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ABSTRACT: We study how sovereign bond markets respond to earthquakes in emerging markets, using data from 96 countries between 2012 and 2023. While earthquakes raise spreads on average, the effect depends critically on state capacity. In low-capacity countries, spreads rise sharply and persist; in high-capacity states, they remain stable or fall. These effects appear immediately, last several months, and are robust to multiple controls and placebo tests. Our findings suggest that markets interpret disasters not simply as economic shocks but as institutional stress tests, penalizing fragile states. Institutional quality, in this context, acts as disaster insurance.

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WORKING PAPERS

Earthquakes and Emerging Market Sovereign Bond Spreads

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1. Introduction

When a powerful earthquake strikes an emerging economy, two tremors unfold. The first is geophysical, rumbling through cities and supply chains; the second is financial, reverberating through global bond markets as investors hurriedly re-price sovereign risk. The macroeconomic cost of natural disasters has long been studied (Noy 2009; Cavallo et al. 2013; Raddatz 2009), with evidence showing that shocks can derail growth, widen fiscal deficits, and strain public institutions, especially in low-income countries. But what happens to a sovereign's cost of market finance when the ground moves beneath it? And why do the effects vary so dramatically?

While sovereign-debt theory makes a clear prediction, that any shock diminishing repayment capacity raises default risk (Eaton and Gersovitz 1981; Arellano 2008), empirical work on this specific mechanism is surprisingly sparse. Indeed, despite a rich literature on sovereign spread determinants, ranging from global "push" factors such as U.S. interest rates and global risk appetite to domestic "pull" factors like fiscal balance, debt structure, and economic growth (Edwards 1984; Eichengreen and Mody 1998; Longstaff et al. 2011), we lack systematic evidence on how acute, exogenous shocks like earthquakes translate into sovereign risk premia.

Recent contributions have begun to integrate climate vulnerability into sovereign risk pricing. Cevik and Jalles (2020) and Mallucci (2020) find that chronic exposure to climate hazards now carries a discernible spread penalty. Yet these studies focus on slow-moving, anticipatable risks, such as rising sea levels or temperature anomalies, not sudden-onset disasters. Case studies, such as Turkey's 1999 Marmara quake (Altug, Fazlioglu and Ozatay 2020), hint at potential market disruption, but cross-country analysis is lacking. Meanwhile, the role of institutional strength remains critically under-explored. Theoretical work (Besley and Persson 2011) and historical indices (O'Reilly and Murphy 2022) underscore that strong fiscal institutions reduce crisis vulnerability. But can such institutions actually reverse, not just attenuate, the market's response to a disaster?

This paper brings these strands together. Exploiting the quasi-random timing of large earthquakes, we assemble monthly data on sovereign bond spreads, seismic activity, and state capacity for 96 emerging-market countries from 2012 to 2023. Earthquakes offer a rare empirical advantage: they are exogenous to domestic policy and macroeconomic conditions yet can exert large fiscal shocks. We treat them as natural experiments, laboratory tests of how investors assess state resilience under pressure.

The results are both striking and asymmetrical. On average, earthquakes raise sovereign spreads. But disaggregating by institutional quality reveals a sharp divide. In countries with low state capacity, spreads rise sharply and persist. In countries with robust institutions, the same earthquakes have no effect or even reduce spreads. These patterns persist after controlling for macroeconomic fundamentals, global financial conditions, and using heterogeneity-robust difference-in-differences estimators (Sun and Abraham 2021; de Chaisemartin and d'Haultfoeuille 2020). Event-study plots reveal no pre-trends and strongly divergent post-shock dynamics.

These results revise the typical disaster narrative. Markets do not mechanically penalize quake-hit sovereigns. Instead, they parse the event through an institutional lens. Where tax systems are credible, bureaucracies competent, and relief swift, investors treat the quake as transitory, perhaps even as a precursor to reconstruction funding or multilateral support. But where state capacity is low, even moderate earthquakes cast doubt on debt sustainability. Earthquakes, in short, shake the ground everywhere, but they rattle bond markets only where fiscal foundations are already cracked.

Our findings make three key contributions. First, we add causal, cross-country evidence to the literature on disaster economics, showing how earthquakes affect sovereign finance in real time. Second, we advance the determinants literature by introducing rare shocks as dynamic inputs into sovereign pricing models. Third, we build on the growing work on state capacity by showing that institutional credibility does not merely moderate risk, it can invert the market's response to crisis.

These insights carry concrete policy implications. For countries, they underscore that investing in fiscal institutions is not just good governance, it is also risk management. For creditors, they suggest that sovereign risk models should integrate not just physical exposure but institutional resilience. And for multilateral lenders, they reveal a frontier: to structure assistance and conditionality not just around outcomes, but around state capability to withstand external shocks.

The remainder of the paper proceeds as follows. Section 2 reviews related literature. Section 3 describes the data and variable construction. Section 4 lays out the empirical strategy. Section 5 presents the main results, including robustness and dynamic analysis. Section 6 concludes with policy implications for disaster financing and sovereign debt architecture in a warming, risk-prone world.

2. Literature Review: Determinants of Sovereign Bond Spreads in Emerging Markets

A now-substantial literature decomposes the forces that move emerging-market sovereign spreads. Early theoretical contributions, including the Eaton and Gersovitz (1981) sovereign default framework and Arellano's (2008) quantitative model predict that spreads rise when adverse shocks impair a government's ability or willingness to repay. Initial empirical work emphasized macroeconomic fundamentals. Edwards (1984) linked higher spreads to weak fiscal and external positions; subsequent studies affirmed the roles of debt levels, inflation, output growth, and reserve adequacy. Over time, researchers incorporated global "push" factors, most notably U.S. interest rates, global risk appetite, and liquidity conditions, as dominant drivers of co-movements across emerging-market spreads (Eichengreen and Mody 1998; Longstaff et al. 2011). Although global drivers often dominate in periods of financial stress, domestic fundamentals and institutions remain central to explaining time-averaged spread levels and their responsiveness to external volatility. Countries with sound fiscal frameworks and stronger institutions face lower sovereign premia and reduced pass-through from global shocks (Ciocchini, Durbin and Ng 2003; Azzimonti and Mitra 2023).

Our paper extends this framework in two directions. First, we treat large earthquakes as exogenous macro-fiscal shocks and examine how markets price them relative to standard determinants. Second, we demonstrate that the market reaction is not uniform but conditional on institutional strength, proxied by state capacity, and can actually reverse the sign of the spread response. In this way, we integrate natural disaster shocks into the canonical sovereign-risk model and provide new evidence on how institutional capability mediates market perceptions of shock absorption and repayment credibility.

A. Economic Impacts of Natural Disasters

The economics of disasters have produced a robust consensus around the near-term macroeconomic costs of major natural catastrophes. Noy (2009) and Cavallo et al. (2013) find that disasters significantly depress GDP growth, particularly in countries with limited fiscal space or weak governance. Raddatz (2009) documents similar effects on industrial output, while Skidmore and Toya (2002) and Loayza et al. (2012) note that smaller or more frequent disasters may have less adverse, or even neutral, long-run effects due to capital deepening and reconstruction.

The fiscal channel is central. Major disasters raise expenditure demands while simultaneously compressing revenues, thereby worsening debt dynamics and constraining policy options. Klomp (2015) shows that catastrophic events systematically increase sovereign bond yields and credit default swap (CDS) spreads. Mallucci (2020), embedding rare disasters into a sovereign default model, finds that elevated disaster risk lowers sustainable debt limits and increases the likelihood of market exclusion.

Parallel to this, a growing climate-finance literature finds that sovereign risk premia reflect not only current economic fundamentals but also anticipated exposure to future climate shocks. Cevik and Jalles (2020) show that chronic vulnerability to climate change is priced into spreads, while Gomez-Gonzalez, Schmukler, and Burger (2024) report that resilience planning, such as early-warning systems and institutional preparedness, can offset these effects. On the other hand, Avila-Yiptong et al. (2025) pointed out that environmental, social and governance (ESG) factors matter for sovereign spreads.

Yet the empirical literature has said surprisingly little about acute, one-off shocks, particularly earthquakes. Most existing work aggregates multiple disaster types or examines single-country cases. A notable example is

Altug, Fazlioglu, and Ozatay (2020), who analyse Turkey's 1999 Marmara earthquake and find that bond markets penalized the government severely in its aftermath. But these idiosyncratic cases cannot speak to the cross-country heterogeneity that emerges when institutional capability varies.

Our contribution is to isolate the effect of earthquakes in a large, monthly panel of emerging markets. Earthquakes are analytically appealing, as they are exogenous, randomly timed, and geographically distinct, making them an ideal quasi-natural experiment for testing market responses to sudden fiscal shocks. By focusing on this specific disaster type, we avoid confounding effects associated with seasonal weather, storm forecasting, or policy anticipation, and we move beyond aggregate disaster indices to examine the shock most likely to trigger immediate, unplanned fiscal demands.

B. State Capacity and Sovereign Risk

An emerging strand in literature concerns state capacity, defined broadly as a government's ability to mobilize revenue, enforce laws, control territory, and deliver public goods. Besley and Persson (2011) developed a theoretical framework linking capacity to fiscal stability and development outcomes. O'Reilly and Murphy (2022) produced a long-run index of state capacity covering more than two centuries and show that high-capacity states achieve more stable fiscal and monetary outcomes over time.

Within the sovereign risk literature, stronger state capacity is associated with lower spreads, fewer defaults, and more counter-cyclical fiscal responses (Qian and Roch 2024). Ciocchini, Durbin, and Ng (2003) find that corruption raises bond spreads even after accounting for debt and growth dynamics. Azzimonti and Mitra (2023) show that institutional quality directly compresses risk premia and reduces financial volatility in crisis periods.

Yet in the context of natural disasters, the role of state capacity is still under-explored. Climate-finance studies suggest that institutional preparedness reduces the pricing of anticipated shocks (Cevik and Jalles 2020; Gomez-Gonzalez et al. 2024), but few have tested whether capacity can actually flip the sign of the market's reaction to a realized, acute disaster. Our paper fills this gap: we show that the same earthquake widens sovereign spreads in low-capacity states but narrows them in high-capacity ones. The mechanism is intuitive. Robust states can respond more credibly, access external support more rapidly, and inspire less panic from investors, but the cross-country empirical evidence has, until now, been missing.

Bringing these literatures together, our paper makes three contributions. First, we integrate rare natural shocks into the established determinants model of sovereign spreads, demonstrating that their effects are neither mechanical nor uniform. Second, we isolate the specific role of state capacity in mediating market responses to exogenous fiscal shocks. Third, we build a bridge between disaster economics and sovereign debt markets, showing that strong institutions not only reduce the cost of borrowing in steady-state, but also shape the trajectory of investor beliefs when crises hit.

Taken together, these findings imply that any forward-looking model of sovereign risk in a disaster-prone, climate-volatile world must account for not only the probability of external shocks, but the institutional capacity of the state to withstand and respond to them. Resilience is not just a fiscal or physical trait, it is also institutional. And for bond markets, that distinction is key.

