Carbon Risk and Sovereign Bond Risk Premiums

Inji Heo [a], **Wook Sohn** [b]

[a] Bank of Korea, 39 Namdaemoon-Ro, Jung-Gu, Seoul, KOREA

[b] KDI School of Public Policy and Management, 263 Namsejong-Ro, Sejong, KOREA

Abstract

This study examines the influence of physical and transition risks associated with climate change on the sovereign bond market, utilizing a fixed-effects panel regression approach across 37 countries from 2000 to 2022. The findings indicate that both physical carbon emissions and low-carbon transition policies contribute to an increase in sovereign bond spreads. The impact is most pronounced within the middle-income group, followed by the low-income group and then the high-income group, highlighting distinct structural characteristics within these income categories. In low-income countries, high macroeconomic volatility tends to attenuate the influence of climate-related factors, whereas in high-income countries, the presence of stable capital markets and strong institutional credibility curtails the immediate pricing of climate risks. The middle-income group, situated between these extremes, experiences a dual challenge of rising emissions due to industrial growth and inconsistent policy implementation. Coupled with less mature institutions, these dynamics render climate risks more significantly and directly observable in sovereign risk premiums.

JEL Classification: G12, G18, Q51

Keywords: Carbon risk, Sovereign bond, Risk premiums

1. Introduction

In recent years, the world has witnessed a series of extreme weather events—including heat waves, heavy rainfall, and wildfires—resulting from global warming. In response to the escalating climate crisis, numerous nations are adopting an array of green policies aimed at achieving carbon neutrality. As climate change accelerates, its repercussions are increasingly permeating global financial systems. Consequently, climate change is now recognized not merely as an environmental challenge but as a systemic macro-financial risk with implications for countries' fiscal sustainability and capital markets.

Interest in the intersection of climate change risks and financial markets, particularly sovereign bond markets, has surged. A range of studies has confirmed the positive relationship between physical climate risk and long-term government bond yields. Fodha et al. (2021) and Barnett & Yannelis (2024) highlight that anticipated climate impacts significantly elevate government bond yields. Similarly, Cevik & Jalles (2020) report that increased climate vulnerability corresponds with higher bond spreads, while enhanced climate resilience tends to reduce them—these effects being accentuated in developing nations. Bingler (2022) identifies physical risk as a contributing factor to rising long-term bond yields but suggests that low-credit countries exhibit less sensitivity to climate-related risks compared to their high-credit counterparts. Additionally, Bolton & Kacperczyk (2023) demonstrate that the influence of carbon emissions on investment premiums is stronger in nations characterized by lower GDP, higher reliance on manufacturing, and less inclusive political systems. Anyfantaki et al. (2025) further categorize physical risks into chronic (e.g., temperature rise) and acute (e.g., natural disasters), revealing that while chronic risks have minimal impact, acute risks tend to increase bond yields significantly in countries with elevated debt levels.

Regarding transition risk, Battiston & Monasterolo (2020) indicates that countries pursuing low-carbon initiatives often experience reduced bond spreads, whereas fossil fuel-dependent countries face increased spreads in response to climate policy changes. Bingler (2022) finds that transition risks significantly contribute to lower long-term yields, particularly among high-rated countries. Furthermore, Collender et al. (2023) reveal that in advanced economies, the consumption of renewable energy correlates with reduced bond risk premiums, while in developing economies, it tends to elevate them. This suggests that low-carbon policies are perceived favorably in advanced economies but as sources of uncertainty and financial burden in developing contexts. Cheng et al. (2023) assert that lower sustainability levels are associated with higher sovereign bond yields, with this association strengthening in the absence of robust green policy frameworks.

Numerous studies—such as those conducted by Capelle-Blancard et al. (2019), Semet et al. (2021), Fodha et al. (2021) and Crifo et al. (2023) —indicate that stronger institutional quality significantly mitigates sovereign risk premiums. Additionally, Zhang(2022), Bolton & Kacperczyk (2023) report a negative response of stock prices to perceived shifts in climate risk.

The influence of climate change on sovereign bond yields is multifaceted, resulting in heterogeneous outcomes across countries that are contingent upon their specific circumstances. Cevik and Jalles (2020), Zhang (2022), Collender et al. (2023) and Anyfantaki et al. (2025) illustrate that the reflection of climate risks varies according to a country's development level (developing vs. advanced economies). Likewise, Semet et al. (2021) and Bolton & Kacperczyk (2023conduct analyses based on income levels (high vs. low), Bingler (2022) discusses differing reflections of risk based on credit ratings (high vs. low), and Battiston & Monasterolo (2020) differentiate based on national energy structures (low-carbon vs. fossil fuel-dependent). Table 1 presents a comparative summary of previous studies.

This study investigates the pricing of both physical and transition risks associated with carbon emissions—an essential factor in climate change—within sovereign bond markets. Previous research on the correlation between climate risk and the sovereign bond risk premium has predominantly employed a binary framework (e.g., differentiating between advanced and developing economies, high and low credit ratings, or low-carbon and fossil fuel-dependent economies). In contrast, this paper advances the discourse by categorizing countries into three distinct groups based on their Gross Domestic Product (GDP) levels. This approach provides new insights into how nations with differing economic capacities can effectively manage carbon risk to mitigate potential increases in borrowing costs.

