Natural Disasters and the Term Structure of Sovereign Debt: Evidence from Africa

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April 22, 2026

Abstract

We study how natural disasters affect the term structure of domestic sovereign borrowing costs in Africa. Using instrument-level data on about 47,000 bonds and Treasury bills across 39 countries over 2000–2025, we estimate local projections with separate shocks for floods, storms, and droughts. Floods steepen the domestic yield curve at issuance: long-maturity yields rise while short-maturity yields move little. The effect is concentrated in high-debt sovereigns, where flood-induced steepening is roughly twice as large and more persistent. Droughts reinforce the steepening in high-debt countries; storms show no discernible effect. Our results indicate that as climate change intensifies, long-term borrowing could become disproportionately more expensive in fiscally vulnerable African sovereigns.

Keywords: Natural disasters, yield curve, sovereign debt, Africa, local projections, term structure

JEL Codes: F34, G12, H63, Q54

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Disclosure. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. The author is employed by the Financial Stability Board and is a PhD candidate at Vrije Universiteit Amsterdam; the views expressed are his own and do not necessarily reflect those of either institution. The author has no other relevant or material financial interests that relate to the research described in this paper.

1 Introduction

How do natural disasters affect the cost of sovereign borrowing across the maturity spectrum? A growing literature documents that climate and disaster shocks raise sovereign borrowing costs and strain public finances, but this work has relied almost exclusively on country-level panels of average yields or spreads—treating the yield curve as a single price rather than as a schedule of prices across maturities. Systematic evidence is also scarce for Africa, where domestic markets are thin, disaster exposure is high, and climate change is projected to intensify physical risks. We address both gaps.

This paper studies the effect of natural disasters on the domestic yield curve across 39 African countries over 2000–2025. We exploit instrument-level microdata from the African Debt Database (Manger et al., 2025), which records the terms of approximately 47,000 individual domestic sovereign instruments—bonds and Treasury bills—at issuance. Working at the instrument level lets us identify the slope of the yield curve from within-country-quarter variation in maturity: instruments of different tenors issued in the same country and quarter trace out the term structure directly. We combine these data with event-level disaster records from EM-DAT and macroeconomic controls from the Global Macro Database (Müller et al., 2025), and estimate local projections (Jordà, 2005) at quarterly frequency over horizons of up to two years. We focus on floods, storms, and droughts, the most relevant disaster categories for Africa, and enter them as separate shocks in the regression.

Our main finding is that *floods steepen the domestic yield curve.* The differential impact of a flood shock on longer- versus shorter-maturity instruments is positive and statistically significant at impact and for two quarters thereafter. Storms produce no detectable steepening, likely reflecting the smaller scale of affected populations in African storm events relative to floods and droughts. Droughts produce a smaller but precisely estimated steepening at impact.

The effect is strongly concentrated among *high-debt sovereigns.* When we split the sample at the median government debt-to-GDP ratio, the flood-induced steepening in high-debt countries is roughly twice as large as in the full sample and more persistent. In

low-debt countries the effect is attenuated. The drought effect is statistically significant from impact through $h = 5$ in high-debt countries, whereas it is near zero elsewhere. A complementary split by the fiscal balance confirms the same pattern, indicating that both debt stock and fiscal flow matter. This heterogeneity is consistent with a fiscal-risk pricing mechanism: when fiscal space is thin, the market reprices longer-maturity debt more aggressively in response to disaster-induced fiscal deterioration.

Our empirical design centers on the instrument-level microdata. Each observation is a single bond or Treasury bill at issuance, which lets us trace out the term structure from within-country-quarter variation in maturity. In our most demanding specification, we include country×quarter fixed effects that absorb all variation at the country-quarter level—including the level component of each disaster shock—so that slope coefficients are identified exclusively from comparing instruments of different tenors issued in the same country in the same quarter. The flood and drought steepening effects in high-debt countries survive this saturated specification.

This paper contributes to the intersection of four literatures. First, it contributes to the literature on climate risk and sovereign borrowing costs, which has focused on average yields and spreads rather than the term structure. We show that the yield curve response is not uniform across maturities and not uniform across disaster types: floods steepen the curve, storms do not, and droughts contribute mainly in fiscally vulnerable economies. Second, it contributes to the literature on the macroeconomic consequences of natural disasters, which has decomposed growth and fiscal responses by disaster type but has not examined differential effects on the sovereign term structure. Third, it relates to the asset-pricing literature on the term structure of sovereign credit risk, which has examined theoretical implications of disaster and tail risk for yield components but has not tested how realised disaster events reshape domestic yield curves. Fourth, our Africa-specific focus addresses a geographical gap: most climate-sovereign risk evidence comes from Caribbean small island states or broad cross-country panels, while the African domestic debt market—thin, heterogeneous, and highly exposed to disaster risk—has received little systematic attention.

The remainder of the paper is organized as follows: Section 2 reviews the related literature, Section 3 describes the data sources, Section 4 presents the empirical strategy, Section 5 reports the main results, Section 6 presents a robustness check, and Section 7 concludes.

2 Literature Review

This paper connects four strands of literature: the macroeconomic and fiscal effects of natural disasters, the link between climate risk and sovereign borrowing costs, the term structure of sovereign credit risk, and the emerging data infrastructure for African sovereign debt.

Macroeconomic and fiscal effects of natural disasters

A large body of work documents the macroeconomic consequences of natural disasters. Noy (2009) provides early cross-country evidence that disasters reduce output growth, with effects concentrated in developing countries where institutional capacity and financial depth are weaker. Raddatz (2009) estimates that climatic disasters reduce real GDP per capita by at least 0.6 percent, with droughts producing the largest cumulative losses. Loayza et al. (2012) decompose disaster effects by type and economic sector, showing that the sign and magnitude of growth impacts depend on disaster severity and the structure of the affected economy—moderate floods, for instance, can have positive effects in some sectors, while severe disasters are uniformly negative.