3. Data

To investigate how earthquakes affect sovereign bond spreads and how this relationship depends on institutional quality, we assemble a panel dataset that merges high-frequency financial, geophysical, and institutional information for 96 emerging-market economies from January 2012 to November 2023. The dataset integrates four core blocks: sovereign spreads, earthquake activity, state capacity, and macro-financial controls. A detailed list of country coverage is provided in Annex [1], and summary statistics appear in Annex [2].

A. Sovereign Spread

Our measure of sovereign borrowing costs is the Weighted-Average Sovereign Spread (WASS), compiled from Bloomberg's Back Office platform. The construction follows strict inclusion criteria to ensure liquidity and legal comparability: bonds must be denominated in U.S. dollars or euros, issued under foreign (UK or New York) or euro-area law, and have a minimum size of USD/EUR 250 million. Bullet bonds are required to have at least one year of remaining maturity, while amortizing structures require eighteen months. Spreads are computed relative to the U.S. Treasury or German Bund curve, depending on the currency of issuance.[1] These base curves are smoothed using the most liquid recent benchmarks and capped at a fifteen-year maturity horizon. The resulting sovereign spread aggregates are weighted by par value and computed monthly, resulting in a balanced series that reflects market pricing for tradable debt instruments. The average spread across our panel is 403 basis points, but distributional tails are long, with some crisis-episode observations exceeding 14,000 basis points.

B. The State Capacity and External Debt

O'Reilly and Murphy (2022) introduce a detailed state capacity measure, which they define as a government's ability to effectively collect revenue, maintain control over violence, deliver public goods, and enforce law.[2] The

[1] The dataset contains a total of 11,799 data points.
[2] See https://colinworeilly.com/state-capacity-index/

index assesses the impartial and strict enforcement of laws, control over its territory, and the efficiency of public administration. Additionally, it looks at how public funds are spent on general goods versus specific interests and evaluates the modernity and efficiency of revenue sources. The annual data covers the period from 1789 to 2018, facilitating a long-term study of state capacity. We also collect data on short-term external debt from the World Development Indicator (WDI).[3]

C. Earthquake Disasters

The data was collected daily from *National Earthquake Hazards Reduction Program (NEHRP)[4]*, covering 1,667,000 events from January 2012 to November 2023. The highest recorded Richter magnitude is 8.6. The recorded earthquake events were recorded by longitude and latitude and then merged with the corresponding country locations. The total number of earthquake events merged from the National Earthquake Hazards Reduction Program dataset with corresponding locations in 96 countries from the Spread dataset is 44,089 events.

We then proceed to measure in a specific month of the year for a given country, two main indicators that reflect earthquake activity: (i) a dummy indicator if an earthquake occurred in that month, and (ii) the intensity, which is the average magnitude of earthquakes in that month. Thus, the final dataset contains information on (i) whether an earthquake occurred in country c (among the 96 countries listed in the Annex [1]) during the corresponding month m, and (ii) the average magnitude of the earthquakes. The data covers from January 2012 to November 2023 (the period for which spread data is available).

Additionally, we collect data from various other sources, including (1) GDP per capita (PPP, constant 2021 international dollars) from World Development Indicators and (2) banking system crises as proposed by Laeven and Valencia (2020).[5] According to this, a banking crisis (represented as a dummy variable) can be characterized as an event that satisfies two criteria: a manifestation of financial distress within the banking sector, demonstrated by substantial bank runs, losses in the banking system, and/or bank liquidations; along with substantial policy interventions by banking authorities in response to significant losses within the banking system. The data details are described in Annex [2]. Short-term debt is particularly relevant, as countries with high near-term refinancing needs may face sharper market reactions after an exogenous shock. The crisis dummy captures months during which domestic financial systems experience acute distress, such as bank runs, large-scale insolvencies, or government bailouts, events that are known to compound sovereign risk.

After merging the four data blocks, we retain 11,389 complete country-month observations, approximately 97 percent of the theoretical maximum. Missing variables are limited and primarily driven by gaps in short-term

[3] https://databank.worldbank.org/source/world-development-indicators#
[4] https://earthquake.usgs.gov/earthquakes/search/
[5] https://www.imf.org/en/Publications/WP/Issues/2018/09/14/Systemic-Banking-Crises-Revisited-46232

debt reporting among low-income countries. Results are robust to excluding these controls or imputing missing values with country-specific averages.

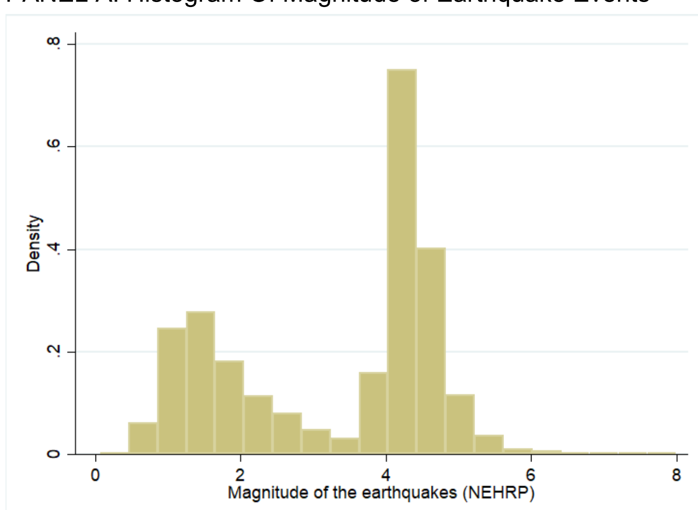
The descriptive statistics confirm the empirical salience of our variables. Earthquakes are rare but not negligible: roughly 28 percent of country-months experience at least one seismic event. Most of these are mild, but the upper tail includes several magnitude-6 or higher events. Spreads are volatile and skewed, with the interquartile range stretching from 64 to 410 basis points in general. State capacity is similarly dispersed, with a majority of countries clustering near the global mean, but with meaningful representation in both tails (see Figure 1). Figure 2 maps the earthquake frequency and reveals its potential to condition market responses to external shocks.

Taken together, these data provide a rich setting for evaluating whether and how sovereign bond markets react to earthquakes and more importantly, whether those reactions depend on the perceived quality of the state that must respond.

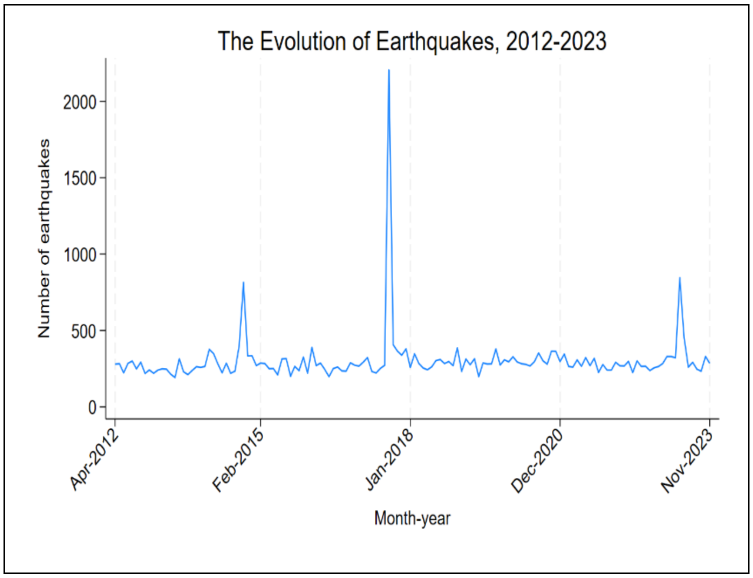
The next section introduces our empirical framework to test whether sovereign spreads react systematically to earthquakes and whether that response depends on the state's capacity to manage the fallout.

Figure 1. Histogram of Magnitude and Evolution of Earthquakes

PANEL A: Histogram Of Magnitude of Earthquake Events

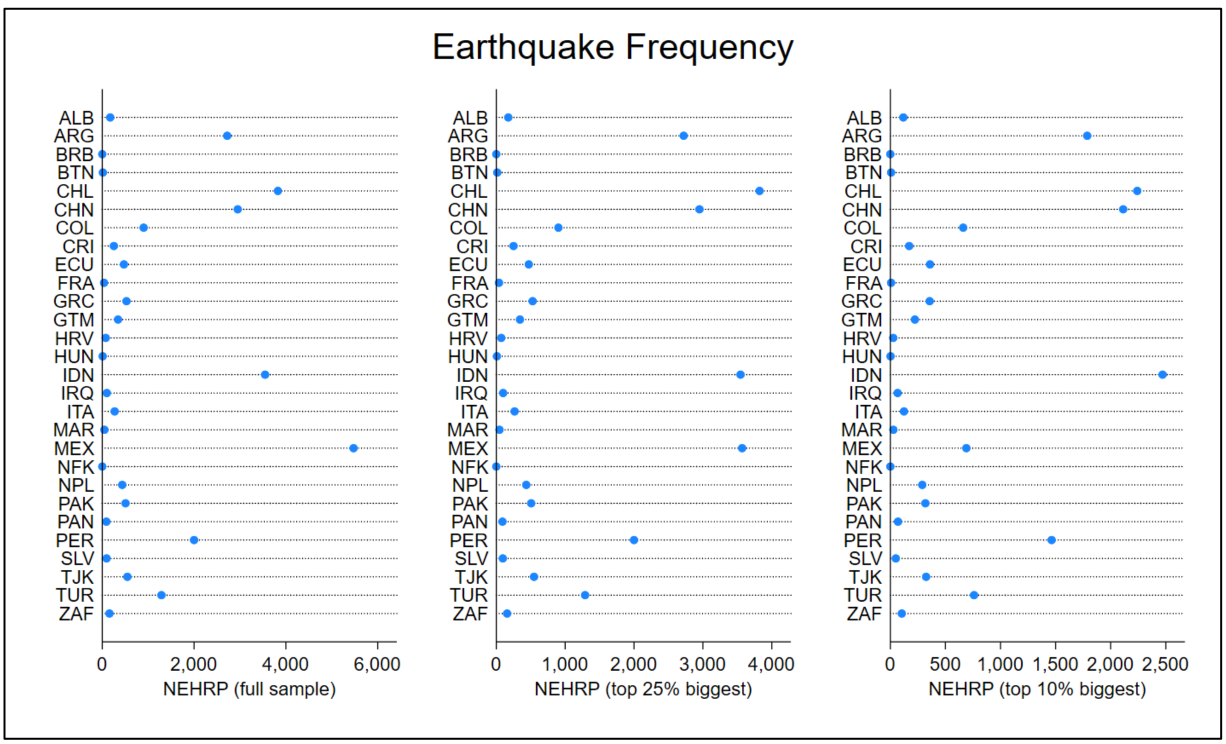


Panel B: Evolution of The Earthquake (Monthly Frequency)



Source: Authors. *Note: Given the 96 countries in Annex [1], the total number of earthquake events recorded from the NEHRP data is 44,089 events.*

Figure 2. Earthquake Frequency by Country



Source: Authors. Note: The top 10% (res 25%) of earthquakes with the largest magnitudes in the NEHRP data set include those with a Richter scale magnitude of 4.2 (res 2.14) or higher.