This study employs fixed-effects regression analysis alongside the risk classification framework proposed by the Task Force on Climate-related Financial Disclosures (TCFD, 2017), which differentiates between physical and transition risks. According to the TCFD (2017), physical risk encompasses the financial repercussions of increasingly frequent and severe climate-related disasters; consequently, this study utilizes CO_2 emissions as a proxy for physical risk. Transition risk, on the other hand, pertains to the risks that stem from political, legal, technological, and market shifts. Given the focus on carbon, the intensity of low-carbon policies, as measured by a low-carbon policy index, is employed as a proxy for transition risk. Additionally, to account for various macroeconomic factors that may influence sovereign bond risks, seven control variables are included in the analysis.

The results indicate that both CO_2 emissions (representing physical risk) and low carbon policies (indicating transition risk) contribute to an increase in sovereign risk premiums. Notably, the impact is most pronounced in middle-income countries when compared to their lower and higher-income counterparts.

2. Data

The dataset encompasses 37 countries, categorized into advanced and developing nations, over the period from 2000 to 2022. The sample is stratified into three groups based on their GDP levels. Given that GDP levels fluctuate annually, countries were classified according to their average GDP per capita over the specified period. This average was computed for the entire 23-year span (2000–2022), independent of the number of available observations for each country. Table 2 presents summary statistics for Group L (low), Group M (middle), and Group H (high), with each group consisting of either 12 or 13 countries.[1]

Figures 1 and 2 depict the trends in physical and transition carbon risk across various GDP groups. Figure 1 illustrates that global average CO_2 emissions per capita experienced a gradual increase from the early 2000s until approximately 2012, followed by a moderate decline. At the group level, the relative ranking of the groups (Group L < Group M < Group H) has remained stable; however, the disparity between them has gradually diminished over time. Group L shows a continuous upward trend, while Groups M and H exhibit a distinct downward trajectory. This indicates that higher-income countries have successfully achieved more significant reductions in carbon emissions, although the absolute levels of emissions continue to be prevalent.[2]

In Figure 2, the low-carbon policy index demonstrates a general upward trend across all income groups from 2000 to 2022, indicating a strengthening of global climate policy efforts over time. Groups H and M consistently report the highest index values, reaching 59 and 58, respectively, in 2022. This finding suggests that wealthier economies tend to implement more stringent climate policies. Conversely, Group L maintains the lowest index level (41 in 2022) but shows gradual improvement since the 2010s, indicating an increasing engagement by

[1] Group L, the lowest income category, comprises countries with an average GDP per capita ranging from USD 5,487 to USD 24,694. Group M, representing the middle-income cohort, includes countries with average GDP per capita between USD 26,951 and USD 50,174. Group H, the highest income group, consists of countries with averages spanning from USD 50,426 to USD 84,718.

[2] According to data from Our World in Data (OWID), China's emissions have increased more than threefold since 2000, reflecting the country's rapid industrialization. The United States continues to be the world's largest emitter. While it has achieved notable long-term reductions in emissions, the pace of decline has slowed in recent years.

developing countries in climate policy initiatives. From 2018 to 2022, all groups exhibit an upward trend, likely reflecting the bolstering of carbon neutrality policies and the adoption of Environmental, Social, and Governance (ESG) frameworks across countries.

3. Methodology

This study utilized a country fixed effects model to account for unobserved, time-invariant characteristics unique to each country.[3] Given that the distributions of certain variables, including CO_2 emissions per capita, low-carbon policy index, and GDP per capita, exhibit skewness, logarithmic transformations were applied to enhance normality and interpretability. The regression model employed in this study is outlined as follows.

$$Risk\ Premium_{it} = \alpha + \beta_1 ln(CO_2\ Emission_{it}) + \beta_2 ln(Low\ Carbon\ Policy_{it}) + \beta_3 Current\ Account\ Balance_{it} + \beta_4 Government\ Debt_{it} + \beta_5 ln(GDP_{it}) + \beta_6 GDP\ Growth_{it} + \beta_7 Inflation_{it} + \beta_8 Trade\ Openness_{it} + \beta_9 Credit_{it} + \mu_i + \varepsilon_{it} \quad (1)$$

The dependent variable in this study, *Risk Premium*, refers to the sovereign bond risk premium, measured by the risk premium of each country's 10-year sovereign bond yield, as sourced from Bloomberg. Specifically, it is calculated as the difference between each country's 10-year sovereign bond yield and the 10-year U.S. Treasury yield.