The fiscal channel is central to the transmission from disasters to sovereign borrowing conditions. Noy and Nualsri (2011) estimate a panel VAR using quarterly data for 1990–2005 and find that developed countries mount countercyclical fiscal responses after disasters—expanding spending and accepting temporary deficits—while developing countries adjust pro-cyclically, cutting expenditure even as revenues rise. This asymmetry implies that the sovereigns most exposed to disaster risk are also those least able to smooth the fiscal adjustment, generating financing pressure that propagates into debt

markets. Acevedo (2014) documents a related pattern for Caribbean states, showing that floods increase the debt-to-GDP ratio while storms do not, a difference for which the author finds weak evidence of a role for external aid and debt relief that follows high-visibility storm events but not floods. Klomp (2017) extends this line of inquiry to a broader sample and finds that large-scale disasters raise the probability of sovereign default by approximately three percentage points, with earthquakes and storms contributing the most through widespread physical damage.

Climate risk and sovereign borrowing costs

A more recent literature connects climate vulnerability directly to the pricing of sovereign debt. Çevik and Jalles (2022) provide cross-country evidence from 98 countries over 1995–2017 that both climate vulnerability and resilience are priced into sovereign bond yields and spreads, with vulnerability raising borrowing costs and resilience lowering them. Mallucci (2022) develops a quantitative sovereign default model with disaster risk calibrated to Caribbean small island states and shows that disaster exposure reduces the government's ability to issue debt, with climate change further restricting market access by increasing the frequency and severity of shocks. Beirne et al. (2021) estimate the effect of climate risk on sovereign borrowing costs for 40 advanced and emerging economies, finding that countries with higher climate vulnerability face elevated bond yields and that this premium has increased over time. Kling et al. (2025) provide the first systematic estimate of the climate vulnerability premium on sovereign debt, finding that 40 members of the V20 climate-vulnerable forum paid an estimated USD 62 billion in additional interest over 2007–2016 due to their climate exposure, and that investments in social readiness can partially offset this premium. Anyfantaki et al. (2025) analyse a panel of 52 advanced and emerging economies over 2000–2023 and document a key nonlinearity: physical climate risk has no measurable impact on sovereign yields on average, but raises borrowing costs significantly in highly indebted economies, pointing to fiscal space as a critical moderator.

These contributions establish that climate and disaster risk affect the *level* of sovereign

borrowing costs. However, they focus almost exclusively on average yields, spreads, or ratings—treating the yield curve as a single price. Whether disasters affect short- and long-term borrowing costs differentially—that is, whether they *reshape the yield curve*—remains an open question. This distinction is economically important: if disasters steepen the yield curve, long-term borrowing becomes disproportionately more expensive, creating an incentive to shift toward short-term rollover strategies that carry their own risks.

The term structure of sovereign credit risk

A separate literature in asset pricing studies the determinants of the sovereign credit risk term structure. Augustin (2018) examines the slope of the CDS term structure across sovereigns and finds that the relative importance of global versus domestic risk factors varies with the shape of the curve: when the CDS slope is positive, global shocks dominate, while a negative slope signals that domestic fundamentals are the primary driver of credit risk variation. Barro (2006) shows that the potential for rare economic disasters—calibrated to twentieth-century GDP contractions across 35 countries—can explain several asset-pricing puzzles, including the high equity premium and low risk-free rate, by introducing a small probability of large output drops. Borensztein et al. (2009) apply catastrophic risk modelling to sovereign debt sustainability in Belize and argue that disaster insurance can improve debt sustainability by reducing the variance of fiscal outcomes. Closest to our setting, Moench and Schaal (2025) estimate local projections on a global panel of sovereign yields and document that high-debt advanced economies see larger term-premium responses to extreme weather events, while low-debt economies primarily reprice expected short rates.

Together, these papers establish that disaster and tail risk have term-structure implications for sovereign yields. We complement this literature—most directly Moench and Schaal (2025)—by estimating the slope response at the instrument level, exploiting within-country-quarter variation in maturity across a comprehensive panel of African domestic sovereign debt.

African sovereign debt data

A practical constraint on studying African sovereign debt has been the absence of comprehensive instrument-level data, particularly for domestic debt. Presbitero et al. (2016) document the characteristics of international sovereign bond issuance by developing countries, showing that only a subset of Sub-Saharan African countries access international markets and that those that do face higher spreads than comparable issuers elsewhere. The domestic market—which accounts for the majority of public debt in many African countries—has been harder to study due to the fragmentation of issuance records across central bank auction results, finance ministry reports, and stock exchange bulletins. Manger et al. (2025) address this gap with the African Debt Database, which compiles over 50,000 individual debt instruments across 54 countries over 2000–2025. The instrument-level granularity of these data enables the within-country-quarter maturity comparisons that are central to our identification strategy, and distinguishes our approach from the country-level panel regressions used in the existing climate-sovereign risk literature.

Our contribution

This paper contributes to the intersection of these literatures. First, we move beyond average yields and spreads to estimate how disasters reshape the *term structure* of domestic borrowing costs, complementing the country-level global panel evidence of Moench and Schaal (2025). Second, we decompose the yield curve response into supply-side (coupon) and demand-side (price) components and find that both channels contribute to the steepening. Third, working at the instrument level, we identify the slope response by comparing bonds and bills of different maturities issued in the same country and quarter—a within-quarter comparison that isolates how disasters differentially affect short and long maturities. Fourth, our Africa-specific focus addresses a geographical gap: the climate-sovereign risk literature has concentrated on Caribbean small island states (Mallucci, 2022) or broad cross-country panels (Çevik and Jalles, 2022; Beirne et al., 2021), while the African domestic debt market—thin, heterogeneous, and highly exposed to disaster

risk—has received little systematic attention.