4. Estimation Strategy

A. Benchmark regression

The timing and intensity of natural disasters are arguably exogenous shocks which facilitate the exploration of the causal effect of these shocks on the economy. Earthquakes, in particular, offer an almost ideal identification setting: they arrive without warning, are unrelated to domestic economic policy or political cycles, and vary in timing and magnitude across space.[6] Yet while their physical characteristics are random, their financial consequences are anything but, as investors' reactions depend critically on the state's fiscal capacity, institutional quality, and access to external resources. What markets care about is not the quake *per se*, but the state's perceived ability to absorb it. Our estimation strategy leverages this contrast between the exogeneity of the shock and the endogeneity of the response, to assess how sovereign spreads react to earthquakes, and whether that reaction is conditioned by institutional strength.

We begin with a panel difference-in-differences (DiD) framework at the monthly frequency:

$$\Delta Spread_{c,m} = \alpha_i + \tau Spread_{c,m-1} + \beta Earthquake_{c,m-s} + \lambda_m + \delta_{season} + \varepsilon_{c,m} \tag{1}$$

Where $\Delta spread_{c,m}$ denotes the sovereign spread of country *c* in month *m*, measured as the weighted average yield premium over U.S. Treasuries or German Bunds.

The coefficient of interest we are focusing on is β, which is reasonably expected to be positive. The earthquake variables include both a binary indicator ($Earthquake_{c,m-s}$) and a continuous intensity measure ($Intensity_{c,m-s}$) based on the average Richter magnitude in that month. The lag in the impact of earthquakes on spreads is captured by s, where $s = 1$ signifies a one-month delay. The effect of earthquakes on spreads may be mitigated by a country's level of resilience. α_i, λ_m, and δ_{season} represent country-fixed effects, month-fixed effects, and seasonal-fixed effects, respectively. Month-fixed effects are ordered chronologically from January 2012 ($= 1$) to November 2023 ($= 140$). Due to the control of multi-dimensional fixed-effects, the estimation used is a high-dimensional fixed-effect estimator for benchmark regression (Correia, 2017).

While this baseline specification isolates the average effect of earthquakes, it implicitly assumes that all countries respond similarly, an assumption our data strongly reject. To account for heterogeneity in institutional resilience, we extend the model by interacting earthquake exposure with the O'Reilly–Murphy (2022) index of state capacity:

[6] Further, we account for the predictability of earthquakes including stemming from aftershocks.

$$\Delta Spread_{c,m} = \alpha_i + \tau Spread_{c,m-1} + \beta Earthquake_{c,m-s} + \delta Earthquake_{c,m-s} \times \overline{SC} + \lambda_m + \delta_{season} + \varepsilon_{c,m} \tag{2}$$

$\overline{SC}$ represents the averaged value of state capacity. For the extension, we also consider the moderating effect of external debt in the relationship as follows.

$$\Delta Spread_{c,m} = \alpha_i + \tau Spread_{c,m-1} + \beta Earthquake_{c,m-s} + \delta Earthquake_{c,m-s} \times \overline{DEBT} + \lambda_m + \delta_{season} + \varepsilon_{c,m} \tag{2.1}$$

$\overline{DEBT}$ corresponds to the average value of short-term external debt over GDP for the entire period.

B. Unanticipated shock measurement

One might consider the public's expectation of earthquakes, which refers to their knowledge of likely events during certain times of the year. For example, in Japan, earthquakes are commonly expected in March or August (Heki, 2003), allowing for the prediction of their effects. Therefore, we assess a variable that represents either the occurrence or intensity of an earthquake while taking into consideration factors that can predict such events:

$$\mathrm{EQ}_{\mathrm{c,y,m}} = \gamma \mathrm{EQ}_{\mathrm{c,y,m-1}} + \lambda_m + \delta_{season} + \alpha_i + \varepsilon_{\mathrm{c,y,m}} \tag{*}$$

where $EQ_{c,y,m}$ is a dummy variable that indicates either the occurrence or intensity of an earthquake in country c during year y and month m. $\varepsilon_{c,y,m}$ represents the component that captures the absence of anticipation for earthquake events, allowing us to use this indicator to denote earthquakes that occur without anticipation (Kent and Cashin, 2003).

C. Heterogeneity-Robust Difference-in-Differences

Superior to traditional Difference-in-Differences (DID) models, which generally assume homogeneous treatment effects and rely on parallel trends, our study utilizes the methodology developed by De Chaisemartin and d'Haultfoeuille (2020, 2023). This advanced model is designed to handle heterogeneous treatment effects across both temporal and geographical dimensions, thereby enhancing its robustness against deviations from the assumed parallel trends.

In our specific application, we have integrated several key features that enhance the methodological rigor of our analysis:[7] (i) we assess the impact of the treatment across six post-treatment periods (*effects(6)*), and (ii) we examine data from three pre-treatment periods (*placebo(3)*) to validate the parallel trends assumption. By

[7] $Setup$: $did\_multiplegt\_dyn\ outcome\ ID\ time\ Treatment,\ effects(6)\ placebo(3)\ \ switchers(in)\ \ controls(Z)\ trends\_lin$

distinguishing between these impacts, we can more accurately determine causal relationships, focusing our analysis on capturing the causal effects on the former group (*switchers in*) rather than the latter (*switchers out*). Moreover, to further strengthen the causal inference of our study, we incorporate control variables such as state capacity (*controls(Z)*) and linear time trends (*trends_lin*). These additions help to mitigate confounding factors and account for temporal variations, making our methodology particularly effective in dynamic and heterogeneous settings.

D. Local Projections DID

We also utilize the Local Projections Difference-in-Differences (LP-DiD) approach, as developed by Dube et al. (2023), which offers a solid framework for mitigating the typical biases associated with negative weighting in conventional Difference-in-Differences (DiD) analyses. This innovative method increases the flexibility in defining treated and control groups and is particularly effective in contexts with dynamic effects and staggered treatment adoption. Furthermore, LP-DiD streamlines the implementation process, enhances computational efficiency, and provides robust estimations, proving to be an essential tool for researchers seeking precise causal inference in intricate scenarios. Our estimation is conducted as follows.[8]

$$\begin{aligned} \Delta_h\, Change\ in\ Spread_{c,m} = EQ_{c,m+h} - EQ_{c,m-1} = \beta^{h\ LP-DiD}\Delta EQ_{c,m} &\quad \text{\} treatment indicator} \\ + \gamma_m^h &\quad \text{\} time effects} \\ + \varepsilon_{c,m}^h \quad , &\quad \text{for } h = 0, \dots, 6 \end{aligned}$$

limiting the sample to observations that are either:

$$\begin{cases} newly\ treated & \Delta EQ_{c,m} = 1, \\ or\ clean\ control & EQ_{c,p+h} = 0 \end{cases} \qquad (3)$$

Here, the estimates are examined monthly (from January 2012 to November 2023) across country units c and time periods $m = 1, \dots, T$. The term $\Delta_h Change\ in\ spread_{c,p}$ represents the difference of sovereign spread changes over h future periods. Units undergo a binary treatment as indicated by the variable $EQ_{c,m}$, which is assigned a value of 0 or 1 (if an earthquake occurs in the corresponding month). γ_m indicates time-specific effects. The term h refers to the time horizon, with $h = 0$ corresponding directly to a first-difference regression, commonly used in Difference-in-Differences (DiD) analyses. ε symbolizes the error term. To allocate weights to each cohort-specific effect, we employ a re-weighted LP-DiD regression approach (‘rw’) rather than using an equally-weighted average treatment effect on the treated (Dube et al., 2023).

[8] $In\ Stata$: $lpdid\ change\_spread, time(cmonth)\ unit(ID)\ treat(treat)\ pre(3)\ post(6)\ rw$

All regressions use heteroskedasticity-robust standard errors clustered at the country level. In robustness checks, we also test clustering by region and employ Conley-type spatial autocorrelation corrections (Cameron & Miller, 2015). These exercises confirm that inference remains valid under plausible correlation structures.

In sum, our estimation framework is designed to leverage the exogeneity of earthquakes while allowing for rich institutional heterogeneity in the market response. It combines high-frequency identification with institutional structure, enabling us to answer a question at the heart of the paper: When disaster strikes, do markets panic, or do they trust the state to cope?

The next section presents the empirical results and documents the asymmetric spread responses that emerge depending on the state's capacity to act.

5. Main Results

We now turn to the central question of the paper: how do sovereign spreads respond to earthquakes, and how does that response vary with state capacity? The analysis proceeds in five parts. First, we estimate the average effect of earthquakes on spreads across the entire sample. Second, we examine whether institutional quality conditions the market response. Third, we test for nonlinearities in this interaction. Fourth, we estimate dynamic treatment effects to assess timing and persistence. Finally, we subject the findings to a battery of robustness checks.

A. Benchmark Results

Table 1 presents the core benchmark estimates. The results show that sovereign spreads tend to rise in the aftermath of earthquakes, but the effect is not immediate. The coefficients on earthquake dummies one month prior to the observed spread (m–1) and three months prior (m–3) are small and statistically insignificant. The effect materializes two months after the earthquake (m–2), with a coefficient of approximately 9 basis points, significant at the 5 percent level. This lagged reaction aligns with the typical time frame in which fiscal implications of a disaster become apparent. Relief expenditures, borrowing needs, or political instability may only emerge with a delay.

The results using intensity (Columns 4–6) mirror this pattern. Each unit increase in average earthquake magnitude two months prior is associated with a spread increase of approximately 2.3–2.4 basis points, again statistically significant. These results underscore a key point: markets do not mechanically price earthquakes immediately but rather respond after observing how the shock unfolds fiscally and politically.

This is consistent with the theoretical intuition of Eaton and Gersovitz (1981) and Arellano (2008), where default risk rises not from the shock itself, but from the erosion of repayment capacity. Disasters are fiscal in nature, but it is their interaction with the institutional response that ultimately matters.

