Climate Shocks and Its Impact on Sovereign Bonds

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Abstract

How does Climate change affect Sovereign bonds? Which are the channels by which they are linked? There are many studies which suggest that at the time of disaster government debt increased by considerable figures. Also we see that there is ample amount of research studying the macroeconomic impact of climate change but there is little research when we talk about the Sovereign bonds and climate change. We can also see that climate change vulnerability in developing countries causes a high risk premium for their sovereign debt which reduces their funds to invest in climate change resilience. Climate change affects sovereign bond yields by separating countries into developed and developing countries. We will use the Time Varying Panel Data Model, applying a local least squares and principal component method to estimate the time-varying coefficients and factor loadings, along with the common factors that affect all units in the panel. Finally after interpreting the results obtained from this model, we will provide some policy insights.

With this study we have not only tried to capture the effect of climate change vulnerability and resilience on sovereign bond yields in 35 countries over the period 1995 2016, but also investigate the temporal variation in their effects. The main hypothesis is that the financial markets, when factoring climate risks into credit assessments, would demand higher interest rates from countries more susceptible to climate change impacts. Conversely, nations demonstrating greater resilience to climate disruptions are expected to experience lower borrowing costs. In my study I have found that the vulnerability and resilience have a significant impact on cost of sovereign borrowing, after controlling for the conventional determinants of sovereign risk

1. Introduction

Climate change refers to the average change in weather over a long period usually over 30 years and Sovereign bonds are the bonds issued by the governing body of a country to collect the funds for investing in various sectors of the economy for its sustainable growth and development. The consequences of climate change can be felt all over the world. But the extent to which a particular country is vulnerable to climate anomalies depends on the size and composition of its economy, capacity to adapt and the resilience of its institutions and physical infrastructure.

Development (2019) estimations for a group of 31 developing countries suggest that public debt-to-GDP ratios would have to rise from 47% to 185% to finance basic investments to meet the Sustainable Development Goals in poverty, nutrition, health, and education if these investments had to be financed through debt. There is a lot of literature stating that countries with earning dependent more on natural resources and renewable energy consumption are associated with high borrowing costs. Literature also indicates that there are significant negative effects of climate related shifts in the physical environment on economic growth. This study empirically establishes one such negative effect that is on sovereign borrowing cost. According to literature government bonds are exposed to both transition risk and physical risk related to climate change. The expenses related to nations making the shift to a greener economy mainly constitute the transition risk, as these expenses are majorly financed by the government. Physical climate risk, on the other hand, describes the harm and disruptions brought on by extreme weather conditions like heat waves, floods, and storms that have an immediate impact on the economy and sovereign debt. In this study we mainly focus on the countries' exposure to physical risks. By using a new dataset of climate change vulnerability and resilience created by the Notre Dame Global Adaptation Institute (ND-GAIN), we extend the conventional determinants of government bond yields and spreads to investigate the impact of climate change on the pricing of sovereign risk. The main policy takeaway from this study is that, despite the fact that climate change may not be stopped, governments may nevertheless strengthen economic resilience to withstand shocks and improve public financial management.

1. Hypothesis Design

The present study investigates the following objectives:

Objective 1: To empirically verify the negative effect of climate change on sovereign borrowing.

This objective aims to investigate and confirm the hypothesis that climate change has a detrimental impact on a country's ability to borrow money. Specifically, it involves analyzing how changes in climate-related factors—such as increased frequency and severity of natural disasters, rising temperatures, and sea-level rise—affect the cost of borrowing for sovereign states. This could include examining changes in bond yields in response to climate-related events. The research would involve collecting data on sovereign bond yields and climate change indicators over a specified period and using statistical methods to establish a causal relationship. By empirically verifying this effect, the study seeks to provide concrete evidence that climate change imposes financial costs on nations by making it more expensive for them to access capital markets.

Objective 2: To find the temporal variation of climate change's impact on sovereign debt.
This objective focuses on understanding how the impact of climate change on sovereign debt has evolved over time. It aims to identify whether the negative effects of climate change on borrowing costs have become more pronounced, remained constant, or fluctuated over different periods. This involves a detailed temporal analysis of sovereign debt data and climate change metrics from various timeframes. The study would look into specific periods to determine if there are patterns or trends, such as whether the impact was less significant in the early 2000s but grew stronger in the subsequent years. This analysis helps in understanding not only the current state of the relationship between climate change and sovereign debt but also how this relationship has developed and may continue to evolve. By doing so, the research can provide insights into the long-term financial risks posed by climate change to countries and help policymakers and investors make informed decisions.