3 Data

We combine three data sources: instrument-level domestic sovereign debt microdata from the African Debt Database, event-level natural disaster records from EM-DAT, and macroeconomic aggregates from the Global Macro Database. The three sources are merged at the country-quarter level to form the estimation panel.

3.1 The African Debt Database

The domestic debt data are drawn from the African Debt Database (ADD), compiled by Manger et al. (2025). The ADD records the terms of over 50,000 individual sovereign debt instruments across 54 African countries over 2000–2025, totalling approximately USD 6.3 trillion. It is, to our knowledge, the first dataset to provide comprehensive instrument-level coverage of domestic sovereign debt across the continent. The domestic component of the ADD is assembled from central bank auction results, finance ministry reports, stock exchange bulletins, and central securities depository records across 43 countries.

Each instrument record includes the creditor identity, instrument type (Treasury bill or bond), interest rate at issuance, coupon rate, issuance price, maturity, and disbursed amount in both local currency and US dollars. We restrict the sample to domestic market issuances denominated in local currency and apply a series of data quality filters detailed in Section 4—excluding inflation-linked bonds, foreign-currency instruments, coupon and price outliers, zero-yield or zero-maturity records, ultra-short instruments with maturity below 0.1 years, and countries with fewer than 20 quarterly observations over the sample period. After these exclusions, the estimation sample comprises approximately 47,000 instruments across 39 countries.

The sample is composed primarily of Treasury bills (about 70%) and bonds (about 30%). The two instrument types occupy different segments of the maturity spectrum:

bills have a median maturity of 6 months, while bonds have a median maturity near 6 years. This maturity separation is central to our identification strategy, as the within-country-quarter variation in maturity across bills and bonds traces out the yield curve and allows us to estimate how disasters differentially affect short- and long-term borrowing costs.

3.2 Disaster Data

Natural disaster data are drawn from the EM-DAT International Disaster Database, which records event-level information on disaster type, location, timing, and humanitarian impact. For each African country-quarter in our sample, we compute three separate measures of disaster intensity: the affected population from *floods*, from *storms*, and from *droughts*. We focus on these three categories for two reasons. First, they are directly climate-related: their frequency and severity are projected to intensify with climate change. Second, they account for the overwhelming majority of disaster events in Africa over 2000–2024 (approximately 980 flood, 230 storm, and 175 drought events in EM-DAT, together accounting for roughly 90% of the ∼1,540 African disaster events in the database). Other disaster types—wildfires, earthquakes, volcanic activity, mass movements, extreme temperature events—are less common, more geophysically heterogeneous, or less directly affected by climate dynamics, and we do not include them as separate regressors. Our treatment variables are the inverse hyperbolic sine transformations of the affected-population share for each of the three types, as described in Section 4.[1] We use the affected-population share rather than reported monetary damages because damage coverage in EM-DAT is sparse for African events: only about 13% of flood, storm, and drought records carry a total-damage figure, whereas over 90% report the affected population.

[1]The inverse hyperbolic sine (IHS) transformation, $\operatorname{arcsinh}(x) = \ln\left(x + \sqrt{x^2+1}\right)$, approximates the natural logarithm for large values of x while remaining well-defined at zero; it is therefore well suited to variables with many zero observations, such as the share of population affected by disasters in a given quarter.

3.3 Macroeconomic Data

Macroeconomic and fiscal data are drawn from the Global Macro Database (GMD), as described in Müller et al. (2025). The GMD provides harmonised annual series compiled from major international databases (IMF, World Bank, OECD) and historical sources across 243 countries. We use four control variables: central government debt-to-GDP, the general government fiscal balance-to-GDP (a signed variable: negative values denote a deficit), real GDP growth, and the current account balance-to-GDP. The series are available at annual frequency; within each country-year, they enter the quarterly estimation panel as the annual value from the previous year, ensuring that macro conditions are pre-determined relative to the disaster shock.

3.4 Sample Overview

Figure 1 displays the country-year coverage of the African Debt Database domestic data, distinguishing between years in which a country's domestic market data include Treasury bills only, bonds only, or both. Coverage begins with a handful of countries in 2000 and expands progressively as central bank auction records and finance ministry reports become available, reaching 43 countries by 2022; of these, 39 enter our estimation sample after applying the data quality filters described in Section 4. Most countries enter the sample with bill data first and add bond data in later years.