The primary explanatory variables of interest are the physical and transition risks associated with climate change. Physical risk encompasses hazards related to carbon emissions, including rising temperatures, sea-level rise, and deteriorating air quality, which are measured by CO_2 emissions per capita from Our World in Data (OWID). Transition risk pertains to the risks arising from policy shifts during the transition to a low-carbon society. It is represented

[3] A fixed effects model is appropriate for this study, rather than a random effects model, because the unobserved country-specific factors are likely correlated with the explanatory variables, violating the random effects assumption and potentially leading to biased estimates.

by low-carbon policy, specifically quantified by the Adjusted Emissions Growth Rate for Carbon Dioxide (CDA), a sub-indicator of the Environmental Performance Index (EPI).[4] The EPI, developed collaboratively by Yale University and Columbia University with the World Economic Forum, quantitatively assesses each country's performance in environmental policy. This composite index incorporates multiple sub-indicators across 30 issue categories and 58 performance indicators, evaluating over 180 countries' environmental outcomes to promote policy improvements toward sustainability.

The EPI assesses national environmental performance across two broad policy objectives: Environmental Health (e.g., air quality, sanitation, drinking water, exposure to heavy metals) and Ecosystem Vitality (e.g., climate change mitigation, biodiversity and habitat, fisheries, agriculture, and water resources), utilizing more than 40 performance indicators. It employs standardized and weighted, outcome-oriented metrics that facilitate cross-country comparisons. Since its inception in 2002, the EPI has become a recognized benchmark in environmental governance (Yale Center for Environmental Law & Policy, 2022). The CDA indicator specifically represents the average annual rate of carbon emissions from 2013 to 2022, adjusted for economic trends to isolate changes attributed to policy efforts rather than economic fluctuations.[5] A high CDA score indicates substantial reductions in carbon emissions due to effective policy implementation, reflecting a country's commitment to proactive climate action.

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[4] The EPI comprises three primary components: Ecosystem Vitality (45%), Climate Change (30%), and Environmental Health (25%). Within the Climate Change category, the 'Adjusted Emissions Growth Rate for Carbon Dioxide (CDA)' contributes 25%, which translates to 7.5% of the overall EPI score.

[5] A score of 100 indicates that a country is reducing its emissions by 13% or more per year, while a score of 0 signifies that emissions are increasing by 13% or more per year.

Additionally, the study incorporates macroeconomic control variables that may influence the sovereign bond risk premium, including the current account balance (as a percentage of GDP), government debt (% of GDP), GDP per capita (USD), GDP growth (%), inflation (%), trade openness (% of GDP), and credit (Moody's score).[6]

Table 3 presents the sample data for this analysis, which includes up to 716 observations across key variables: 225 in Group L, 233 in Group M, and 258 in Group H. The sovereign bond risk premium exhibits notable differences across income levels, with Group L having the highest average at 3.69% (with a substantial standard deviation of 3.24), indicating relatively high sovereign risk and considerable variability among low-income countries. Group M displays an average of 1.01%, while Group H shows -0.30%, suggesting a trend towards lower risk premiums in higher-income countries. Among the groups, Group L reflects the largest within-group standard deviations for both CO_2 emissions and low-carbon policy.

The data utilized in this study were sourced from Bloomberg, the World Bank, OWID, and the Yale Center for Environmental Law & Policy (YCELP). Bloomberg provides insights for the financial sector, while the World Bank offers vital economic indicators. OWID serves as an open-access platform compiling reliable global statistics across various topics, including health, education, and economic development. YCELP is an academic institution affiliated with Yale University, renowned for producing the EPI.

4. Empirical Results

Table 4 indicates that in the total sample, both CO_2 emissions per capita (5.622, $p < 0.001$) and the low-carbon policy index (2.253, $p < 0.001$) exert significantly positive effects

[6] The scale comprises 21 distinct notches, ranging from Aaa, which represents the highest credit quality, to C, the lowest. To quantitatively represent these ratings, each rating is assigned an integer score from 1 to 21, where a score of 1 corresponds to the highest rating (Aaa) and a score of 21 corresponds to the lowest rating (C).

on sovereign bond risk premiums. This suggests that across the full sample of countries, both physical risk (represented by CO_2 emissions) and transition risk (indicated by low-carbon policy) contribute to an increase in sovereign borrowing costs. However, the magnitude and statistical significance of these effects exhibit variation across different income groups.

In Group L, which comprises the lowest income countries, the coefficients for CO_2 emissions per capita (8.845) and low-carbon policy (2.436) are statistically significant at the 0.1% level. This finding implies that higher emissions and greater policy stringency are associated with a substantial increase in sovereign borrowing costs. Notably, these coefficients are lower than those observed in Group M. Furthermore, the coefficient for GDP per capita is -7.151 ($p < 0.001$), indicating the strongest negative relationship among the three groups. This outcome suggests that, in the context of Group L, the influence of both carbon risks on sovereign bond spreads is significantly positive yet constrained, as countries in this group are more sensitive to macroeconomic factors like GDP. This aligns with Bingler's (2022) research, which posits that countries with lower credit ratings tend to be more responsive to macroeconomic indicators, resulting in a relatively limited reflection of climate-related factors.

