
- Şeker, A., İşgüven, M.K. (2025), *The Nexus Between Biodiversity and Sovereign Credit Ratings: Global Environmental and Economic Interdependencies from a Sustainability Perspective*, "Sustainability", 17 (11), 4977, <https://doi.org/10.3390/su17114977>
- Shang, Y., Sang, S., Tiwari, A.K., Khan, S., Zhao, X. (2025), *Impacts of renewable energy on climate risk: A global perspective for energy transition in a climate adaptation framework*, "Applied Energy", 362, 122994, <https://doi.org/10.1016/j.apenergy.2024.122994>
- Sheedy, E.A., Griffin, B., Barbour, J.P. (2017), *A Framework and Measure for Examining Risk Climate in Financial Institutions*, "Journal of Business and Psychology", 32, pp. 101–116, <https://doi.org/10.1007/s10869-015-9424-7>
- Standard and Poor's (2014), *Climate Change Is A Global Mega-Trend For Sovereign Risk*, <https://www.maalot.co.il/publications/GMR20140518110900.pdf> (accessed: 14.09.2025).
- Stawasz-Grabowska, E. (2020), *Sovereign Credit Rating Determinants of the EU Countries: The Role of the Euro Area Crisis and Its Legacy*, "Entrepreneurial Business and Economics Review", 8 (2), pp. 47–69, <https://doi.org/10.15678/EBER.2020.080203>
- Sun, X., Shen, Y., Guo, K., Ji, Q. (2023), *Sovereign ratings change under climate risks*, "Research in International Business and Finance", 66, 102040, <https://doi.org/10.1016/j.ribaf.2023.102040>
- Takawira, O., Mwamba, J.W.M. (2022), *Sovereign Credit Ratings Analysis Using the Logistic Regression Model*, "Risks", 10 (4), 70, <https://doi.org/10.3390/risks10040070>
- Yang, L., Hamori, S. (2023), *Modeling the global sovereign credit network under climate change*, "International Review of Financial Analysis", 87, 102618, <https://doi.org/10.1016/j.irfa.2023.102618>
- Zhai, P., Fan, Y., Ji, Q., Ma, Y.-R. (2024), *Climate risks and financial markets: A review of the literature*, "Climate Change Economics", 15 (4), 2440008, <https://doi.org/10.1142/S2010007824400086>
- Zhang, W.L., Chang, C.P. Xuan, Y. (2022), *The impacts of climate change on bank performance: What's the mediating role of natural disasters?*, "Economic Change Restructuring", 55, pp. 1913–1952, <https://doi.org/10.1007/s10644-021-09371-3>

Jak odporność na zmiany klimatu wpływa na ryzyko kredytowe kraju: badanie porównawcze na próbie międzynarodowej

Celem artykułu jest identyfikacja wpływu odporności kraju na ryzyko klimatyczne na jego rating kredytowy oraz odpowiedź na pytanie, czy podatność na ryzyko może być łagodzona przez aktywną politykę klimatyczną państwa. Analiza uwzględnia również trwałość zaobserwowanych zależności w odniesieniu do krajów o ratingu inwestycyjnym oraz spekulacyjnym. Badanie opiera się na próbie 67 państw i koncentruje się na zależności między ratingami kredytowymi nadawanymi przez agencje Standard & Poor's i Moody's a indeksem ryzyka klimatycznego ND-GAIN, w tym jego składowymi – podatnością i gotowością. W celu weryfikacji zależności między ratingami kredytowymi państw a ich odpornością klimatyczną zastosowano analizę skupień opartą na podatności klimatycznej, zdolności adaptacyjnej oraz ratingach kredytowych, a także model regresji liniowej. Wyniki wskazują na pozytywną zależność między odpornością klimatyczną kraju a jego ratingiem kredytowym. Podatność na ryzyko klimatyczne wpływa negatywnie na ocenę wiarygodności kredytowej, natomiast pozytywny wpływ gotowości klimatycznej jest bardziej widoczny w krajach o wyższych ratingach niż w tych o gorszej

ocenie wiarygodności kredytowej. Wnioski dostarczają nowych informacji na temat czynników determinujących ratingi kredytowe państw oraz wpływu ryzyka klimatycznego na wiarygodność kraju, co ma istotne znaczenie dla polityki klimatycznej oraz metodologii wyznaczania ratingów suwerennych przez agencje ratingowe.

Słowa kluczowe: ryzyko klimatyczne, rating państwowy, podatność, gotowość, indeks ND-GAIN

Appendix

List of countries included in the study		
Argentina	Guatemala	Philippines
Australia	Hungary	Poland
Austria	India	Portugal
Bangladesh	Indonesia	Romania
Belgium	Ireland	Russian Federation
Brazil	Israel	Serbia
Bulgaria	Italy	Singapore
Canada	Jamaica	Slovak Republic
Chile	Japan	Slovenia
China	Korea, Rep.	Spain
Colombia	Latvia	Suriname
Costa Rica	Lithuania	Sweden
Croatia	Luxembourg	Switzerland
Cyprus	Malaysia	Thailand
Czech Republic	Malta	Trinidad and Tobago
Denmark	Mexico	Turkey
Ecuador	Morocco	United Kingdom
El Salvador	Netherlands	United States
Estonia	New Zealand	Uruguay
Finland	Norway	Venezuela
France	Pakistan	Vietnam
Germany	Panama	
Greece	Peru	

Source: own study.