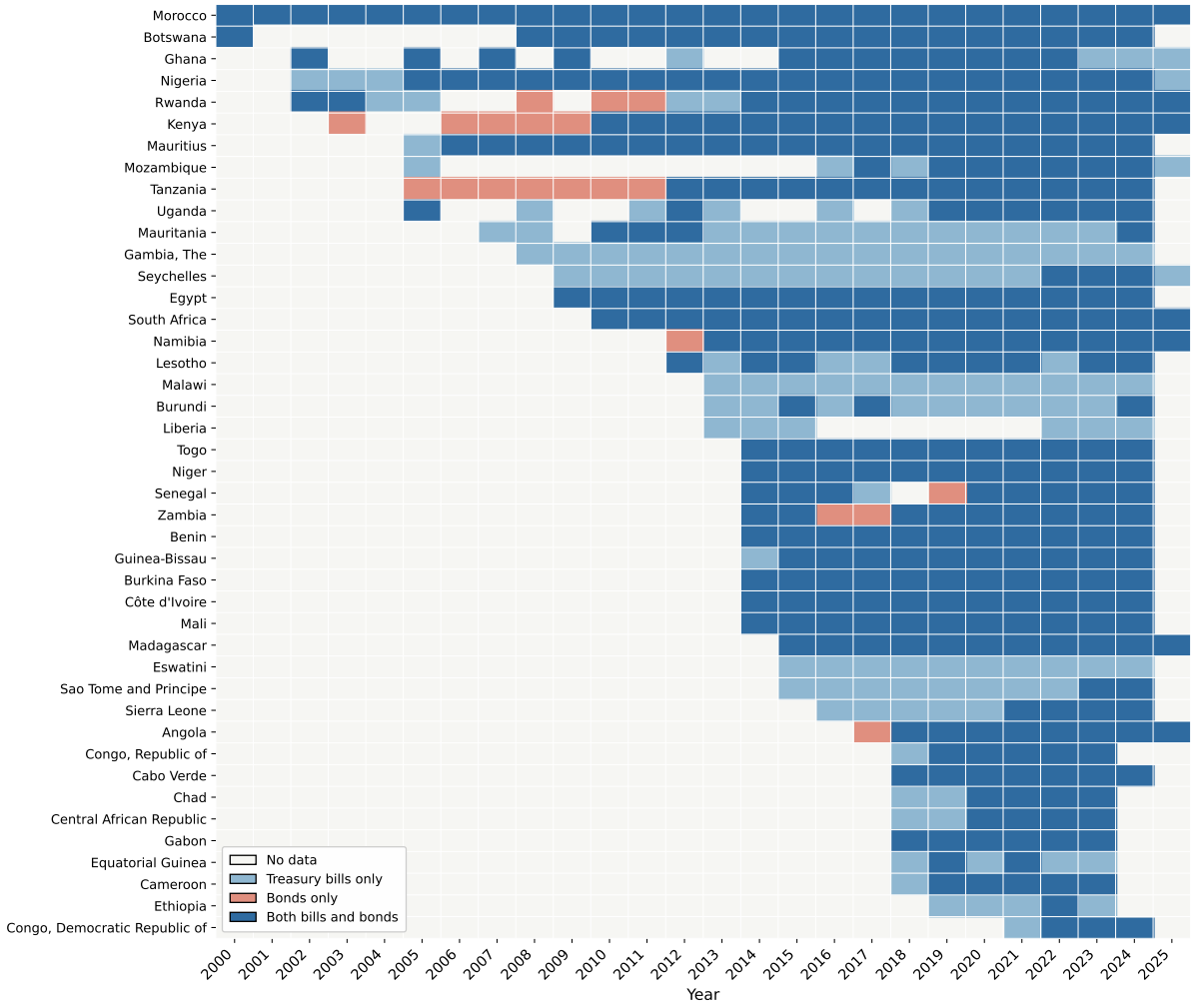


Figure 1: Country-Year Coverage of Domestic Debt Data

Notes: Each cell indicates whether the African Debt Database contains domestic-currency instruments for a given country-year combination, and whether the available instruments are Treasury bills only (light blue), bonds only (coral), or both (dark blue). White cells indicate no data. Countries are sorted by first year of data availability. The figure shows the 43 countries covered by the ADD's domestic component over 2000–2025; four of these (Central African Republic, Democratic Republic of the Congo, Ethiopia, Liberia) are dropped from our estimation sample for having fewer than 20 quarters of data, leaving 39 countries.

Table 1 reports descriptive statistics for the estimation sample. Panel A describes the instrument-level variables, separately for Treasury bills and bonds. Panel B reports statistics for the three disaster shocks (in IHS-transformed affected-population units), conditional on non-zero shocks. Panel C reports the macroeconomic controls at the country-year level.

Table 1: Descriptive Statistics

	N	Mean	SD	P10	P25	P50	P75	P90
Panel A: Instrument-level variables								
Yield at issuance (%)	46,950	10.38	6.40	3.41	5.64	8.98	13.91	18.94
Maturity (years)	46,950	3.23	5.91	0.25	0.50	0.98	2.87	10.01
Treasury bills (N = 33,018; 70.3% of sample)								
Yield at issuance (%)	33,018	9.91	6.31	3.21	5.37	8.21	13.43	18.05
Maturity (years)	33,018	0.59	0.30	0.25	0.25	0.50	1.00	1.00
Bonds (N = 13,932; 29.7% of sample)								
Yield at issuance (%)	13,932	11.49	6.48	3.95	6.50	10.15	14.90	23.00
Maturity (years)	13,932	9.48	7.87	2.00	3.01	6.67	14.15	21.84
Panel B: Disaster shocks (IHS of affected population %, non-zero CQs)								
Floods	763	0.397	0.710	0.003	0.015	0.100	0.404	1.237
Storms	179	0.443	0.792	0.000	0.005	0.042	0.529	1.611
Droughts	131	2.820	1.218	1.190	1.976	2.850	3.874	4.333
Panel C: Macroeconomic controls (country-year)								
Govt. debt / GDP (%)	1,033	63.54	60.94	18.21	30.52	47.92	74.52	119.32
Fiscal balance / GDP (%)	1,265	−2.38	7.87	−7.78	−4.88	−2.64	−0.70	2.71
Real GDP growth (%)	1,339	4.00	6.28	−1.07	2.10	4.26	6.31	8.49
Current account / GDP (%)	1,294	−4.83	10.58	−14.81	−9.08	−4.44	−0.78	6.75

Notes: Sample comprises 46,950 domestic-currency instruments issued across 39 African countries over 2000–2025, after the data quality filters described in Section 4. Panel B reports statistics for the IHS-transformed affected-population shock *conditional on a non-zero shock*, separately for floods, storms, and droughts. Note that droughts affect much larger shares of the population per event than floods and storms (median $\sinh(2.850) \approx 8.5\%$ vs $\sinh(0.100) \approx 0.10\%$), reflecting the slow-onset nature of droughts. Panel C reports lagged macroeconomic controls from the Global Macro Database (Müller et al., 2025). The median government debt-to-GDP ratio, used to split the sample for the heterogeneity analysis, is 48.7%.