Table 1. Benchmark Result: Earthquake Disaster on Sovereign Spread

Dependent variable	ΔWeighted Average Sovereign Spread					
Columns	(1)	(2)	(3)	(4)	(5)	(6)
$WA\ Spread_{m-1}$	-0.010***	-0.010***	-0.010***	-0.010***	-0.010***	-0.010***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$(Dummy)\ Earthquake_{m-1}$	-0.022	-0.022	-0.016			
	(0.045)	(0.045)	(0.044)			
$(Dummy)\ Earthquake_{m-2}$	0.097**	0.097**	0.092**			
	(0.046)	(0.045)	(0.045)			
$(Dummy)\ Earthquake_{m-3}$	-0.022	-0.019	-0.021			
	(0.046)	(0.046)	(0.045)			
$(Intensity)\ Earthquake_{m-1}$				-0.005	-0.005	-0.004
				(0.011)	(0.011)	(0.010)
$(Intensity)\ Earthquake_{m-2}$				0.024**	0.024**	0.023**
				(0.011)	(0.011)	(0.010)
$(Intensity)\ Earthquake_{m-3}$				-0.005	-0.004	-0.004
				(0.011)	(0.011)	(0.010)
Country Fes	Yes	Yes	Yes	Yes	Yes	Yes
Seasonal Fes	No	Yes	Yes	No	Yes	Yes
Time Fes	No	No	Yes	No	No	Yes
Observations	11,389	11,389	11,389	11,389	11,389	11,389
R-squared	0.011	0.014	0.077	0.011	0.014	0.077
Number of months	137	137	137	137	137	137
Number of countries	96	96	96	96	96	96

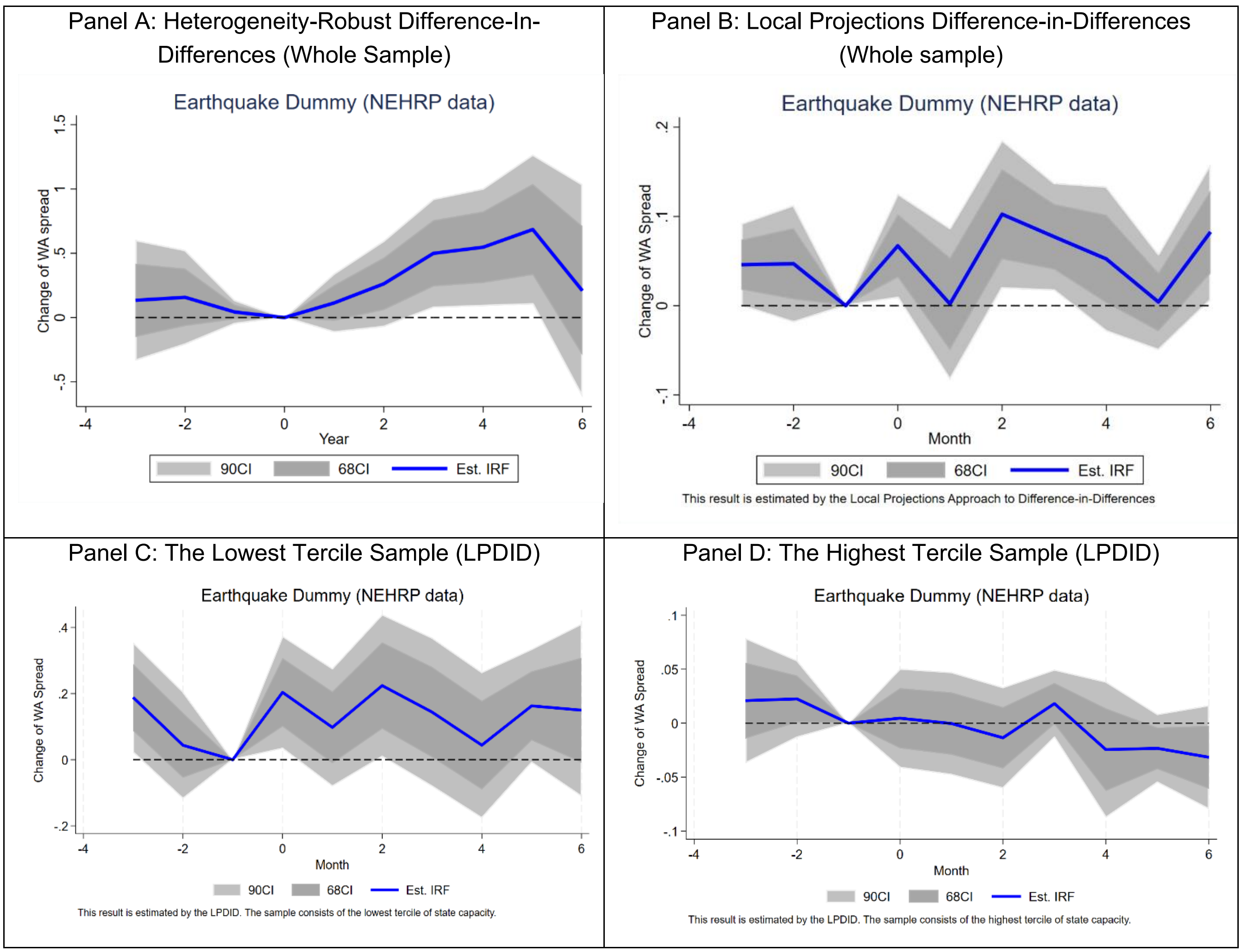
Note: The analysis utilizes data from 96 countries detailed in the sovereign spread dataset (refer to Annex *[1]), spanning from January 2012 through November 2023. We employ a method that accounts for high-dimensional fixed effects. The dependent variable analyzed is the logarithmic change in sovereign bond spreads, obtained from the Bloomberg Back Office. The (Dummy) Earthquake variable, which is set to 1 if an earthquake is reported in the dataset, reflects the presence of earthquakes. These earthquake events are identified by their longitude and latitude before being linked with the relevant country's location for a given month. Post-merger, the NEHRP dataset, which lists over 44,089 observations. Months without an earthquake event are coded with a zero. Earthquake intensity is measured by magnitude on the Richter scale. Seasonal adjustments compensate for the inverse seasonal patterns observed between the Northern and Southern Hemispheres (i.e., seasonal timing is reversed; for example, summer in the Northern Hemisphere corresponds to winter in the Southern Hemisphere). Standard errors are indicated in parentheses. Significance levels are denoted as follows: *** p<0.01, ** p<0.05, * p<0.1.*

We validate our impact results using the approach developed by De Chaisemartin and d'Haultfoeuille (2020, 2023), which allows us to relax the assumption of homogeneous treatment effects and instead depend on parallel trends. Detailed results are presented in Table [2] and illustrated in Panel A of Figure [3]. The pre-test in Table [2] cannot reject the joint nullity of the placebos, indicating that the assumptions of parallel trends and no anticipation have not been violated. In Panel B of Figure [3], we present results using the Local Projections Difference-in-Differences approach, which addresses the common biases linked with negative weighting found in traditional Difference-in-Differences (DiD) analyses. Accordingly, the result once again confirms that the occurrence of an earthquake significantly increases spreads afterwards, with assured pre-trends.

Substantively, the results suggest that each standard deviation increase in state capacity attenuates the spread impact of an earthquake by roughly 24 basis points. This implies that in high-capacity states, earthquakes have little effect on spreads and may even reduce them slightly. Conversely, in low-capacity environments, markets penalize disaster exposure more severely. These findings are consistent with theories of sovereign risk that emphasize fiscal credibility and enforcement capacity as key determinants of default probabilities (Besley and Persson 2011).

Figure 3 plots the marginal effect of an earthquake on sovereign spreads across the distribution of state capacity. The slope is upward and nonlinear (Panels A and B). In the lowest tercile (Panel C), earthquakes increase spreads by about 30 basis points; in the highest tercile (Panel D), the effect is negative, though not statistically significant at conventional levels. This pattern strongly suggests that investors condition their reactions to shocks on institutional strength.

Figure 3. Earthquake Disaster on Sovereign Spread: New DID Techniques



Source: Authors. Note: *We use the Two-Way Fixed Effects and Differences-in-Differences method with Heterogeneous Treatment Effects in Panel A, and the Local Projections Difference-in-Differences approach in Panels B, C, and D.*

We validate our benchmark findings using the estimator proposed by De Chaisemartin and d'Haultfoeuille (2020, 2023), which addresses concerns of treatment effect heterogeneity common in difference-in-differences designs. Table 2 and Figure 3, Panel A, confirm the delayed and persistent effect of earthquakes on spreads. While the initial post-disaster period shows a moderate and statistically uncertain increase, the spread response becomes more pronounced over time: by three to five months after the event, spreads rise by up to 68 basis points (month 5), with confidence intervals excluding zero.

Importantly, the placebo leads (months t–1 to t–3) are jointly insignificant, and the p-value of the joint null is 0.384. This supports the parallel trends assumption and the validity of earthquakes as exogenous shocks in this context.

Panel B of Figure 3 presents the local projections DiD results. These show a smoother trajectory but confirm the same core conclusion: markets adjust spreads upward following earthquakes, but only after observing the fiscal or macroeconomic implications.

These dynamic results echo Mallucci (2020), who models rare disasters as catalysts of sovereign risk. Our empirical contribution is to show that this channel operates through both time and institutional credibility.

Table 2. The Effect of Earthquake Disaster on Sovereign Spread: Heterogeneity-Robust Difference-In-Differences

Estimation of treatment effects: Event-study effects						
	Estimate	SE	LB-CI	UB-CI	Observation	Switchers
$Effect_{t+1}$	0.114	0.139	-0.159	0.386	795.000	33.000
$Effect_{t+2}$	0.262	0.204	-0.137	0.661	776.000	33.000
$Effect_{t+3}$	0.500	0.257	-0.005	1.004	755.000	32.000
$Effect_{t+4}$	0.547	0.278	0.003	1.091	740.000	32.000
$Effect_{t+5}$	0.685	0.354	-0.008	1.378	726.000	32.000
$Effect_{t+6}$	0.209	0.503	-0.777	1.194	674.000	31.000
Testing the parallel trends and no anticipation assumptions						
	Estimate	SE	LB-CI	UB-CI	Observation	Switchers
$Placebo_{t-1}$	0.043	0.056	-0.067	0.154	740.000	30.000
$Placebo_{t-2}$	0.158	0.223	-0.280	0.595	676.000	26.000
$Placebo_{t-3}$	0.134	0.285	-0.425	0.693	615.000	24.000
Test of joint nullity of the placebos: p-value = 0.384						

Source: Authors. *Note: The null hypothesis of the placebo's joint nullity test assumes parallel trends and no anticipation.*

B. Heterogeneous effects (Thresholds)

To assess whether market reactions depend on disaster severity, we use threshold dummies for earthquake intensity, starting at the 30^{th} percentile and moving up to the 90^{th} percentile (Table 3). Specifically, we do not merely examine whether country c experienced an earthquake in month m, but further distinguish the intensity of the earthquake event. To achieve this, prior to merging the earthquake data by longitude and latitude to country-level observations, we retain only those earthquake events whose magnitudes, measured on the Richter scale, fall above selected percentile thresholds, ranging from the 30^{th} to the 90^{th} percentile of all recorded events. Accordingly, a threshold dummy for the 30^{th} percentile indicates whether country c in month m experienced an earthquake with a magnitude equal to or exceeding the 30^{th} percentile (approximately 1.0 on the Richter scale). Similarly, the 90^{th} percentile threshold corresponds to events with a magnitude of approximately 4.2 or higher. The spread response two months after the shock is positive and significant across all thresholds, indicating a discontinuous pricing pattern.