3. Data Overview

The balanced panel dataset utilized in this study includes observations from 35 advanced and developing countries between 1995 and 2016. The dependent variable is government bond spread as measured by 10-year foreign-currency-denominated government bond spread vis-a-vis the U.S. benchmark. The major explanatory variables of importance are vulnerability and resilience to climate change, as evaluated by the ND-GAIN indices, which represent a country's overall susceptibility to climate-related disruptions and capability to deal with climate change repercussions, respectively. Figure 1 displays the temporal profile of the vulnerability and resilience indices for the full dataset

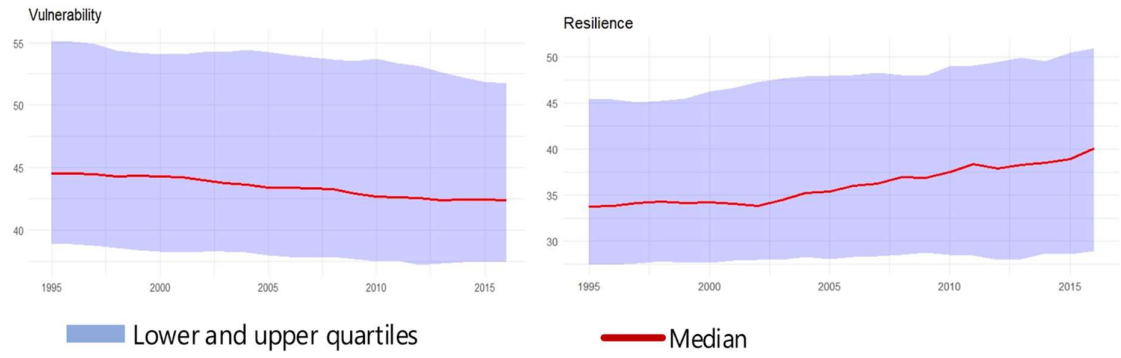

Figure 1: Graph of Vulnerability and Resilience over Time

It is apparent from statistics that vulnerability reduces over time. It also illustrates that resilience has increased over time, particularly since the early 2000s. It is worth noting that the vulnerability score is calculated using 36 factors, whereas the resilience score is calculated using 9 factors. In line with the previous research, we include a set of control variables, including the growth rate of real GDP, consumer price inflation, the public debt-to-GDP ratio, the budget balance-to-GDP ratio, international reserves as a share of GDP, bureaucratic quality, government effectiveness and terms of trade.

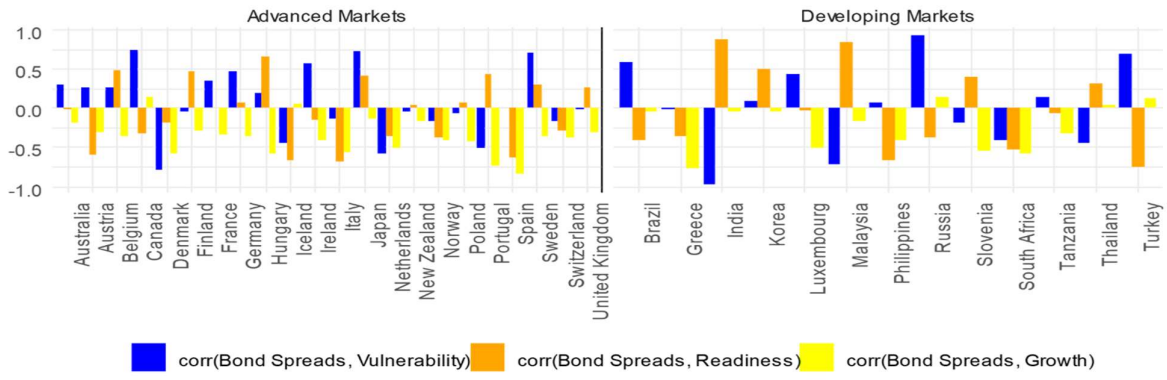

Figure 2: Correlation coefficients between bond spreads and three independent variables (vulnerability, readiness, and growth)

Advanced Countries

- **France** shows a strong positive correlation between bond spreads and growth. This implies that as economic growth increases, bond spreads in these countries also tend to increase. This can be indicative of investors demanding higher spreads for perceived higher risks associated with rapid growth.
- **Germany** and **Australia** also show a positive correlation, but it is less strong. This indicates a moderate relationship where bond spreads increase with growth.
- **Norway**, **Switzerland**, and **Sweden** exhibit a negative correlation between bond spreads and growth. This suggests that as economic growth improves, bond spreads decrease in these countries. This could be due to investors perceiving lower risk with better economic performance, thus demanding lower spreads.
- **Belgium** shows very low or near-zero correlation, indicating that economic growth has little to no impact on bond spreads in these markets.
- Similarly remaining countries tend to show variation in the direction and strength of growth correlations. This reflects differing economic structures, investor perceptions, and market dynamics.