In Group M, which represents the middle-income countries, both CO_2 emissions per capita (11.384, $p < 0.001$) and low-carbon policy (3.474, $p < 0.001$) exhibit large and statistically significant coefficients. These coefficients are the highest among all three groups, indicating that both physical risk and transition risk are substantially integrated into sovereign bond spreads within middle GDP countries. This finding aligns with existing theories regarding the vulnerabilities faced by middle-income nations. According to Foxley (2010), middle-income countries are particularly susceptible to both economic and social challenges. Furthermore, Aiyar et al. (2013) introduced the concept of the "Middle-Income Trap," which suggests that these economies often experience recurring growth slowdowns, rendering them especially vulnerable to external shocks. Thus, the strong relationship between carbon risks and sovereign bond spreads in Group M underscores the unique challenges that these countries encounter in the context of climate risk and economic stability.

In Group H, which consists of the highest income countries, the coefficient for CO_2 emissions per capita (3.990) is significant at the 1% level, although it is the smallest in magnitude among the three groups. In contrast, the low-carbon policy variable is not statistically significant. This outcome implies that financial markets have a high level of confidence in the fiscal capacities and policy responsiveness of these countries. This observation is consistent with the findings of Anyfantaki et al. (2025), who argue that the impact of CO_2 emissions on sovereign bond yields is more pronounced in emerging and developing economies than in high-income countries. The lack of statistical significance for the low-carbon policy variable suggests that simply implementing policies is inadequate to change market perceptions of risk.

To further validate the robustness of the findings, the study replaces the transition risk variable (low-carbon policy) with the World Bank's Regulatory Indicators for Sustainable Energy (RISE). The RISE serves as an index framework developed by the World Bank to evaluate and compare countries' sustainable energy policies and regulatory environments. In this analysis, the sub-index "Renewable Energy – Governance" from RISE is utilized.

Table 5 demonstrates that the results remain qualitatively consistent with those in Table 4. Both CO_2 emissions (reflecting physical risk) and RISE (representing transition risk) exhibit a significantly positive relationship. Group M once again reports the largest coefficients for both variables, while transition risk shows no significant association in Group H, reaffirming the patterns observed in the initial analysis.

Table 6 presents the results categorized by GDP per capita levels as classified by the World Bank. The majority of countries in the sample fall into the high-income category, leading to statistically significant results exclusively within this group. Conversely, countries classified as low-, lower-middle-, and upper-middle-income do not demonstrate statistically meaningful results. This observation suggests that relying solely on the World Bank's classification to assess development levels could be misleading, as it overlooks the complexities and variances in the relationships between climate risks and sovereign bond risk premiums across different income categories. The implications of these findings highlight the need for a nuanced understanding of how income classifications impact the assessment of climate-related financial risks..

6. Conclusion

Both high current emissions and active low carbon transition policies can raise sovereign spreads because investors see higher risk to growth, fiscal stability, and policy predictability in these situations, and those channels are especially fragile in middle income countries. Middle-income countries are often more reliant on carbon-intensive production and natural resource rents, and less diversified into high-productivity, low-carbon sectors, so climate policies or external demand shifts hit growth and exports harder. At the same time, they typically have shallower financial markets, higher initial debt ratios, and weaker institutions, which make investors more sensitive to any shock that could worsen debt dynamics, magnifying the impact of both emissions-related physical risk and transition policies on spreads

This study offers important policy implications regarding how carbon risks can be utilized to manage borrowing costs in accordance with national income levels. Both physical and transition risks demonstrate statistically significant and positive effects on bond spreads. Notably, the most substantial impacts are observed in middle-income countries, indicating that their heightened sensitivity to physical risks underscores the necessity for the establishment of stable and predictable carbon emission reduction policies. Such policies can help ensure consistency and build credibility among investors and financial markets.

However, this study has certain limitations. The proxies utilized for measuring physical and transition risks do not fully capture their multidimensional and complex nature. Due to constraints on the availability of time series data, the study relied on indicators covering the broadest possible range of countries and years. Future research could benefit from integrating multiple indices or developing composite measures that more accurately reflect the intricacies of carbon risks. Additionally, incorporating trend-based analyses would enhance understanding. Investigating how the effects of carbon risks on sovereign bond yields have evolved over time—particularly during periods characterized by stronger climate policies, technological advancements, or heightened international cooperation—would yield valuable insights for future studies.