The effect grows with severity. For earthquakes in the top decile of intensity, the spread response is 10.9 basis points, larger than for milder events. This result suggests that markets apply a mental threshold. Not every tremor matters but beyond a certain intensity, the event is interpreted as a meaningful test of sovereign solvency.

This echoes patterns observed in the literature on sovereign debt intolerance (Reinhart, Rogoff and Savastano 2003), where thresholds of vulnerability can trigger nonlinear financial responses.

Table 3. The Heterogeneous Effect of Earthquake Disaster on Sovereign Spread

Dependent variable	ΔWeighted Average Sovereign Spread							
Columns	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$WA\ Spread_{m-1}$	-0.010***	-0.010***	-0.010***	-0.010***	-0.010***	-0.010***	-0.010***	-0.010***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$Intensity_{m-2}$	0.022**							
	(0.010)							
$30^{th}\ percentile\ threshold_{t-2}$		0.089**						
		(0.044)						
$40^{th}\ percentile\ threshold_{t-2}$			0.089**					
			(0.044)					
$50^{th}\ percentile\ threshold_{t-2}$				0.089**				
				(0.044)				
$60^{th}\ percentile\ threshold_{t-2}$					0.089**			
					(0.044)			
$70^{th}\ percentile\ threshold_{t-2}$						0.089**		
						(0.044)		
$80^{th}\ percentile\ threshold_{t-2}$							0.090**	
							(0.044)	
$90^{th}\ percentile\ threshold_{t-2}$								0.109**
								(0.048)
Country Fes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Seasonal Fes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11,484	11,484	11,484	11,484	11,484	11,484	11,484	11,484
R-squared	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076
Number of month	138	138	138	138	138	138	138	138
Number of countries	96	96	96	96	96	96	96	96

Source: Authors. *Note: We employ a method that accounts for high-dimensional fixed effects. The data spans from January 2012 to November 2023. Earthquake intensity is measured by magnitude on the Richter scale. The threshold is a dummy variable determined at the 30th, 40th, 50th, 60th, 70th, 80th, and 90th percentiles of the total sample.*

C. The role of State Capacity

Having established that earthquakes raise spreads and that the effect depends on intensity and timing, we now turn to the institutional context. Table 4 presents the interaction of earthquakes with state capacity.

Column (1) shows that each standard deviation increase in state capacity reduces the spread impact of an earthquake by 6.4 basis points. This effect is robust, statistically significant, and economically meaningful. In Columns (2) and (3), we split countries by institutional quality: in low-capacity countries, earthquakes raise spreads significantly, while in high-capacity countries, the effect is reversed, spreads actually decline. This sharp bifurcation is not simply an attenuation; it represents a reversal of sign.

The same result holds when using intensity as the shock variable (Columns 4–6). In high-capacity states, intensity increases have no effect or slightly reduce spreads. In low-capacity states, they trigger spread increases exceeding 4 basis points per unit magnitude.

This evidence confirms a core contribution of the paper: that state capacity is not just a buffer, it is a filter. Strong institutions change how markets interpret the same shock. Rather than penalizing the disaster itself, investors reassess the fiscal credibility of the sovereign. In this sense, earthquakes act as institutional stress tests, revealing fragility where it exists and resilience where it is earned.

These results align with work by Besley and Persson (2011) and Azzimonti and Mitra (2023), who argue that institutional quality underpins fiscal credibility and determines borrowing costs.

Table 4. The Effect of Earthquake on Sovereign Spread: State Capacity (SC)

Dependent variable	ΔWeighted Average Sovereign Spread					
Columns	(1)	(2)	(3)	(4)	(5)	(6)
$WA\ Spread_{m-1}$	-0.010***	-0.010***	-0.010***	-0.010***	-0.010***	-0.010***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$Dummy_{m-2}$	0.143**	0.020	0.169***			
	(0.056)	(0.057)	(0.056)			
$Dummy_{m-2} \times \overline{SC}$	-0.064					
	(0.039)					
$Dummy_{m-2} \times bottom\ \overline{SC}\ (p40)$		0.177*				
		(0.090)				
$Dummy_{m-2} \times Top\ \overline{SC}\ (p40)$			-0.214**			
			(0.091)			
$Intensity_{m-2}$				0.034***	0.005	0.039***
				(0.013)	(0.013)	(0.013)
$Intensity_{m-2} \times \overline{SC}$				-0.015*		
				(0.009)		
$Intensity_{m-2} \times bottom\ \overline{SC}\ (p40)$					0.041**	
					(0.021)	
$Intensity_{m-2} \times Top\ \overline{SC}\ (p40)$						-0.049**
						(0.022)
Country Fes	Yes	Yes	Yes	Yes	Yes	Yes
Seasonal Fes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,877	11,484	11,484	10,877	11,484	11,484
R-squared	0.079	0.077	0.077	0.079	0.077	0.077
Number of months	138	138	138	138	138	138
Number of countries	89	96	96	89	96	96

*Note: We employ a method that accounts for high-dimensional fixed effects. The dependent variable analyzed is the logarithmic change in sovereign bond spreads, obtained from the Bloomberg Back Office. The (Dummy) Earthquake variable, which is set to 1 if an earthquake is reported in the dataset, reflects the presence of earthquakes. Months without an earthquake event are coded with a zero. Earthquake intensity is measured by magnitude on the Richter scale. Seasonal adjustments compensate for the inverse seasonal patterns observed between the Northern and Southern Hemispheres (i.e., seasonal timing is reversed; for example, summer in the Northern Hemisphere corresponds to winter in the Southern Hemisphere). State capacity is measured as suggested by the study of O'Reilly and Murphy (2022). The 'bottom SC' dummy variable equals 1 if a country c's average state capacity is below the 40th percentile of the sample, and 0 otherwise. The 'top SC' equals 1 if it exceeds 60th percentile, and 0 otherwise. The number of countries in Column (1) is 89 due to missing values in the original state capacity index. In Columns (2)–(6), however, we classify the small states with missing values into groups using governance indicators (e.g., WGI, CPIA), which allows us to maintain the group assignments for top and bottom state capacity. See additional estimates using a split-sample approach based on high- and low-state capacity groups in Annex 3. Standard errors are indicated in parentheses. Significance levels are denoted as follows: *** p<0.01, ** p<0.05, * p<0.1.*

D. Unanticipated Shocks

We now turn to addressing the concern related to unanticipated shocks (see estimates in Annex 4). We isolate unanticipated shocks by removing predictable variation in earthquake timing (Tables 5–6).

Our main results are robust to using solely unanticipated shocks from earthquakes. In other words, earthquakes which are not anticipated are leading to an increase in bond spreads. The increase in spread appears two months after the shock. Institutional capacity moderates or even reverse the increase in spread stemming from (unanticipated) shocks from earthquakes. All in all, the removal of the anticipated component from the earthquake reinforce the effect of earthquakes on bond spreads.

Table 5. Unanticipated Earthquake Disaster On Sovereign Spread

Dependent variable	ΔWeighted Average Sovereign Spread					
Columns	(1)	(2)	(3)	(4)	(5)	(6)
$WA\ Spread_{m-1}$	-0.010***	-0.010***	-0.011***	-0.010***	-0.010***	-0.011***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$(Shock)\ Dummy_{m-1}$	-0.021	-0.020	-0.020			
	(0.046)	(0.046)	(0.045)			
$(Shock)\ Dummy_{m-2}$	0.091**	0.091**	0.088**			
	(0.046)	(0.046)	(0.045)			
$(Shock)\ Dummy_{m-3}$	-0.018	-0.017	-0.017			
	(0.046)	(0.046)	(0.045)			
$(Shock)\ Intensity_{m-1}$				-0.005	-0.005	-0.005
				(0.011)	(0.011)	(0.010)
$(Shock)\ Intensity_{m-2}$				0.023**	0.022**	0.022**
				(0.011)	(0.011)	(0.010)
$(Shock)\ Intensity_{m-3}$				-0.004	-0.003	-0.003
				(0.011)	(0.011)	(0.010)
Country Fes	Yes	Yes	Yes	Yes	Yes	Yes
Seasonal Fes	No	Yes	Yes	No	Yes	Yes
Time Fes	No	No	Yes	No	No	Yes
Observations	11,295	11,295	11,295	11,295	11,295	11,295
R-squared	0.011	0.014	0.076	0.011	0.014	0.077
Number of months	136	136	136	136	136	136
Number of countries	96	96	96	96	96	96

Source: Authors. *Note: The occurrence of an unanticipated earthquake is quantified using the error term in equation (*). Standard errors are presented in parentheses. *** p<0.01, ** p<0.05, * p<0.1.*

Table 6. The Effect of (Unanticipated) Earthquake on Sovereign Spread: State Capacity

Dependent variable	ΔWeighted Average Sovereign Spread					
Columns	(1)	(2)	(3)	(4)	(5)	(6)
$WA\ Spread_{m-1}$	-0.010***	-0.010***	-0.010***	-0.010***	-0.010***	-0.010***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$(Shock)\ Dummy_{m-2}$	0.136**	0.024	0.167***			
	(0.057)	(0.057)	(0.056)			
$(Shock)\ Dummy_{m-2} \times \overline{State\ Capacity}$	-0.056					
	(0.040)					
$(Shock)\ Dummy_{m-2} \times bottom\ \overline{SC}\ (p40)$		0.165*				
		(0.092)				
$(Shock)\ Dummy_{m-2} \times Top\ \overline{SC}\ (p40)$			-0.209**			
			(0.093)			
$(Shock)\ Intensity_{m-2}$				0.033**	0.006	0.039***
				(0.013)	(0.014)	(0.013)
$(Shock)\ Intensity_{m-2} \times \overline{State\ Capacity}$				-0.014		
				(0.009)		
$(Shock)\ Intensity_{m-2} \times Bottom\ \overline{SC}\ (p40)$					0.039*	
					(0.021)	
$(Shock)\ Intensity_{m-2} \times Top\ \overline{SC}\ (p40)$						-0.048**
						(0.022)
Country Fes	Yes	Yes	Yes	Yes	Yes	Yes
Seasonal Fes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,789	11,389	11,389	10,789	11,389	11,389
R-squared	0.079	0.077	0.077	0.080	0.077	0.077
Number of months	137	137	137	137	137	137
Number of countries	89	96	96	89	96	96

Source: Authors. *Note: The occurrence of an unanticipated earthquake is quantified using the error term in equation (*). Standard errors are presented in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The re-estimation model (1) using a split sample based on state capacity is also conducted in Annex [5].*

6. Robustness Checks

We subject our findings to a wide array of robust checks.

Table 11 confirms a similar result for debt: countries with high external debt are more likely to benefit from international support post-disaster, partially offsetting market pessimism.

A. Robustness Checks: Controlling for Crisis

One might be concerned that the study results could be overshadowed by global crises, which significantly affect spreads. Thus, we further validate the robustness of our findings by controlling for banking system crises, which are defined by two criteria: (i) clear signs of financial distress in the banking sector, marked by significant bank runs, losses, or bank liquidations; (ii) considerable policy interventions by banking authorities in response to these losses (Laeven and Valencia, 2020). The results, presented in Tables [7], [8] and [9] confirm our findings. While crises significantly raise spreads (by over 280 basis points), controlling for them does not alter our main results. Earthquakes retain their spread impact, and institutional interactions remain significant.