Developing Countries

- **Malaysia** shows a positive correlation, suggesting that bond spreads increase with economic growth. This might reflect investor concerns about overheating economies or structural risks associated with rapid growth.
- **Philippines** and **India** also display a positive correlation, a bit weaker, indicating a modest increase in bond spreads with growth.
- **Brazil**, **Turkey**, and **Russia** show a negative correlation between bond spreads and growth, implying that as these economies grow, bond spreads decrease. This could indicate that investors see growth as a stabilizing factor, reducing perceived risk.
- **South Africa** also demonstrates a negative correlation, suggesting that improved economic growth is associated with lower bond spreads.
- **Thailand** shows low or neutral correlation, indicating minimal impact of economic growth on bond spreads.
- Rest of the countries also display diverse correlations, highlighting the varied economic conditions and risk perceptions across these countries.

4. Empirical strategy and results

First, we analyse the time series properties of data to avoid spurious result by conducting panel unit root test, for this we use the Im-Persaran-Shin (2003) procedure. The test results shows that bond spreads are stationary and climate indices become stationary after first differencing. To empirically evaluate the influence of climate change on sovereign bond spreads, we use a panel linear model with the following specification:

$$y_{it} = \beta_1 + \beta_2 y_{it-1} + \beta_3 \Delta vul_{it} + \beta_4 \Delta res_{it} + \beta_5 X_{i,t} + \eta_i + \mu_t + \varepsilon_{i,t}$$

The dependent variable is the bond spread in country i and time t and independent variables are vulnerability, resilience and other control variables. We have tried 7 different specification based on the inclusion of independent variables in the analysis. The results these 7 specifications are shown in the Table 1.

	Dependent variable:						
	Bond spread						
Specification	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Vulnerability		2.013***		1.616***	0.572***		0.326*
		(0.267)		(0.297)	(0.183)		(0.194)
Resilience			-0.421***	-0.234***		-0.219***	-0.188***
			(0.071)	(0.078)		(0.049)	(0.052)
Real GDP growth	-0.167***				-0.179***	-0.193***	-0.197***
	(0.035)				(0.035)	(0.035)	(0.035)
Inflation	0.387***				0.371***	0.369***	0.362***
	(0.026)				(0.027)	(0.026)	(0.026)
Debt	0.050***				0.052***	0.054***	0.055***
	(0.007)				(0.007)	(0.007)	(0.007)
Budget balance	0.041				0.039	0.043	0.041
	(0.038)				(0.038)	(0.038)	(0.038)
International reserves	-0.006				-0.005	-0.008	-0.007
	(0.015)				(0.015)	(0.015)	(0.015)
Bureaucratic quality	-0.792				-0.675	-0.240	-0.251
	(0.781)				(0.777)	(0.781)	(0.780)
Government effectiveness	-0.797				-0.589	-0.271	-0.227
	(0.710)				(0.709)	(0.711)	(0.711)
Terms of trade	0.006				0.014	0.011	0.015
	(0.011)				(0.011)	(0.011)	(0.011)
Note:							*p<0.1; **p<0.05; ***p<0.01

Table 1: Results of the fixed effect panel linear model

- As a baseline, we start with a specification that includes only macroeconomic and institutional variables, as shown in column (1) of Table 1. This serves as a point of reference for our analysis.
- In columns (2), (3), and (4), we present parsimonious specifications where we individually and jointly include climate change vulnerability and resilience as explanatory variables.
- In columns (5), (6), and (7), we introduce the climate variables alongside the macroeconomic variables.

- Across all specifications, the coefficient for climate change vulnerability ranges from 0.326 to 2.013. Importantly, it remains consistently positive and statistically significant. Similarly, the coefficient for resilience ranges from -0.421 to -0.188, consistently negative and statistically significant.

  These results support our hypothesis and consistent with the previous research

Then we apply the time varying panel linear model on the balanced panel dataset. The results of this analysis are specified in figure 3. It can be inferred from the results that the impact of vulnerability or resilience to climate change vary non-linearly over time. The effect of vulnerability and resilience (in terms of magnitude) decreases from 1996, having its minimum in 2004-05, and then increases from 2005 onwards.

