The Economic Consequences of Climate Change on Sovereign Debt

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-: Abstract :-

The emergence of climate change, driven by anthropogenic activities, now constitutes a major threat to the world economic landscape. A series of literature supports the notion that climate change slows economic development, posing significant challenges, particularly for developing nations. These countries, requiring substantial funds to develop infrastructure and other critical elements of economic growth, predominantly rely on sovereign borrowing.

This study investigates the influence of climate change on the cost of sovereign borrowing, recognizing that while climate change is a global phenomenon, the measures taken by individual countries to mitigate its effects vary significantly. To quantify each country's susceptibility to climate risks and their adaptive capacity, this study utilizes two indices: vulnerability and resilience. The analysis is based on a panel dataset comprising observations for 35 countries over the period 1995-2017, employing a panel linear model to discern the impact.

The results, after controlling for the conventional determinants of sovereign risk, indicate a significant effect of vulnerability and resilience on the cost of sovereign borrowing. Specifically, countries that exhibit higher vulnerability and lower resilience to climate-related shocks are found to incur higher interest rates on their sovereign debt compared to those with lower vulnerability and higher resilience. These findings empirically validate the literature suggesting the detrimental effect of climate change on economic development.

Furthermore, this study employs a time-varying panel linear model to examine the temporal variation in the effects of vulnerability and resilience. The results reveal that the impact of these indices varies non-linearly over time, reaching its minimum during the period 2004-05. This temporal analysis underscores the evolving nature of climate change's impact on sovereign borrowing costs and highlights critical periods where the influence is most pronounced.

In conclusion, the study provides robust evidence that climate change, through its differential effects on vulnerability and resilience, significantly affects the cost of sovereign borrowing. This has important implications for policymakers, suggesting that enhancing resilience and reducing vulnerability to climate-related risks can potentially mitigate the adverse economic impacts of climate change, thereby stabilizing the costs associated with sovereign debt.

-: Introduction :-

Climate risk refers to the investment risk predominantly caused by climatic calamities. These risks can significantly impact bond yields, and they are primarily categorized into two types: physical risk and transition risk. Physical risk pertains to the damage and disruptions brought on by extreme weather conditions, such as heat waves, floods, and storms. These events have an immediate impact on the economy and subsequently affect a country's ability to repay its debt. Transition risk, on the other hand, is related to the costs incurred by a nation transitioning to a greener economy. These expenses are often financed through sovereign debt, and the returns on these investments may not yield high returns initially.

The consequences of climate change are globally pervasive, but the degree of vulnerability and resilience to climatic anomalies varies significantly. This variability depends on factors such as the size and composition of economies, institutional quality, physical infrastructure, and the capacity for climate change adaptation. The literature extensively documents the negative impact of climate change on economic development. However, empirical evidence specifically linking climate change to the cost of sovereign borrowing is not as abundant. This study aims to address this gap by incorporating the vulnerability and resilience indices, developed by the Notre Dame Global Adaptation Institute (ND-GAIN), into the conventional determinants of sovereign bond yields.

In investigating the relationship between sovereign bond yields and the effects of climate change, this study connects several dots previously

explored in disparate strands of literature. Prior research has identified several determinants of bond yields and spreads, including the level and composition of sovereign debt, institutional quality, and other macroeconomic variables. Parallel research indicates that climate-related shocks impede economic development processes. However, the direct link between sovereign bond yields and climate change has not been rigorously examined due to a lack of comprehensive variables that measure the effects of climate change.

-: Data Overview :-

We have constructed a balanced panel dataset that contains observations for 35 countries over the period 1995-2016 for 11 variables, their definitions are given below:

- Bond spread: It is our only dependent variable, for calculating it we have used long term 10-year sovereign bond yield relative to that of U.S.
- Vulnerability: It refers to a country's exposure, sensitivity, and capacity to adapt to the impacts of climate change. This index comprises of six life supporting sectors – food, water, health, ecosystem services, human habitat and infrastructure.
- Resilience: It assesses a country's capacity to apply economic investments and convert them to adaptation actions and covers three areas – economic, governance and social readiness – with nine indicators.
- Inflation: In this study we have used consumer price inflation.
- Debt: This is the country's sovereign debt and to consider the size of economy we have taken it as the percentage of real GDP.
- Budget balance: It is the government budget balance as a percentage of real GDP.
- International reserves: It is the country's foreign currency reserve as a percentage of real GDP.

- Bureaucratic quality: It is an index that measures the quality of the country's bureaucratic system by considering indicators like rule of law, regulatory quality etc.
- Government effectiveness: It is an index that measures the quality of policy formulation and implementation, and the credibility of government's commitment to such policies.
- Terms of Trade: Terms of trade measure the relative prices of a country's average exports to its average imports. An improvement in terms of trade means that a country can buy more imports for a given quantity of exports.

We have used IMF's International Financial Statistics (IFS), World Economic Outlook (WEO), World Bank Development Indicators (WDI), ND-GAIN indices, and Federal Reserve Economic Data to construct our panel database.

The temporal variation of vulnerability and resilience is shown in figure 1.