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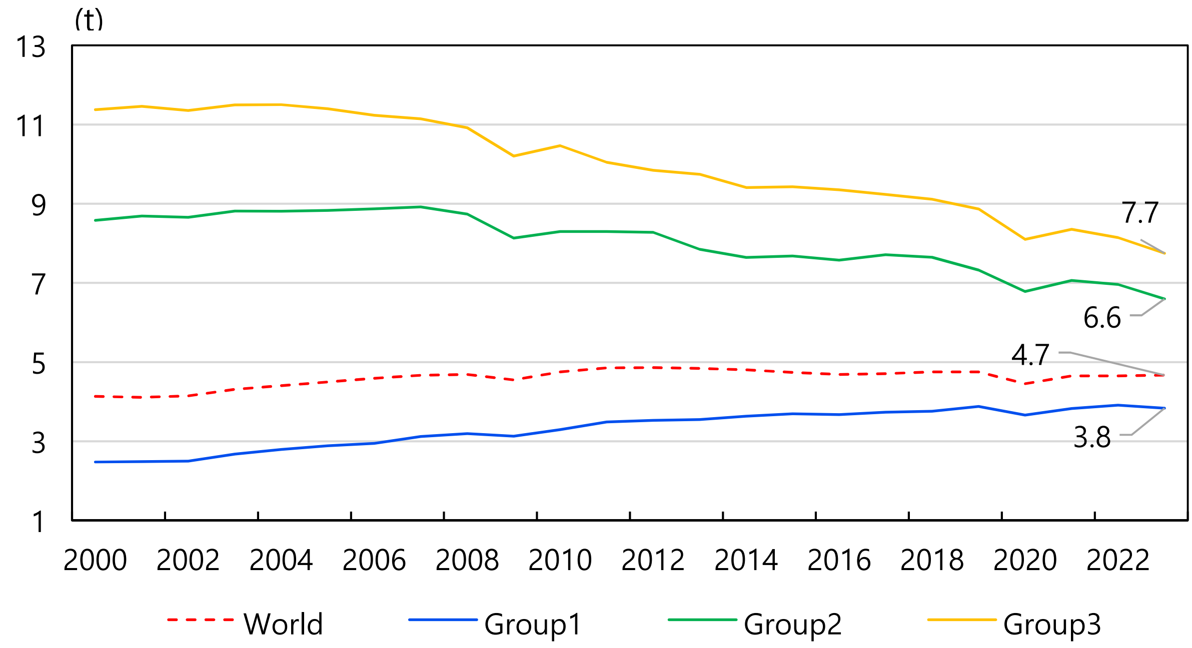

Figure 1. Physical risk

Notes: Physical risk is measured by Average CO_2 Emissions per Capita (t). It is important to note that the world average includes numerous low-income countries that are not part of the sample, which may affect the overall representation of carbon emissions and their impact on sovereign bond risk premiums in the analyzed countries.

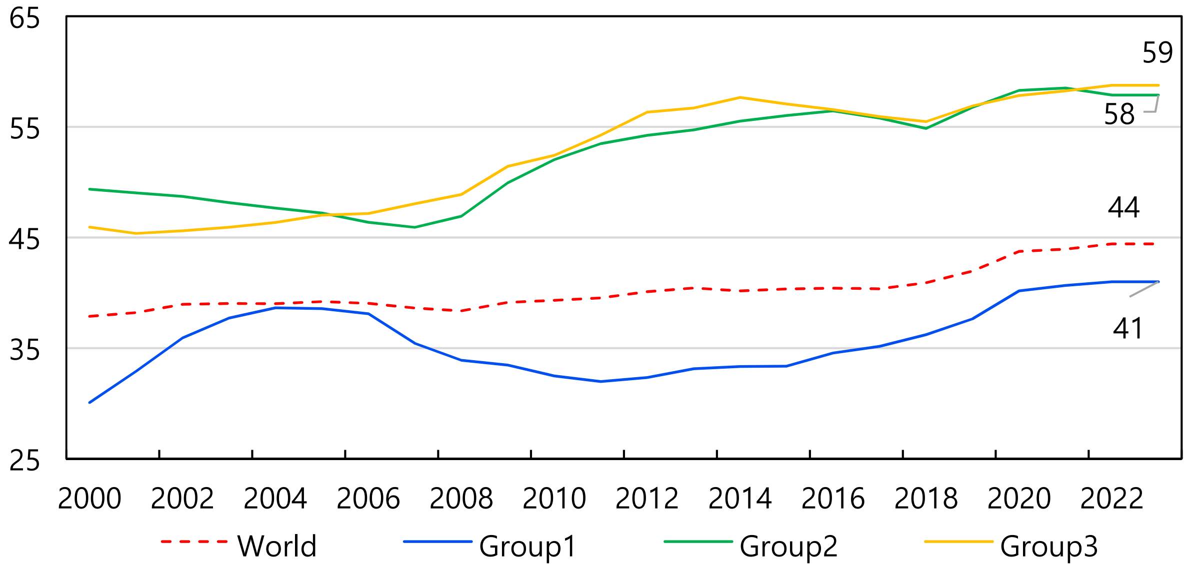

Figure 2. Transition risk

Notes: Transition risk is measured by the Low-Carbon Policy Index. It is crucial to acknowledge that the world average includes many low-income countries that are not part of the sample, which may influence the overall assessment of low-carbon policies and their impact on sovereign bond risk premiums in the countries included in the analysis.