4 Empirical Strategy

4.1 Instrument-Level Local Projections

We estimate the effect of natural disasters on the domestic yield curve using the local projections (LP) framework of Jordà (2005). The central feature of our design is that we work at the *instrument level*: each observation is a single bond or Treasury bill at its issuance date, rather than a country-quarter aggregate. Instruments issued in the same country-quarter but with different maturities trace out the yield curve, allowing us to identify how disasters reshape the term structure of borrowing costs. Floods, storms, and droughts enter the regression as separate shocks, together with their maturity interactions, so that each disaster type has its own level and slope coefficient.

Let $y_{i,c,\tau}$ denote the yield at issuance for instrument i issued in country c during quarter τ, and let m_i denote the instrument's maturity in years. For each disaster type $d \in \{\text{Flood}, \text{Storm}, \text{Drought}\}$, let $D^d_{c,\tau-h}$ denote the IHS-transformed affected-population shock of type d, measured h quarters before the instrument's issuance date. We estimate a separate regression for each horizon $h = 0, 1, \ldots, 8$:

$$\begin{aligned} y_{i,c,\tau} = \alpha_c + \delta_\tau + \sum_d \beta^h_{1,d}\, D^d_{c,\tau-h} + \sum_d \beta^h_{2,d}\, \left(D^d_{c,\tau-h} \times m_i\right) + \gamma_1\, m_i + \boldsymbol{\gamma}'\mathbf{X}_{c,\tau-h} \\ + \eta_1\, \mathbf{1}_{\text{bond},i} + \eta_2\, \left(\mathbf{1}_{\text{bond},i} \times m_i\right) \\ + \sum_d \phi^d_1\, D^d_{c,\tau-h-1} + \sum_d \phi^d_2\, D^d_{c,\tau-h-2} + \varepsilon_{i,c,\tau} \end{aligned} \tag{1}$$

where α_c denotes country fixed effects and δ_τ quarter-of-issuance fixed effects. The country fixed effects absorb time-invariant differences in sovereign borrowing costs across countries; the quarter fixed effects absorb global common shocks such as shifts in risk appetite, commodity price cycles, and international monetary conditions. The instrument-type dummy $\mathbf{1}_{\text{bond},i}$ and its interaction with maturity account for systematic differences between Treasury bills and bonds. Two lags of each disaster shock ($D^d_{c,\tau-h-1}$ and $D^d_{c,\tau-h-2}$) are included to absorb pre-trends and serial correlation in disaster exposure.

The coefficients of interest are $\{\beta^h_{2,d}\}_{d=\text{Flood,Storm,Drought}}$. Each captures the *slope* effect

for its disaster type: whether a shock of that type differentially affects longer-maturity instruments relative to shorter ones. The coefficients $\{\beta^h_{1,d}\}$ capture the corresponding *level* shifts in borrowing costs following a disaster of type d h quarters earlier.

The vector $\mathbf{X}_{c,\tau-h}$ includes four lagged macroeconomic controls: central government debt-to-GDP, the general government fiscal balance-to-GDP (signed; negative values denote a deficit), real GDP growth, and the current account balance-to-GDP. The identifying assumption is that, conditional on country and quarter fixed effects, the macroeconomic controls, and the lags of all three shocks, the disaster shocks are orthogonal to unobserved determinants of instrument-level borrowing costs. As a robustness check, we also estimate a more demanding specification that replaces the separate country and quarter fixed effects with a full set of country×quarter fixed effects (Section 6); in that specification, the level coefficients $\{\beta^h_{1,d}\}$ are absorbed and the slope coefficients are identified exclusively from within-country-quarter variation in maturity.[2]

4.2 Treatment Variables

The three disaster shocks are constructed from the Emergency Events Database (EM-DAT). For each country-quarter and each disaster type d, we compute the share of the total population affected by events of type d and apply the inverse hyperbolic sine (IHS) transformation (Burbidge et al., 1988):

$$D^d_{c,\tau} = \operatorname{arcsinh}\big(\text{Affected}^d_{c,\tau}/\text{Pop}_{c,\tau} \times 100\big)\,. \tag{2}$$

The IHS transformation approximates the natural logarithm for large values while accommodating the mass of zeros in the disaster distribution. The affected-population counts are computed separately by disaster type from the event-level EM-DAT data, so each shock reflects only events of the corresponding type. A one-unit increase in any shock corresponds to a disaster of that type affecting approximately 1.2% of the population.

[2]Standard errors are clustered at the country level throughout. With 39 countries in the sample, the number of clusters is sufficient for reliable asymptotic inference. We report statistical significance at the 10%, 5%, and 1% levels.

4.3 Sample Construction

Starting from the domestic-currency instrument universe described in Section 3, we apply several data quality filters. First, we exclude South African inflation-linked bonds, which carry real coupons of 2–3.5% and would be compared within the same country-quarter to nominal bonds with coupons of 8–10%, conflating the inflation-linked/nominal distinction with the maturity dimension.[3] Second, we exclude foreign-currency-denominated domestic instruments (primarily Angolan USD-denominated bonds). Third, we exclude a small number of coupon outliers exceeding 20%, which are likely data errors. Fourth, we exclude instruments with a recorded price of zero or a price exceeding 150% of par, which reflect missing data coded as zeros and extreme reopening prices. Fifth, we exclude instruments with yields below zero or above 50%, which are data errors arising from the price anomalies described above. Sixth, we drop instruments with a recorded maturity of zero or below 0.1 years, since ultra-short instruments have auction-specific yield dynamics unrelated to the term structure. Finally, we retain only countries with at least 20 quarterly observations (five years of data) over the sample period, to ensure meaningful within-country time-series variation. Observations from 2026 (a partial year with only 20 instruments) are also dropped.