Table 7. Earthquake Disaster on Sovereign Spread: Controlling for Crisis Events

Dependent variable	ΔWeighted Average Sovereign Spread					
Columns	(1)	(2)	(3)	(4)	(5)	(6)
$WA\ Spread_{m-1}$	-0.010***	-0.010***	-0.011***	-0.010***	-0.010***	-0.011***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$(Dummy)\ Earthquake_{m-1}$	-0.023	-0.024	-0.018			
	(0.045)	(0.045)	(0.044)			
$(Dummy)\ Earthquake_{m-2}$	0.099**	0.099**	0.093**			
	(0.045)	(0.045)	(0.044)			
$(Dummy)\ Earthquake_{m-3}$	-0.021	-0.017	-0.020			
	(0.046)	(0.045)	(0.045)			
$(Intensity)\ Earthquake_{m-1}$				-0.005	-0.006	-0.005
				(0.011)	(0.011)	(0.010)
$(Intensity)\ Earthquake_{m-2}$				0.024**	0.024**	0.023**
				(0.011)	(0.011)	(0.010)
$(Intensity)\ Earthquake_{m-3}$				-0.005	-0.004	-0.004
				(0.011)	(0.011)	(0.010)
$\text{Banking system Crisis}_{m-3}$	2.791***	2.790***	2.819***	2.791***	2.790***	2.819***
	(0.411)	(0.410)	(0.401)	(0.411)	(0.410)	(0.401)
Country Fes	Yes	Yes	Yes	Yes	Yes	Yes
Seasonal Fes	No	Yes	Yes	No	Yes	Yes
Time Fes	No	No	Yes	No	No	Yes
Observations	11,389	11,389	11,389	11,389	11,389	11,389
R-squared	0.015	0.018	0.081	0.015	0.018	0.081
Number of months	137	137	137	137	137	137
Number of countries	96	96	96	96	96	96

*Note: A banking system crisis (DUMMY) is defined as an event that meets two conditions: visible signs of financial distress in the banking sector, evidenced by significant bank runs, losses, or liquidations; and major policy interventions by authorities in response to these losses. The data is proposed by Laeven and Valencia (2020). Standard errors are indicated in parentheses. Significance levels are denoted as follows: *** p<0.01, ** p<0.05, * p<0.1.*

Table 8. The Effect of (Unanticipated) Earthquake Disaster on Spread: Controlling for Crisis Events

Dependent variable	ΔWeighted Average Sovereign Spread					
Columns	(1)	(2)	(3)	(4)	(5)	(6)
$WA\ Spread_{m-1}$	-0.010***	-0.010***	-0.011***	-0.010***	-0.010***	-0.011***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$(Shock)\ Dummy_{m-1}$	-0.022	-0.022	-0.021			
	(0.046)	(0.046)	(0.045)			
$(Shock)\ Dummy_{m-2}$	0.093**	0.093**	0.090**			
	(0.046)	(0.046)	(0.045)			
$(Shock)\ Dummy_{m-3}$	-0.017	-0.016	-0.016			
	(0.046)	(0.046)	(0.045)			
$(Shock)\ Intensity_{m-1}$				-0.006	-0.005	-0.005
				(0.011)	(0.011)	(0.010)
$(Shock)\ Intensity_{m-2}$				0.023**	0.023**	0.022**
				(0.011)	(0.011)	(0.010)
$(Shock)\ Intensity_{m-3}$				-0.003	-0.003	-0.003
				(0.011)	(0.011)	(0.010)
Banking system Crisis_{m-3}	2.785***	2.784***	2.815***	2.785***	2.784***	2.816***
	(0.412)	(0.412)	(0.403)	(0.412)	(0.412)	(0.403)
Country Fes	Yes	Yes	Yes	Yes	Yes	Yes
Seasonal Fes	No	Yes	Yes	No	Yes	Yes
Time Fes	No	No	Yes	No	No	Yes
Observations	11,295	11,295	11,295	11,295	11,295	11,295
R-squared	0.015	0.018	0.081	0.015	0.018	0.081
Number of months	136	136	136	136	136	136
Number of countries	96	96	96	96	96	96

*Note: Standard errors are indicated in parentheses. Significance levels are denoted as follows: *** p<0.01, ** p<0.05, * p<0.1.*

Table 9. The Effect of Earthquake on Spreads: State Capacity (Crisis Control)

Dependent variable	ΔWeighted Average Sovereign Spread					
Columns	(1)	(2)	(3)	(4)	(5)	(6)
$WA\ Spread_{m-1}$	-0.010***	-0.010***	-0.010***	-0.010***	-0.010***	-0.010***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$Dummy_{m-2}$	0.149***	0.019	0.175***			
	(0.056)	(0.057)	(0.056)			
$Dummy_{m-2} \times \overline{State\ Capacity}$	-0.067*					
	(0.039)					
$Dummy_{m-2} \times bottom\ \overline{SC}\ (p40)$		0.187**				
		(0.091)				
$Dummy_{m-2} \times Top\ \overline{SC}\ (p40)$			-0.220**			
			(0.092)			
$Intensity_{m-2}$				0.035***	0.005	0.040***
				(0.013)	(0.013)	(0.013)
$Intensity_{m-2} \times \overline{State\ Capacity}$				-0.016*		
				(0.009)		
$Intensity_{m-2} \times bottom\ \overline{SC}\ (p40)$					0.043**	
					(0.021)	
$Intensity_{m-2} \times Top\ \overline{SC}\ (p40)$						-0.051**
						(0.022)
Banking system $Crisis_{m-3}$	2.824***	2.824***	2.823***	2.825***	2.824***	2.823***
	(0.412)	(0.401)	(0.401)	(0.412)	(0.401)	(0.401)
Country Fes	Yes	Yes	Yes	Yes	Yes	Yes
Seasonal Fes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,789	11,389	11,389	10,789	11,389	11,389
R-squared	0.084	0.081	0.081	0.084	0.081	0.081
Number of months	137	137	137	137	137	137
Number of countries	89	96	96	89	96	96

*Note: Significance levels are denoted as follows: *** p<0.01, ** p<0.05, * p<0.1.*

B. Additional Robustness Checks: Tripple Interactions

Now, we examine whether moderating factors like state capacity and external debt are driven by a country's income. That is, countries with higher incomes likely have greater state capacity and can sustain higher debt levels. Thus, we conducted a triple interaction analysis among earthquake, income level (IL), and state capacity (SC), as well as the first two with external debt.

Regarding the triple interaction between earthquake, income, and state capacity, the results in Table [10] suggest that state capacity can reduce the impact of earthquakes on spreads (columns [1] and [4]), especially in countries below the 40th income percentile of the study sample (columns [2] and [5]). Regarding the triple interaction between earthquake, income, and external debt, the results shown in Table [11] suggest that higher external debt is associated with a reduced impact of earthquakes on spreads (columns [3] and [6]), potentially due to foreign aid from other countries,[9] while income level does not significantly moderate this relationship. The results are instructive. State capacity is most valuable in low-income countries, those least able to borrow or absorb shocks through external reserves. This implies that institution-building is especially potent in fragile environments, where market signals are most volatile.

As an additional robustness check, we replace the average monthly earthquake magnitude with the maximum magnitude observed in each country-month pairs. This alternative measure captures the possibility that infrequent but high-magnitude earthquakes drive sovereign spread dynamics, which may otherwise be obscured by the averaging procedure. The results, reported in Appendix VII (Panels A and B), remain consistent with our baseline findings that is sovereign spreads respond significantly to earthquake shocks, and the conditioning role of state capacity continues to hold.

[9] Concessional funds can attenuate sovereign bond spreads by providing governments with access to low-cost, stable financing that reduces rollover risks and signals external support. Empirical studies show that access to concessional finance helps smooth debt servicing and mitigate market perceptions of default risk, especially in low-income countries (Presbitero & Zazzaro, 2011). Moreover, concessional resources often complement emergency assistance following natural disasters, thereby reducing the need for costly market borrowing and stabilizing sovereign risk premia (Arellano et al., 2023).

Table 10. Tripple Interactions: Earthquake, State Capacity, and Income Levels

Dependent variable	ΔWeighted Average Sovereign Spread					
Columns	(1)	(2)	(3)	(4)	(5)	(6)
$WA\ Spread_{m-1}$	-0.010***	-0.010***	-0.010***	-0.010***	-0.010***	-0.010***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$Dummy_{m-2}$	1.512**	0.051	0.144**			
	(0.729)	(0.089)	(0.062)			
$Dummy_{m-2} \times \overline{IL}$	-0.145*					
	(0.077)					
$Dummy_{m-2} \times \overline{SC}$	-1.023*	-0.005	-0.090*			
	(0.579)	(0.052)	(0.054)			
$Dummy_{m-2} \times \overline{SC} \times \overline{IL}$	0.098*					
	(0.058)					
$Dummy_{m-2} \times bottom\ \overline{IL}\ (p40)$		0.145				
		(0.115)				
$Dummy_{m-2} \times \overline{SC} \times bottom\ \overline{IL}\ (p40)$		-0.153*				
		(0.090)				
$Dummy_{m-2} \times Top\ \overline{IL}\ (p40)$			-0.033			
			(0.149)			
$Dummy_{m-2} \times \overline{SC} \times Top\ \overline{IL}\ (p40)$			0.059			
			(0.092)			
$Intensity_{m-2}$				0.378**	0.012	0.034**
				(0.165)	(0.020)	(0.014)
$Intensity_{m-2} \times \overline{IL}$				-0.036**		
				(0.017)		
$Intensity_{m-2} \times \overline{SC}$				-0.283**	-0.000	-0.023*
				(0.134)	(0.012)	(0.012)
$Intensity_{m-2} \times \overline{SC} \times \overline{IL}$				0.027**		
				(0.013)		
$Intensity_{m-2} \times bottom\ \overline{IL}\ (p40)$					0.036	
					(0.026)	
$Intensity_{m-2} \times \overline{SC} \times bottom\ \overline{IL}\ (p40)$					-0.040*	
					(0.021)	
$Intensity_{m-2} \times Top\ \overline{IL}\ (p40)$						-0.009
						(0.034)
$Intensity_{m-2} \times \overline{SC} \times Top\ \overline{IL}\ (p40)$						0.018
						(0.022)
Country Fes	Yes	Yes	Yes	Yes	Yes	Yes
Seasonal Fes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,877	10,877	10,877	10,877	10,877	10,877
R-squared	0.080	0.080	0.079	0.080	0.080	0.080
Number of months	138	138	138	138	138	138
Number of countries	89	89	89	89	89	89