Table 1. Summary of Literature

Authors (year of publication)	Title	Methodology	Dependent Variable	Independent Variables	Key Findings
Capelle-Blancard et al. (2019)	Sovereign bond yield spreads and sustainability: An empirical analysis of OECD countries	Dynamic panel model	Sovereign bond yield spreads	ESGGI (overall ESG index) and sub-indexes: • GOVI (governance index) • SODI (social development index) • ENVI (environmental quality index)	• Countries with higher ESG performance face lower sovereign bond yield spreads. • Governance and social factors drive this effect; the environmental pillar shows no significant impact. • ESG factors matter more in euro-area countries and especially after the Global Financial Crisis.
Battiston& Monasterolo (2020)	The Climate Spread of Sovereign Bonds	CLIMAFIN Framework (Stress testing)	10-year sovereign bond yields and spreads	• Changes in country-specific energy mix • Share of low-carbon sectors • Climate policy scenarios Market share shocks	• Countries transitioning to a low-carbon economy experience a decrease in sovereign bond yields. • Fossil-fuel-dependent countries see an increase in sovereign bond spreads when implementing climate policies (positive climate spread).
Cevik & Jalles (2020)	This Changes Everything: Climate Shocks and Sovereign Bonds	Fixed Effects Panel Regression	10-year sovereign bond yields and spreads	• Climate change vulnerability index (ND-GAIN) • Climate change resilience • index (ND-GAIN)	• Climate change vulnerability is positively correlated with sovereign bond spreads. • Climate change resilience is negatively correlated with sovereign bond spreads. • These effects are more pronounced in developing countries.

Authors (year of publication)	Title	Methodology	Dependent Variable	Independent Variables	Key Findings
Semet et al. (2021)	ESG and Sovereign Risk: What is Priced in by the Bond Market and Credit Rating Agencies?	Lasso Regression	10-year sovereign bond spread	• ESG indicators	• ESG factors have a significant impact on both sovereign bond spreads and credit ratings. • In high-income countries, governance (G) is key, while in middle-income countries, social (S) factors matter more; environmental (E) factors remain underweighted in credit ratings.
Fodha et al. (2021)	On Stranded Assets and Climate Risk: Are Financial Markets the Last Resort?	Fixed Effects Panel Regression	• Sovereign risk premium (measured as lending rate – treasury bill rate) • Average cost of debt • Sovereign External Default	• Natural resources (Minerals, fossil fuels) • Environmental variables (CO_2 emissions, greenhouse gas emissions, Environmental Performance Index (EPI))	• Fossil fuel wealth leads to an increase in the risk premium. • Higher CO_2 emissions per capita lead to higher borrowing costs. • The better the environmental quality (EPI, institutional factors), the lower the premium. • Better institutional quality leads to a decrease in the risk premium.
Bingler (2022)	Expect the worst, hope for the best: The valuation of climate risks and opportunities in sovereign bonds	Fixed Effects Panel Regression	5 and 10-year sovereign bond spread	• Physical risk: ND-GAIN exposure • Transition risk: CCPI national policy score • Innovation opportunity: Patent Asset Index for SDG 13, Patent Asset Index climate share	• Low-rated countries: Exposure to physical risks has a significant impact on raising long-term yields. • High-rated countries: Transition risks and innovation opportunity have a significant impact on lowering long-term yields. • Overall, low-rated countries are more sensitive to macroeconomic indicators, while their reflection of climate-related factors is relatively limited.

Authors (year of publication)	Title	Methodology	Dependent Variable	Independent Variables	Key Findings
Zhang (2022)	Are Investors Sensitive to Climate-Related Transition and Physical Risks? Evidence from global stock markets	• Textual analysis • Predictive regression	Firm return	Indices constructed through textual analysis of news articles - Transition risk - Physical risk	• Stock prices respond negatively to perceived changes in climate risk • "Green" ("Brown") firms are rewarded (penalised) by the market when climate risks increase • Firms in advanced economies show clear sensitivity to climate risks, whereas those in emerging markets display only weak or insignificant reactions.
Bolton & Kacpercxyk (2023)	Global Pricing of Carbon-Transition Risk	Fixed Effects Panel Regression	• Stock returns (by company) Sovereign bond spreads (by country)	• Carbon emissions • Emission growth rates • Country characteristics	• [Firm] Higher carbon emission and growth rates are associated with higher stock returns. • [Country] The premium on emissions growth is greater in countries with lower GDP per capita, higher dependence on manufacturing, and less inclusive political systems. • [Country] The premium on emission levels is higher in countries with stricter domestic climate policies.
Cheng et al. (2023)	Do green financial policies offset the climate transition risk penalty imposed on long-term sovereign bond yields?	Two-way Fixed Effects (country FE + year FE)	10-year sovereign bond yield	• Reversed Sustainable Development Index • CO_2 emissions per GDP	• Lower sustainability and higher CO_2 intensity are associated with higher sovereign bond yields. • This effect is particularly strong in countries without green financial policies. • Green policy adoption itself also helps reduce borrowing costs.