After these exclusions, the estimation sample comprises 46,950 instruments across 39 countries over 2000–2025 (104 quarters).[4] Because each observation is an instrument that was actually issued at auction, the specification identifies the yield response *conditional on issuance* rather than a hypothetical structural yield curve covering all possible tenors; if disasters induce governments to skip issuing long bonds or investors to stop bidding at the long end, the estimated slope could partly reflect this selection. We return to this caveat in Section 6, where we re-estimate on the subsample of country-quarters in which at least one bill and at least one bond are issued.

[3] We identify these as South African domestic bonds with a coupon below 4%, which corresponds to the known set of South African government inflation-linked bonds.

[4] One country has no country-quarter observations with complete macroeconomic controls, so the baseline yield regressions are estimated on 38 country clusters; the country×quarter fixed-effect specification, which absorbs the macro controls, uses all 39.

5 Results

This section presents the main results of estimating Equation (1) at horizons $h = 0$ through $h = 8$ quarters. We first report the full-sample estimates (Section 5.1), then examine the heterogeneity by country debt level (Section 5.2).

5.1 Full-Sample Estimates

Table 2 reports the slope coefficients for the three disaster shocks, jointly estimated on the full sample, and Figure 2 displays the corresponding impulse response functions.

The dominant finding is that *floods steepen the domestic yield curve at issuance*: longer-maturity instruments issued after a flood clear auction at disproportionately higher yields than shorter-maturity ones issued in the same country and quarter. The flood-maturity interaction is positive and statistically significant at impact (0.126, $p < 0.10$), rises to its peak at $h = 1$ (0.257, $p < 0.01$) and $h = 2$ (0.232, $p < 0.05$), and becomes statistically indistinguishable from zero thereafter. At the peak, a one-unit increase in the IHS-transformed flood shock—equivalent to a flood affecting approximately 1.2 percent of the population—raises the yield on a 10-year bond by roughly 2.3 percentage points more than on a 1-year bill.

Storms, by contrast, produce no steepening at any horizon. All storm-maturity coefficients in the full sample are statistically indistinguishable from zero. We interpret this null with caution.[5]

Droughts produce a small but precisely estimated steepening at impact (0.024, $p < 0.10$), which dissipates quickly. In the full sample the drought effect is modest relative to floods.

[5]Two features of the data caution against reading the storm null as a precisely estimated zero. First, storm events in Africa affect a considerably smaller share of the population than floods or droughts: the median non-zero storm quarter affects 0.04% of the population, compared with 0.10% for floods and 8.6% for droughts, so storm shocks occupy a much narrower range of the treatment distribution. Second, storm exposure is heavily concentrated in a small number of cyclone-prone countries—Madagascar alone accounts for roughly 18% of non-zero storm country-quarters—which thins the within-country variation available to identify the slope coefficient. The combination of small per-event magnitudes and narrow geographic coverage limits statistical power at longer maturities, where relatively few bond issuances coincide with storm quarters.

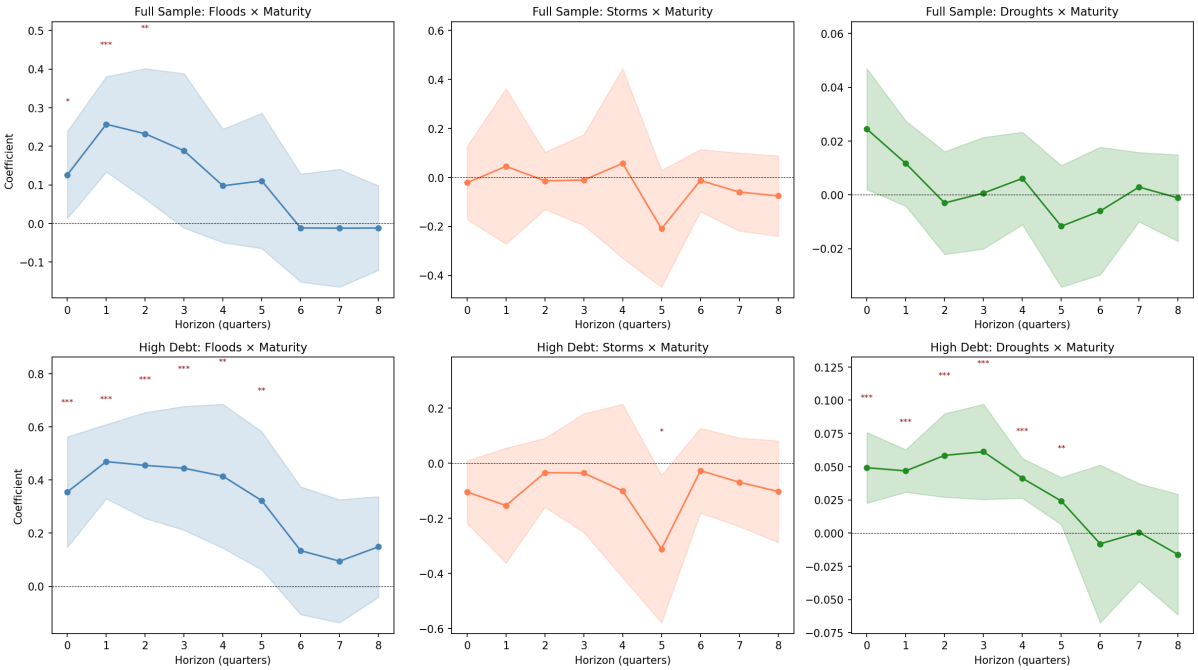


Figure 2: Impulse Response Functions: Three Disaster Types

Notes: The figure plots the slope coefficients ($\hat{\beta}^h_{2,d}$, $d\times$maturity) from Equation (1) for floods, storms, and droughts, for horizons $h = 0, \ldots, 8$ quarters. Top row: full sample. Bottom row: high-debt subsample. Shaded areas denote 90% confidence intervals based on country-clustered standard errors. Stars: $^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 2: Yield at Issuance: Flood, Storm, and Drought Shocks (Full Sample)