-: Empirical strategy :-

First, we analyse the time-series properties of the data to avoid any spurious results by conducting panel unit root test. We use the Im-Persaran-Shin (2003) procedure to check the stationarity of all the variables which is widely used in the empirical literature to conduct panel unit root test. Its results indicate that the bond spreads are stationary and the vulnerability and resilience to climate change become stationary after first differencing. All the other variables are either stationary or become stationary after first differencing. Also, by using the Friedman's chi-square distributed statistic, we check for cross-sectional dependence and the results indicates the absence of any significant presence of cross-sectional correlation.

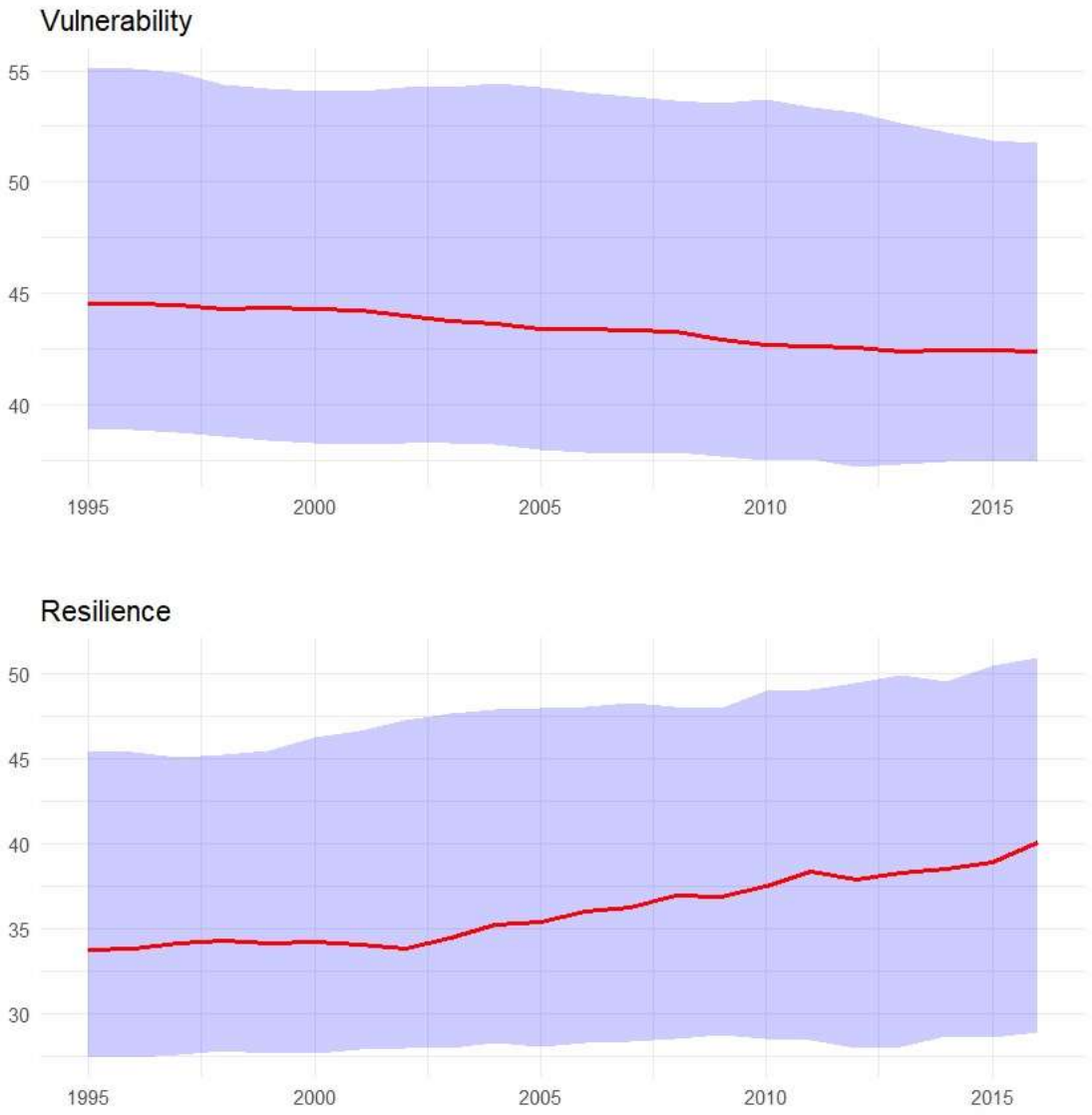

Figure 1

Fixed effect panel linear model:

To analyse the effect of vulnerability and resilience on bond spreads we use the fixed effect panel linear model. The specification of the model is given below:

$$Y_{it} = \beta_1 \Delta vul_{it} + \beta_2 \Delta res_{it} + \beta_3 X_{it} + \eta_i + \mu_t + \varepsilon_{it}$$

Y_{it} denotes the bond spread for country i in year t.

vul_{it} denotes vulnerability to climate change for country i in year t.

res_{it} denotes resilience to climate change for country i in year t.

Δ denotes the first difference operator.

X_{it} denotes the rest control variables.

η_i denotes the time-invariant country-specific effects.