Authors (year of publication)	Title	Methodology	Dependent Variable	Independent Variables	Key Findings
Collender et al. (2023)	Climate Transition Risk in Sovereign Bond Markets	Fixed Effects Panel Regression	10-year sovereign bond yields and spreads	• CO_2 Emissions • Natural resource rents • Renewable energy consumption	• In developing economies, CO_2 emissions and renewables raise premiums, but resource rents lower them. • In advanced economies, CO_2 emissions and resource rents raise risk premiums, while renewables lower them.
Crifo et al. (2023)	The effect of countries' ESG ratings on their sovereign borrowing costs	Panel regression with country FE + year FE	• Sovereign bond yields (10-year)	• ESG rating (overall) + E, S, G pillar scores (Refinitiv)	• Better ESG ratings lower sovereign borrowing costs. • Governance and environmental scores drive the effect; social pillar is weak. • ESG matters more for **emerging markets**, where yields respond more strongly.
Barnett & Yannelis (2024)	Does Climate Change Impact Sovereign Bond Yields?	Cross-sectional regression	10-year sovereign bond spread	• Projected climate change damage (measured as a percentage reduction in GDP)	• Greater climate damage leads to higher long-term government bond yields. (No significant effect on short-term bonds) • 1%p GDP loss results in 10–17 basis points increase in long-term yields. • Effect has strengthened since 2010.

Authors (year of publication)	Title	Methodology	Dependent Variable	Independent Variables	Key Findings
Anyfantaki et al. (2025)	Decoding climate-related risks in sovereign bond pricing: a global perspective	Fixed Effects Panel Regression	10-year sovereign bond spread	• Transition risk: CO_2 emissions • Chronic physical risk: Average annual temperature change • Acute physical risk: Frequency and magnitude of climate-related natural disasters	• Increase in CO_2 emissions leads to a rise in sovereign bond yields (reflecting a transition risk premium), with the effect particularly strong in emerging and developing countries. • Chronic physical risk (temperature increase) does not have a statistically significant impact on sovereign bond yields. • Countries with high levels of debt tend to record higher sovereign yields as acute physical risk increases.
Kling (2025)	Climate Vulnerability and the cost of debt	Panel OLS	Sovereign bond yields	• NDS: Sensitivity Index (ND-GAIN) • NDC: Capacity Index (ND-GAIN) • NDSR: Social Readiness Index (ND-GAIN) • SCORE: PCA-based climate vulnerability index	• Climate vulnerability increases sovereign borrowing costs, with V20 countries paying about 1.17 percentage points more. • Social readiness lowers yields by roughly 0.67 percentage points.

Table 2. Group classification by GDP

Group L (Lowest GDP)		Group M (Middle GDP)		Group H (High GDP)	
Country	GDP per capita	Country	GDP per capita	Country	GDP per capita
India	5,486.5	Romania	26,951.0	Italy	50,425.7
Philippines	6,814.3	Poland	29,082.0	France	51,058.1
Vietnam	8,033.4	Hungary	30,368.2	Australia	52,223.9
Indonesia	9,434.5	Russia	32,392.9	Canada	52,874.5
China	11,526.2	Greece	34,813.7	Sweden	56,407.5
Peru	12,059.3	Portugal	36,865.7	Germany	56,986.2
Colombia	14,786.3	South Korea	38,078.7	Austria	60,437.5
Thailand	16,931.7	Israel	38,477.6	United States	62,314.2
Brazil	16,972.7	Czechia	41,427.8	Netherlands	62,878.4
Bulgaria	21,941.4	Japan	42,176.5	Ireland	73,469.0
Turkey	22,316.5	Spain	43,099.2	Switzerland	74,950.3
Chile	24,400.1	United Kingdom	50,173.5	Norway	84,718.1
Malaysia	24,694.4				

Note. Average GDP per capita in USD from 2000 to 2022

Table 3. Summary statistics

	No. of Sample	Mean	Sd	Min	Max
Sovereign Bond Risk Premium(%p)	716	1.381	3.000	-4.254	22.441
・Group L (Lowest GDP group)	225	3.688	3.236	-1.982	15.342
・Group M (Middle GDP group)	233	1.014	2.787	-4.254	22.441
・Group H (Highest GDP group)	258	-0.298	1.136	-2.937	7.176
CO_2 Emissions per capita <log>	716	1.777	0.725	-0.300	3.061
・Group L (Lowest GDP group)	225	1.027	0.688	-0.300	2.124
・Group M (Middle GDP group)	233	2.016	0.332	1.335	2.563
・Group H (Highest GDP group)	258	2.217	0.462	1.266	3.061
Low-Carbon Policy <log>	716	3.824	0.304	1.792	4.358
・Group L (Lowest GDP group)	225	3.536	0.342	1.792	4.179
・Group M (Middle GDP group)	233	3.949	0.186	3.444	4.358
・Group H (Highest GDP group)	258	3.961	0.133	3.661	4.227
Current Account (% of GDP)	716	0.388	5.260	-21.800	29.420
Government Debt (% of GDP)	716	64.529	42.056	4.916	258.369
GDP per capita <log>	716	10.393	0.708	8.039	11.736
GDP Growth (%)	716	2.203	3.444	-11.989	23.444
Inflation (%)	716	2.952	3.771	-4.448	72.309
Trade Openness (% of GDP)	716	79.804	43.132	19.560	250.108
Credit (Score)	716	13.765	6.312	1.000	21.000
No. of Sample	716				