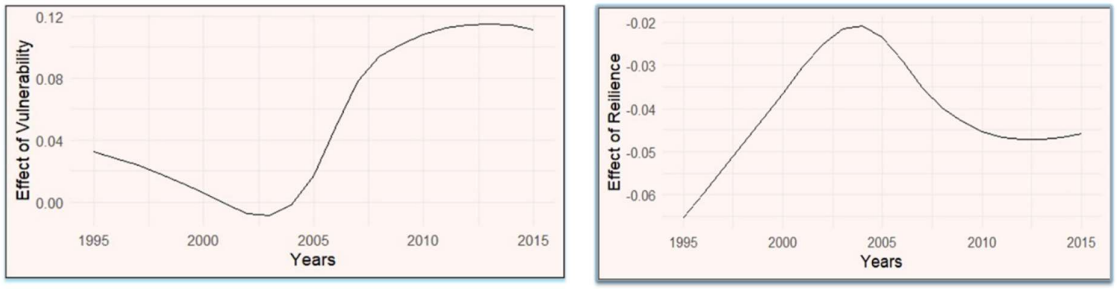

Figure 3: Results of the time-varying panel linear model

The Tvplm model specifications are as follow:

$$y_t = X_t\beta_t + \epsilon_t \quad \text{where} \quad \epsilon_t \sim N(0, \sigma^2)$$

where,

$$\beta_t = \beta_{t-1} + \eta_t \quad \text{where} \quad \eta_t \sim N(0, Q_t)$$

- y_t is the observed time series at time t.
- X_t is a vector of regressors at time t.
- β_t is a vector of time-varying coefficients.
- ϵ_t is the observation noise.
- η_t is the state noise.
- σ^2 is the variance of the observation noise.
- Q_t is the covariance matrix of the state noise.

Country Group Analysis

	vulnerability	readiness	growth	cpi	debt_gdp	OB_gdp	reserves	rqe	gee	tt
Developing	3.1042***	-0.542**	0.154**	0.87***	0.0921	-0.152*	10.2**	-1.786	2.294	0.011
	(1.107)	(0.124)	(0.021)	(0.314)	(0.034)	(0.042)	(0.102)	(0.134)	(1.542)	(0.034)
Advanced	-0.895	-0.532	0.244	0.182**	0.025	0.0383	-0.006	-0.619	0.109	-0.007
	(0.732)	(0.373)	(0.033)	(0.056)	(0.005)	(0.027)	(0.011)	(0.653)	(0.575)	(0.012)

Table 2: Results of Country Group the fixed effect panel linear model

Developing Countries

1. **vulnerability**: Positive and significant (3.1042, significant at 1%), indicating higher vulnerability is associated with the dependent variable.
2. **readiness**: Negative and significant (-0.542, significant at 5%), indicating readiness is inversely related to the dependent variable.
3. **growth**: Positive and significant (0.154, significant at 5%), indicating growth positively impacts the dependent variable.
4. **cpi**: Positive and significant (0.87, significant at 1%), indicating higher CPI is associated with an increase in the dependent variable.
5. **debt_gdp**: Positive but not significant (0.0921).
6. **OB_gdp**: Negative and significant (-0.152, significant at 10%), indicating that a higher overall balance-to-GDP ratio is associated with a decrease in the dependent variable.
7. **reserves**: Positive and significant (10.2, significant at 5%), indicating that higher reserves are associated with an increase in the dependent variable.
8. **rqe**: Negative but not significant (-1.786).
9. **gee**: Positive but not significant (2.294).
10. **tt**: Positive but not significant (0.011).

Advanced Countries

1. **vulnerability**: Negative but not significant (-0.895).
2. **readiness**: Negative but not significant (-0.532).
3. **growth**: Positive and significant (0.244, significant at 1%), indicating growth positively impacts the dependent variable.
4. **cpi**: Positive and significant (0.182, significant at 5%), indicating higher CPI is associated with an increase in the dependent variable.
5. **debt_gdp**: Positive but not significant (0.025).
6. **OB_gdp**: Positive but not significant (0.0383).
7. **reserves**: Negative but not significant (-0.006).
8. **rqe**: Negative but not significant (-0.619).
9. **gee**: Positive but not significant (0.109).
10. **tt**: Negative but not significant (-0.007).

Key Insights

- **Developing Countries**:
  - Vulnerability, growth, CPI, and reserves are significant positive predictors.
  - Readiness and overall balance-to-GDP ratio are significant negative predictors.
- **Advanced Countries**:
  - Growth and CPI are significant positive predictors.

- Other variables are not statistically significant in this model.

5. Conclusion

The fixed effect model indicates that as vulnerability to climate change increases bond spread also increases which means that vulnerability increases the cost of sovereign borrowing. Similarly, it also shows that as resilience to climate change increases bond spread decreases which indicates that resilience decreases the cost of sovereign borrowing. This study also verifies the significance of climate change variables in determining sovereign borrowing costs using a balanced panel dataset. This study utilizes the time-varying panel linear model to analyze the temporal dynamics of climate change vulnerability and resilience, providing insights into how their effects evolve over time. The time varying panel linear model indicates that the effect of climate change on sovereign borrowing cost is increasing from 2005 onwards.

Furthermore, dividing the sample into country groups reveals that the magnitude and statistical significance of these effects are much greater in developing countries with weaker capacity to adapt to and mitigate the consequences of climate change.

6. References

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