μ_t denotes the time effects controlling for the common shocks that affect the financial condition across all countries.

ε_{it} denotes the idiosyncratic error term that satisfy the standard assumptions of zero mean and constant variance.

We have used this model for 7 different specifications and the results are shown in 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)
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)
BB	0.041				0.039	0.043	0.041
	(0.038)				(0.038)	(0.038)	(0.038)
IR	-0.006				-0.005	-0.008	-0.007
	(0.015)				(0.015)	(0.015)	(0.015)
BQ	-0.792				-0.675	-0.240	-0.251
	(0.781)				(0.777)	(0.781)	(0.780)
GE	-0.797				-0.589	-0.271	-0.227
	(0.710)				(0.709)	(0.711)	(0.711)
ToT	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

Time varying panel linear model:

To analyse the temporal variation of the effect of vulnerability and resilience on sovereign bond yields we use the time varying panel linear model on our balanced panel linear dataset. The results of this model are plotted in figure 3.

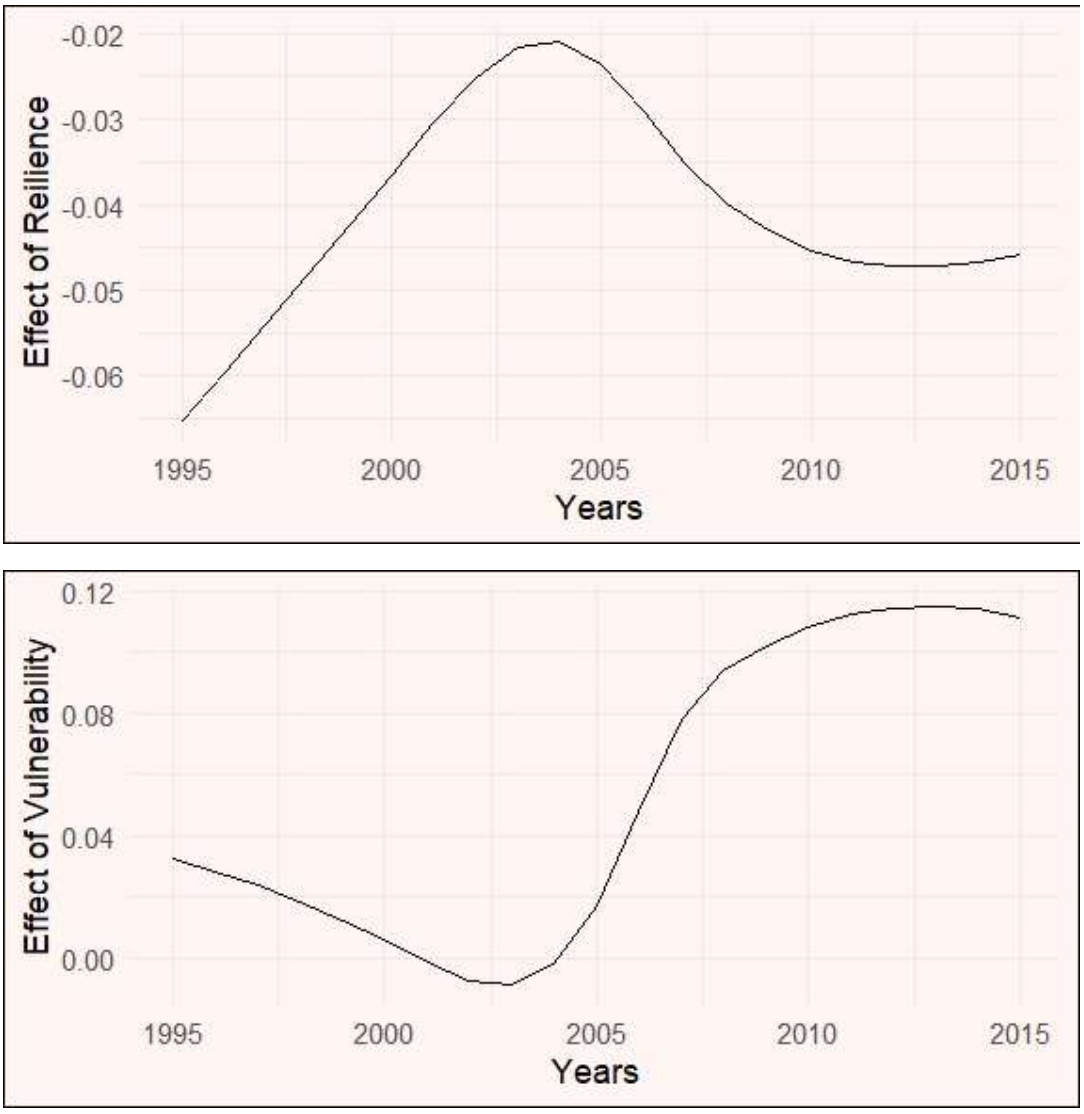

Figure 2

-: Inference :-

The following inference can be drawn from the results:

- 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 indicate a that resilience decreases the cost of sovereign borrowing.
- The time varying panel linear model indicates that the effect of climate change on sovereign borrowing cost is increasing from 2005 onwards.

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