	$h=0$	$h=1$	$h=2$	$h=3$	$h=4$	$h=5$	$h=6$	$h=7$	$h=8$
Flood × maturity	0.126*	0.257***	0.232**	0.188	0.098	0.110	−0.012	−0.012	−0.012
	(0.069)	(0.075)	(0.103)	(0.122)	(0.089)	(0.107)	(0.085)	(0.093)	(0.066)
Storm × maturity	−0.022	0.045	−0.014	−0.011	0.057	−0.210	−0.013	−0.060	−0.076
	(0.091)	(0.193)	(0.071)	(0.113)	(0.235)	(0.145)	(0.077)	(0.097)	(0.100)
Drought × maturity	0.024*	0.012	−0.003	0.001	0.006	−0.012	−0.006	0.003	−0.001
	(0.014)	(0.010)	(0.012)	(0.013)	(0.010)	(0.014)	(0.014)	(0.008)	(0.010)
R^2_{adj}	0.746	0.743	0.743	0.746	0.748	0.749	0.757	0.761	0.760
N	28,848	29,630	30,611	31,624	32,633	33,419	34,370	35,227	35,859
Countries	38	38	38	38	38	38	38	38	38

The following subsection examines how this effect varies with the sovereign's fiscal space.

5.2 Heterogeneity by Debt and Fiscal Space

A sovereign's debt position is a natural candidate for heterogeneity in how disasters are priced into borrowing costs. In a global panel of 52 advanced and emerging economies, Anyfantaki et al. (2025) find that physical climate risk has no effect on sovereign yields in the full sample but a significant positive effect in the high-debt subsample, suggesting that bond markets price climate-related physical risk primarily in fiscally vulnerable economies. Motivated by this evidence, we examine whether the yield curve steepening we document varies with the sovereign's debt burden. For each country-quarter we compare the lagged central-government debt-to-GDP ratio to the sample median (48.7%) and classify the observation as *high-debt* if it lies at or above the median and *low-debt* otherwise. The split therefore operates at the country-quarter level: a given country can contribute observations to both subsamples across time as its debt ratio evolves, and observations from different horizons for the same instrument can also fall in different subsamples because the shock is measured at time $\tau - h$. Of the 38 countries in the full-sample regression, 31 record at least one quarter at or above the median; the remaining 7 are always below and therefore contribute only to the low-debt subsample. Table 3 reports the estimates for the high-debt subsample; the bottom row of Figure 2 plots the corresponding IRFs.

The results are striking. In high-debt countries, the flood-maturity interaction is positive and statistically significant at every horizon from impact through $h = 5$, with peak magnitudes of 0.469 ($p < 0.01$) at $h = 1$ and 0.455 ($p < 0.01$) at $h = 2$. This is roughly *twice* the full-sample estimate and persists for longer: the flood steepening remains significant at the 5% level at $h = 4$ and $h = 5$, whereas in the full sample it has already dissipated by $h = 3$.

Droughts also become important in the high-debt subsample. The drought-maturity interaction is significant at conventional levels from impact through $h = 5$, with coefficients ranging from 0.024 to 0.061. Although the per-unit magnitudes are smaller than for floods, the drought shock variable has a much wider range—the 90th percentile of the IHS-transformed drought shock is 4.3 versus 1.2 for floods (Panel B of Table 1)—so

the implied yield curve response to a severe drought is comparable in magnitude. The fact that the drought effect is precisely estimated across six consecutive horizons provides strong evidence that slow-onset climate shocks also transmit to sovereign borrowing conditions when the debt buffer is thin. Storms show no coherent steepening pattern in the high-debt subsample; one isolated negative coefficient appears at $h = 5$.

To understand where these slope responses come from, we combine the level and slope coefficients from the same regression to predict the yield change at representative maturities. At the peak horizon $h = 1$ in high-debt countries, a one-unit flood shock is predicted to lower the yield on a 6-month bill by roughly 1.6 percentage points and raise the yield on a 10-year bond by about 2.8 percentage points, with a crossover near four years. The flood-induced steepening is therefore two-sided: short-end yields fall while long-end yields rise, consistent with stronger demand for short paper and a larger term premium at the long end. The drought pattern is different—the predicted 6-month response is about -0.5 percentage points and the 10-year response is close to zero, so the drought steepening comes almost entirely from the short end falling rather than the long end rising. Storms show no meaningful movement at either maturity. In the full sample, the flood pattern is qualitatively similar but attenuated, with a modest decline at the short end and a clearer rise at the long end.

A complementary way to read the steepening is to ask whether it comes from the supply side—governments setting higher coupons on longer-dated issues after a shock—or from the demand side—investors bidding down prices on longer-dated issues. Re-estimating the same specification with instrument-level coupon and issue price as dependent variables (reported in appendix Tables 7 and 8), we find that floods in high-debt countries activate both channels simultaneously: the coupon-maturity coefficient is positive and significant at $h = 1$ through $h = 5$, peaking at $+0.14$ per year of maturity, while the price-maturity coefficient is significantly negative at the same horizons, with magnitudes around -1.0. Droughts, by contrast, leave coupons essentially unchanged but produce significantly negative price-maturity coefficients at every horizon from $h = 0$ through $h = 8$, so the drought steepening is entirely a demand-side response. Storms

show no coherent coupon response and a positive price-maturity response that points to mild flattening rather than steepening—consistent with the absence of storm steepening in the main yield regression. The coupon regression is restricted to bonds with a positive coupon, which reduces the high-debt cluster count to 10 countries; the coupon standard errors should accordingly be interpreted with some caution.