Table 4. Regression Results

	Sovereign Bond Risk Premium (%p)			
	Total	Group L (Lowest)	Group M (Middle)	Group H (Highest)
CO_2 Emissions per capita <log>	5.622***	8.845***	11.384***	3.990***
	(0.554)	(1.937)	(1.095)	(0.767)
Low-Carbon Policy <log>	2.253***	2.436***	3.474***	1.193
	(0.428)	(0.753)	(0.957)	(0.836)
Current Account (% of GDP)	-0.022	-0.055	-0.139***	0.015
	(0.018)	(0.036)	(0.043)	(0.016)
Government Debt (% of GDP)	0.014***	0.019	0.025***	0.014***
	(0.004)	(0.015)	(0.006)	(0.005)
GDP per capita <log>	-4.275***	-7.151***	-0.934	-2.433**
	(0.420)	(1.384)	(0.931)	(0.955)
GDP Growth (%)	-0.155***	-0.081**	-0.244***	-0.097***
	(0.017)	(0.034)	(0.030)	(0.019)
Inflation (%)	0.176***	0.132***	0.280***	0.131***
	(0.018)	(0.024)	(0.045)	(0.031)
Trade Openness (% of GDP)	0.006	0.001	-0.014	-0.005
	(0.005)	(0.009)	(0.011)	(0.006)
Credit (Score)	-0.309***	0.144	-0.651***	-0.184***
	(0.033)	(0.088)	(0.051)	(0.057)
Constant	28.158***	58.003***	-27.327**	14.898
	(3.945)	(10.836)	(10.700)	(11.784)
No. of observations	716	225	233	258
R-squared	0.808	0.802	0.790	0.625
Adj. R-squared	0.795	0.781	0.770	0.593

Notes: Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5. Robustness Test Results

	Sovereign Bond Risk Premium (%p)			
	Total	Group L (Lowest)	Group M (Middle)	Group H (Highest)
CO_2 Emissions per capita <log>	5.956***	3.325	6.917***	2.731**
	(0.830)	(2.014)	(1.412)	(1.252)
RISE <log>	0.388**	0.758**	1.189***	-0.042
	(0.185)	(0.339)	(0.396)	(0.176)
Current Account (% of GDP)	-0.032	0.060	-0.163**	0.001
	(0.027)	(0.060)	(0.065)	(0.020)
Government Debt (% of GDP)	-0.030***	0.002	-0.057***	-0.006
	(0.008)	(0.018)	(0.016)	(0.009)
GDP per capita <log>	-3.892***	-5.694***	-5.937***	-5.147***
	(0.953)	(2.056)	(1.632)	(1.473)
GDP Growth (%)	-0.109***	0.008	-0.197***	-0.064***
	(0.022)	(0.036)	(0.038)	(0.023)
Inflation (%)	0.210***	0.069***	0.340***	0.261***
	(0.021)	(0.026)	(0.061)	(0.038)
Trade Openness (% of GDP)	-0.040***	0.005	-0.046***	-0.045***
	(0.010)	(0.017)	(0.017)	(0.013)
Credit (Score)	-0.497***	0.608***	-0.941***	0.037
	(0.070)	(0.142)	(0.094)	(0.100)
Constant	37.602***	50.873***	54.570***	50.249***
	(9.904)	(17.662)	(18.133)	(17.341)
No. of observations	426	129	146	151
R-squared	0.841	0.880	0.850	0.740
Adj. R-squared	0.822	0.856	0.826	0.700

Notes: Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6. Robustness Test Results (based on World Bank's income group classification)

	Sovereign Bond Risk Premium (%p)				
	Total	Low-income	Lower-middle-income	Upper-middle-income	High-income
CO_2 Emissions per capita <log>	5.622***	-61.738	6.779*	3.708*	8.160***
	(0.554)	(.)	(3.510)	(2.057)	(0.711)
Low-Carbon Policy <log>	2.253***	-60.328	0.432	1.243	2.905***
	(0.428)	(.)	(1.331)	(0.940)	(0.779)
Current Account (% of GDP)	-0.022	-1.211	-0.145*	0.009	-0.045**
	(0.018)	(.)	(0.079)	(0.039)	(0.021)
Government Debt (% of GDP)	0.014***	0.335	0.086***	-0.020	0.014***
	(0.004)	(.)	(0.028)	(0.022)	(0.004)
GDP per capita <log>	-4.275***	55.730	-8.404***	-1.292	-0.558
	(0.420)	(.)	(2.608)	(1.481)	(0.828)
GDP Growth (%)	-0.155***	-0.126	-0.065	-0.084**	-0.188***
	(0.017)	(.)	(0.070)	(0.038)	(0.019)
Inflation (%)	0.176***	0.000	0.102	0.127***	0.245***
	(0.018)	(.)	(0.099)	(0.024)	(0.031)
Trade Openness (% of GDP)	0.006	0.000	-0.007	-0.011	-0.012*
	(0.005)	(.)	(0.026)	(0.011)	(0.007)
Credit (Score)	-0.309***	0.000	0.104	-0.062	-0.525***
	(0.033)	(.)	(0.140)	(0.115)	(0.038)
Constant	28.158***	-269.836	61.111***	15.210	-16.926*
	(3.945)	(.)	(18.363)	(12.232)	(9.346)
No. of observations	716	7	79	164	466

Notes: Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$