*Note: Income levels are measured by GDP per capita (constant 2021 US$, PPP), collected from WDI. State capacity is measured as suggested by the study of O'Reilly and Murphy (2022). Standard errors are indicated in parentheses. Significance levels are denoted as follows: *** p<0.01, ** p<0.05, * p<0.1.*

Table 11. Tripple Interactions: Earthquake, Debt, and Income Levels

Dependent variable	ΔWeighted Average Sovereign Spread					
Columns	(1)	(2)	(3)	(4)	(5)	(6)
$WA\ Spread_{m-1}$	-0.013***	-0.013***	-0.013***	-0.013***	-0.013***	-0.013***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
$Dummy_{m-2}$	0.632	0.204	0.363***			
	(1.668)	(0.221)	(0.116)			
$Dummy_{m-2} \times \overline{IL}$	-0.033					
	(0.180)					
$Dummy_{m-2} \times \overline{DEBT}$	0.161	-0.032	-0.043***			
	(0.308)	(0.029)	(0.014)			
$Dummy_{m-2} \times \overline{DEBT} \times \overline{IL}$	-0.021					
	(0.033)					
$Dummy_{m-2} \times bottom\ \overline{IL}\ (p40)$		0.214				
		(0.260)				
$Dummy_{m-2} \times \overline{DEBT} \times bottom\ \overline{IL}\ (p40)$		-0.014				
		(0.033)				
$Dummy_{m-2} \times Top\ \overline{IL}\ (p40)$			-0.244			
			(0.778)			
$Dummy_{m-2} \times \overline{DEBT} \times Top\ \overline{IL}\ (p40)$			0.018			
			(0.110)			
$Intensity_{m-2}$				0.144	0.043	0.082***
				(0.375)	(0.049)	(0.026)
$Intensity_{m-2} \times \overline{IL}$				-0.008		
				(0.040)		
$Intensity_{m-2} \times \overline{DEBT}$				0.041	-0.007	-0.010***
				(0.070)	(0.007)	(0.003)
$Intensity_{m-2} \times \overline{DEBT} \times \overline{IL}$				-0.005		
				(0.007)		
$Intensity_{m-2} \times bottom\ \overline{IL}\ (p40)$					0.053	
					(0.058)	
$Intensity_{m-2} \times \overline{DEBT} \times bottom\ \overline{IL}\ (p40)$					-0.004	
					(0.007)	
$Intensity_{m-2} \times Top\ \overline{IL}\ (p40)$						-0.044
						(0.177)
$Intensity_{m-2} \times \overline{DEBT} \times Top\ \overline{IL}\ (p40)$						0.002
						(0.025)
Country Fes	Yes	Yes	Yes	Yes	Yes	Yes
Seasonal Fes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,331	6,331	6,331	6,331	6,331	6,331
R-squared	0.112	0.112	0.112	0.112	0.112	0.112
Number of months	138	138	138	138	138	138
Number of countries	53	53	53	53	53	53

*Note: Income levels are measured by GDP per capita (constant 2021 US$, PPP), collected from WDI. State capacity is measured as suggested by the study of O'Reilly and Murphy (2022). See Annex 6 for additional results on the heterogeneous effects of earthquakes on spreads conditional on short-term external debt. Standard errors are indicated in parentheses. Significance levels are denoted as follows: *** p<0.01, ** p<0.05, * p<0.1.*

In sum, the results across all tables and figures converge on a consistent message. Earthquakes shake the ground in every country, but they rattle bond markets only where the institutional foundations are weak. Markets are not reacting to the disaster itself, but to what it reveals about the state. Sovereign spreads, in this light, become a referendum on fiscal capacity, policy credibility, and the ability to govern under pressure.

7. Conclusion

Markets are like seismographs: they do not merely register the size of a shock, they trace how it travels through a system. When a natural disaster strikes a sovereign state, the direct physical damage is only part of the story. What truly moves bond markets is the institutional transmission mechanism. Some states absorb the tremor and maintain their footing. Others amplify it, transforming an exogenous shock into a fiscal and financial rupture.

This paper has shown that earthquakes do not mechanically raise sovereign spreads. Rather, they reveal the institutional character of the state. In countries with low state capacity, spreads rise sharply in the months following a disaster. In countries with strong institutions, those that can collect taxes, coordinate relief, and credibly manage reconstruction, spreads remain stable and may even decline. The same physical event yields opposing financial outcomes, depending on whether the sovereign is perceived as fragile or resilient.
The implications are significant. In an era of escalating climate and disaster risk, sovereign bond pricing will increasingly reflect not just exposure to shocks, but the credibility of response. That means state capacity is no longer just a development goal, it is a risk variable. And perhaps more provocatively, it is a discount rate modifier: countries that can govern well in a crisis borrow more cheaply, not just in tranquil times, but precisely when catastrophe strikes.

This insight reorients the disaster policy agenda. The default policy levers, from insurance markets, catastrophe bonds, to foreign aid, often overlook the centrality of state institutions. Our results suggest that investing in governance itself may be the most effective, and market-recognized, form of disaster mitigation. This applies not only to traditional fiscal instruments but also to emerging tools like state-contingent debt, which could explicitly reward institutional resilience. Interestingly, catastrophic bond which is a high-yield debt instrument designed to help corporations in the insurance industry in th event of a natural disaster.

For multilateral lenders, this opens a path to smarter, capacity-linked conditionality. Not punitive but calibrated to strengthen the very institutions that preserve solvency under stress. For sovereign debt investors, it calls for sovereign risk models that treat earthquakes and other natural disasters not simply as exogenous risks, but as informational events, shocks that clarify who is in charge, and whether they can deliver.

Future research can build on these findings in several directions. First, while this paper focuses on earthquakes for their exogeneity, similar frameworks could be applied to other shocks, from floods, droughts, even geopolitical crises. Second, the measurement of institutional strength could be made more dynamic, incorporating real-time indicators such as disaster response times, budget reallocations, or external aid absorption rates. Finally, deeper work is needed to understand how domestic political institutions, such as central-local coordination or executive constraints, mediate the post-disaster fiscal trajectory.

Disasters are here to stay. The question is not whether governments will be tested, but whether they will be believed. Sovereign bond markets, it turns out, offer a running vote of confidence. When a shock arrives, what matters is not just what happened, but how the state is expected to respond. And that response, as we've seen, is priced in basis points

Annex I. List of Countries

AGO	ALB	AND	ARG	ARM	AUT	AZE	BEL	BEN	BGR	BHR	BLR
BMU	BRA	BRB	BTN	CAN	CHL	CHN	CMR	COL	CRI	CYP	DMA
ECU	EGY	ESP	EST	ETH	FIN	FRA	GAB	GEO	GHA	GRC	GTM
HKG	HND	HRV	HUN	IDN	IRL	IRQ	ISL	ISR	ITA	JAM	JOR
KAZ	KEN	KWT	LBN	LKA	LTU	LUX	LVA	MAR	MEX	MLT	MNE
MNG	MOZ	NAM	NFK	NGA	NPL	OMN	PAK	PAN	PER	POL	PRT
PRY	QAT	ROU	RWA	SAU	SEN	SLV	SMR	SRB	SUR	SVK	SVN
SWE	TJK	TTO	TUN	TUR	TUV	UKR	URY	UZB	VNM	ZAF	ZMB

Source: Authors

Annex II. Descriptive Statistics

Variables	Define	Source	Obs	Mean	SD	Min	Max
Weighted Average Sovereign Spread	Measured in 100 bps	Bloomberg Back Office	11695	4.034	7.845	0.003	139.86
Dummy Earthquake (NERHP)	(=1 if an earthquake occurs in the month, =0 otherwise)	NERHP	11799	0.281	0.450	0.000	1.000
Intensity Earthquake (NERHP)	Earthquake intensity measured as the monthly average value on the Richter Scale	NERHP	11799	1.172	1.912	0.000	6.800
Short-term External Debt (% GDP)	Short-term external debt, with a maturity of one year or less and combining both public and private nonguaranteed debt, is expressed in current U.S. dollars and converted to a GDP ratio using GDP in current U.S. dollars	WDI	6537	8.172	8.112	0.000	73.907
State Capacity Baseline	z-score		9135	0.933	1.216	-2.152	3.047
GDP per capital on logarithm	Constant 2021 international US$, PPP	WDI	11618	9.888	0.906	7.273	11.835
Banking Systematic Crisis	Dummy (=1 if Yes)	Laeven and Valencia (2020)	11799	0.0010	0.032	0.000	1.000

Note: Data is recorded monthly from January 2012 to November 2023.

Annex III. The Effect of Earthquake on Sovereign Spread: Split The $\overline{(SC)}$ Sample

PANEL A. HIGH STATE CAPACITY $(\geq p50)$

Dependent variable	ΔWeighted Average Sovereign Spread					
Columns	(1)	(2)	(3)	(4)	(5)	(6)
$WA\ Spread_{m-1}$	-0.036***	-0.036***	-0.038***	-0.036***	-0.036***	-0.038***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
$(Dummy)\ Earthquake_{m-1}$	-0.023	-0.024	-0.018			
	(0.031)	(0.031)	(0.030)			
$(Dummy)\ Earthquake_{m-2}$	0.018	0.017	0.018			
	(0.031)	(0.031)	(0.031)			
$(Dummy)\ Earthquake_{m-3}$	-0.050	-0.051*	-0.056*			
	(0.031)	(0.031)	(0.031)			
$(Intensity)\ Earthquake_{m-1}$				-0.006	-0.007	-0.005
				(0.007)	(0.007)	(0.007)
$(Intensity)\ Earthquake_{m-2}$				0.005	0.005	0.005
				(0.007)	(0.007)	(0.007)
$(Intensity)\ Earthquake_{m-3}$				-0.012	-0.012*	-0.014*
				(0.007)	(0.007)	(0.007)
Country Fes	Yes	Yes	Yes	Yes	Yes	Yes
Seasonal Fes	No	Yes	Yes	No	Yes	Yes
Time Fes	No	No	Yes	No	No	Yes
Observations	6,145	6,145	6,145	6,145	6,145	6,145
R-squared	0.017	0.020	0.075	0.018	0.020	0.076
Number of months	137	137	137	137	137	137
Number of countries	51	51	51	51	51	51

PANEL B. LOW STATE CAPACITY $(< p50)$						
Dependent variable	ΔWeighted Average Sovereign Spread					
Columns	(1)	(2)	(3)	(4)	(5)	(6)
$WA\ Spread_{m-1}$	-0.008***	-0.008***	-0.009***	-0.008***	-0.008***	-0.009***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
$(Dummy)\ Earthquake_{m-1}$	-0.013	-0.010	-0.032			
	(0.089)	(0.089)	(0.086)			
$(Dummy)\ Earthquake_{m-2}$	0.180**	0.181**	0.167*			
	(0.089)	(0.089)	(0.086)			
$(Dummy)\ Earthquake_{m-3}$	0.011	0.023	0.041			
	(0.089)	(0.089)	(0.087)			
$(Intensity)\ Earthquake_{m-1}$				-0.002	-0.002	-0.007
				(0.020)	(0.020)	(0.020)
$(Intensity)\ Earthquake_{m-2}$				0.041**	0.041**	0.039**
				(0.020)	(0.020)	(0.020)
$(Intensity)\ Earthquake_{m-3}$				0.003	0.005	0.010
				(0.020)	(0.020)	(0.020)
Country Fes	Yes	Yes	Yes	Yes	Yes	Yes
Seasonal Fes	No	Yes	Yes	No	Yes	Yes
Time Fes	No	No	Yes	No	No	Yes
Observations	5,244	5,244	5,244	5,244	5,244	5,244
R-squared	0.011	0.016	0.119	0.011	0.016	0.119
Number of months	137	137	137	137	137	137
Number of countries	45	45	45	45	45	45

*Note: We employ a method that accounts for high-dimensional fixed effects. The dependent variable analyzed is the logarithmic change in sovereign bond spreads, obtained from the Bloomberg Back Office. The (Dummy) Earthquake variable, which is set to 1 if an earthquake is reported in the dataset, reflects the presence of earthquakes. Months without an earthquake event are coded with a zero. Earthquake intensity is measured by magnitude on the Richter scale. Seasonal adjustments compensate for the inverse seasonal patterns observed between the Northern and Southern Hemispheres (i.e., seasonal timing is reversed; for example, summer in the Northern Hemisphere corresponds to winter in the Southern Hemisphere). State capacity is measured as suggested by the study of O'Reilly and Murphy (2022). Standard errors are indicated in parentheses. Significance levels are denoted as follows: *** p<0.01, ** p<0.05, * p<0.1.*

Annex IV. Identifying Unanticipated Earthquake Shocks

Dependent variables	Dummy	Magnitude (Intensity)
Columns	(1)	(2)
$Dummy_{m-1}$	0.028***	
	(0.009)	
$Magnitude_{m-1}$		0.031***
		(0.009)
Country Fes	Yes	Yes
Seasonal Fes	Yes	Yes
Time Fes	Yes	Yes
Observations	11,703	11,703
R-squared	0.615	0.605

*Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1*

Annex V. The Effect (Unanticipated) Earthquake on Sovereign Spread: Split The $\overline{(SC)}$ Sample

PANEL A. HIGH STATE CAPACITY $(\geq p50)$

Dependent variable	ΔWeighted Average Sovereign Spread					
Columns	(1)	(2)	(3)	(4)	(5)	(6)
$WA\ Spread_{m-1}$	-0.036***	-0.036***	-0.038***	-0.036***	-0.036***	-0.038***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
$(Shock)\ Dummy_{m-1}$	-0.025	-0.025	-0.021			
	(0.031)	(0.031)	(0.031)			
$(Shock)\ Dummy_{m-2}$	0.019	0.019	0.016			
	(0.031)	(0.031)	(0.031)			
$(Shock)\ Dummy_{m-3}$	-0.051*	-0.052*	-0.056*			
	(0.031)	(0.031)	(0.031)			
$(Shock)\ Intensity_{m-1}$				-0.007	-0.007	-0.006
				(0.007)	(0.007)	(0.007)
$(Shock)\ Intensity_{m-2}$				0.005	0.005	0.005
				(0.007)	(0.007)	(0.007)
$(Shock)\ Intensity_{m-3}$				-0.012	-0.013*	-0.013*
				(0.007)	(0.007)	(0.007)
Country Fes	Yes	Yes	Yes	Yes	Yes	Yes
Seasonal Fes	No	Yes	Yes	No	Yes	Yes
Time Fes	No	No	Yes	No	No	Yes
Observations	6,096	6,096	6,096	6,096	6,096	6,096
R-squared	0.018	0.020	0.076	0.018	0.020	0.076
Number of months	136	136	136	136	136	136
Number of countries	51	51	51	51	51	51

PANEL B. LOW STATE CAPACITY $(< p50)$

Dependent variable	ΔWeighted Average Sovereign Spread					
Columns	(1)	(2)	(3)	(4)	(5)	(6)
$WA\ Spread_{m-1}$	-0.008***	-0.008***	-0.009***	-0.008***	-0.008***	-0.009***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
$(Shock)\ Dummy_{m-1}$	-0.009	-0.006	-0.036			
	(0.090)	(0.090)	(0.087)			
$(Shock)\ Dummy_{m-2}$	0.167*	0.167*	0.161*			
	(0.090)	(0.090)	(0.087)			
$(Shock)\ Dummy_{m-3}$	0.021	0.027	0.049			
	(0.091)	(0.090)	(0.087)			
$(Shock)\ Intensity_{m-1}$				-0.002	-0.001	-0.008
				(0.020)	(0.020)	(0.020)
$(Shock)\ Intensity_{m-2}$				0.039*	0.039*	0.037*
				(0.020)	(0.020)	(0.020)
$(Shock)\ Intensity_{m-3}$				0.006	0.007	0.012
				(0.021)	(0.020)	(0.020)
Country Fes	Yes	Yes	Yes	Yes	Yes	Yes
Seasonal Fes	No	Yes	Yes	No	Yes	Yes
Time Fes	No	No	Yes	No	No	Yes
Observations	5,199	5,199	5,199	5,199	5,199	5,199
R-squared	0.011	0.016	0.119	0.011	0.016	0.119
Number of months	136	136	136	136	136	136

Number of countries	45	45	45	45	45	45

Source: Authors. *Note: The occurrence of an unanticipated earthquake is quantified using the error term in equation (*). Standard errors are presented in parentheses. *** p<0.01, ** p<0.05, * p<0.1.*

Annex VI. The Effect of (Unanticipated) Earthquake on Sovereign Spread: Debt-To-GDP

Dependent variable	ΔWeighted Average Sovereign Spread					
Columns	(1)	(2)	(3)	(4)	(5)	(6)
$WA\ Spread_{m-1}$	-0.013***	-0.013***	-0.013***	-0.013***	-0.013***	-0.013***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
$(Shock)\ Dummy_{m-2}$	0.352***	-0.087	0.174*			
	(0.116)	(0.094)	(0.090)			
$(Shock)\ Dummy_{m-2} \times \overline{DEBT}$	-0.042***					
	(0.014)					
$(Shock)\ Dummy_{m-2} \times bottom\ \overline{DEBT}\ (p40)$		0.366**				
		(0.145)				
$(Shock)\ Dummy_{m-2} \times Top\ \overline{DEBT}\ (p40)$			-0.290**			
			(0.148)			
$(Shock)\ Intensity_{m-2}$				0.079***	-0.020	0.039*
				(0.026)	(0.022)	(0.020)
$(Shock)\ Intensity_{m-2} \times \overline{DEBT}$				-0.010***		
				(0.003)		
$(Shock)\ Intensity_{m-2} \times bottom\ \overline{DEBT}\ (p40)$					0.082**	
					(0.033)	
$(Shock)\ Intensity_{m-2} \times Top\ \overline{DEBT}\ (p40)$						-0.065*
						(0.034)
Country Fes	Yes	Yes	Yes	Yes	Yes	Yes
Seasonal Fes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,278	6,278	6,278	6,278	6,278	6,278
R-squared	0.112	0.112	0.111	0.112	0.112	0.111
Number of months	137	137	137	137	137	137
Number of countries	53	53	53	53	53	53

*Note: The occurrence of an unanticipated earthquake is quantified using the error term in equation (*). Significance levels are denoted as follows: *** p<0.01, ** p<0.05, * p<0.1.*

Annex VII. The Effect of Earthquakes on Sovereign Spreads: Robustness Check with Maximum Magnitude

PANEL A: MAXIMUM MAGNITUDE OF EARTHQUAKE

Dependent variable	ΔWeighted Average Sovereign Spread					
Columns	(1)	(2)	(3)	(4)	(5)	(6)
$WA\ Spread_{m-1}$	-0.010***	-0.010***	-0.010***	-0.010***	-0.010***	-0.010***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$Max\ Intensity_{m-2}$	0.022**	0.034***	0.006	0.039***	0.006	0.040***
	(0.010)	(0.012)	(0.013)	(0.012)	(0.013)	(0.012)
$Max\ Intensity_{m-2} \times \overline{SC}$		-0.015*				
		(0.009)				
$Max\ Intensity_{m-2} \times bottom\ \overline{SC}\ (p40)$			0.038*		0.040**	
			(0.020)		(0.020)	
$Max\ Intensity_{m-2} \times Top\ \overline{SC}\ (p40)$				-0.050**		-0.051**
				(0.021)		(0.021)
$\text{Banking system Crisis}_{m-3}$					2.824***	2.823***
					(0.401)	(0.401)
Country Fes	Yes	Yes	Yes	Yes	Yes	Yes
Seasonal Fes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11,484	10,877	11,484	11,484	11,389	11,389
R-squared	0.076	0.080	0.077	0.077	0.081	0.081
Number of months	96	89	96	96	96	96
Number of countries	138	138	138	138	137	137

Source: Authors. *Note: Maximum intensity is defined as the highest ground shaking recorded from an earthquake within a given month in country c, rather than being calculated as the average value on the Richter scale. Standard errors are presented in parentheses. *** p<0.01, ** p<0.05, * p<0.1.*

PANEL B: (UNANTICIPATED) MAXIMUM MAGNITUDE OF EARTHQUAKE

Dependent variable	ΔWeighted Average Sovereign Spread					
Columns	(1)	(2)	(3)	(4)	(5)	(6)
$WA\ Spread_{m-1}$	-0.010***	-0.010***	-0.010***	-0.010***	-0.010***	-0.010***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$(Shock)\ Max\ Intensity_{m-2}$	0.022**	0.034***	0.007	0.039***	0.007	0.040***
	(0.010)	(0.012)	(0.013)	(0.012)	(0.013)	(0.012)
$(Shock)\ Max\ Intensity_{m-2} \times \overline{SC}$		-0.015*				
		(0.009)				
$(Shock)\ Max\ Intensity_{m-2} \times bottom\ \overline{SC}\ (p40)$			0.037*		0.038*	
			(0.020)		(0.020)	
$(Shock)\ Max\ Intensity_{m-2} \times Top\ \overline{SC}\ (p40)$				-0.050**		-0.050**
				(0.021)		(0.021)
$\text{Banking system Crisis}_{m-3}$					2.823***	2.822***
					(0.401)	(0.401)
Country Fes	Yes	Yes	Yes	Yes	Yes	Yes
Seasonal Fes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fes	Yes	Yes	Yes	Yes	Yes	Yes

Observations	11,389	10,789	11,389	11,389	11,389	11,389
R-squared	0.077	0.080	0.077	0.077	0.081	0.081
Number of months	96	89	96	96	96	96
Number of countries	138	138	138	138	137	137

Source: Authors. *Note: Maximum intensity is defined as the highest ground shaking recorded from an earthquake within a given month in country c, rather than being calculated as the average value on the Richter scale. The occurrence of an unanticipated earthquake is quantified using the error term in equation (*). Standard errors are presented in parentheses. *** p<0.01, ** p<0.05, * p<0.1.*

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