We further test whether fiscal flow conditions also matter by re-splitting the sample at the median lagged general-government fiscal balance-to-GDP ratio (-2.6%, i.e., the median observation runs a 2.6% deficit). We label observations with balances at or below the median—i.e., the larger-deficit half—the *high-deficit* subsample, and the complement the *low-deficit* subsample. In the high-deficit subsample the flood-maturity coefficient is positive and significant at the 1% level at horizons $h = 0$ through $h = 3$, with a peak of 0.39 at $h = 2$ (appendix Table 9), while in the low-deficit subsample it is indistinguishable from zero. Drought and storm slopes in the high-deficit subsample are essentially null. These results reinforce the role of fiscal conditions in the term-structure response to disasters.

Taken together, the debt-based and deficit-based splits point in the same direction: the steepening response is concentrated in countries with less fiscal space—whether because the debt stock is elevated or because the current fiscal flow is already stretched. This heterogeneity is consistent with a fiscal-risk pricing mechanism in which investors reprice longer-maturity debt more aggressively when the sovereign has little room to absorb disaster-induced fiscal deterioration, and it is muted in countries with more fiscal room.

Table 3: Yield at Issuance: Flood, Storm, and Drought Shocks (High-Debt Countries)

	$h=0$	$h=1$	$h=2$	$h=3$	$h=4$	$h=5$	$h=6$	$h=7$	$h=8$
Flood × maturity	0.355^{***}	0.469^{***}	0.455^{***}	0.444^{***}	0.415^{**}	0.322^{**}	0.134	0.095	0.149
	(0.126)	(0.085)	(0.121)	(0.142)	(0.165)	(0.158)	(0.146)	(0.141)	(0.115)
Storm × maturity	−0.105	−0.153	−0.034	−0.036	−0.101	-0.311^{*}	−0.027	−0.069	−0.103
	(0.069)	(0.127)	(0.076)	(0.131)	(0.191)	(0.163)	(0.093)	(0.098)	(0.112)
Drought × maturity	0.049^{***}	0.047^{***}	0.058^{***}	0.061^{***}	0.041^{***}	0.024^{**}	−0.008	0.000	−0.016
	(0.016)	(0.010)	(0.019)	(0.022)	(0.009)	(0.011)	(0.036)	(0.022)	(0.028)
R^2_{adj}	0.791	0.787	0.789	0.792	0.795	0.797	0.804	0.811	0.812
N	17,402	17,736	18,183	18,716	19,241	19,581	20,032	20,418	20,640
Countries	31	31	31	31	31	31	31	31	31

6 Robustness

6.1 Country×Quarter Fixed Effects

Our main specification uses separate country and quarter fixed effects, which identifies both level and slope effects from the full variation in the disaster shocks. A natural concern is that time-varying country-level shocks—coinciding with both disaster exposure and borrowing conditions—may confound the results. To address this, we re-estimate Equation (1) replacing the separate country and quarter fixed effects with a full set of country×quarter fixed effects. This absorbs all variation at the country-quarter level, including the disaster shock levels themselves, and identifies the three slope coefficients exclusively from within-country-quarter variation in maturity: comparing instruments of different tenors issued in the same country in the same quarter.

Tables 4 and 5 report the results for the full sample and the high-debt subsample, respectively. Because the disaster shock levels are absorbed, only the slope coefficients are reported. Figure 3 displays the corresponding IRFs.

The flood steepening survives this much more demanding specification. In the high-debt subsample, the flood-maturity coefficient is statistically significant at $h = 1$ through $h = 4$, with point estimates of 0.21–0.33 that are smaller than in the baseline but still

economically meaningful. The drought-maturity coefficient is statistically significant at conventional levels at every horizon from $h = 0$ through $h = 8$ in the high-debt subsample, with coefficients in the range 0.035–0.050—virtually identical in magnitude to the baseline. Storms again show no consistent steepening pattern: most coefficients are indistinguishable from zero, and the few isolated significant estimates in the full sample lack a coherent profile across horizons. Taken together, the saturated fixed-effects results confirm that the flood and drought steepening is not driven by aggregate country-quarter shocks that happen to correlate with disaster occurrence.[6]

Table 4: Yield at Issuance: Country×Quarter Fixed Effects (Full Sample)

	$h=0$	$h=1$	$h=2$	$h=3$	$h=4$	$h=5$	$h=6$	$h=7$	$h=8$
Flood × maturity	0.083	0.112*	0.126*	0.131	0.094	0.112	0.022	0.089	0.046
	(0.066)	(0.067)	(0.074)	(0.085)	(0.087)	(0.096)	(0.057)	(0.093)	(0.064)
Storm × maturity	0.072	0.105	0.061	0.076	0.196***	0.115	0.065	0.122	0.121*
	(0.096)	(0.090)	(0.104)	(0.104)	(0.055)	(0.122)	(0.105)	(0.076)	(0.065)
Drought × maturity	0.020	0.017	0.010	0.012	0.013	0.001	0.013***	0.021***	0.026**
	(0.013)	(0.017)	(0.012)	(0.011)	(0.010)	(0.008)	(0.004)	(0.008)	(0.011)
R^2_w	0.308	0.306	0.306	0.306	0.305	0.305	0.304	0.305	0.306
N	46,121	46,468	46,628	46,715	46,739	46,705	46,677	46,645	46,610
CQ cells	1,667	1,675	1,678	1,678	1,678	1,677	1,676	1,675	1,674

[6]In an additional robustness check, we augment the baseline specification with two lags of each shock × maturity interaction to control for persistent slope effects from past disasters—a concern particularly relevant given the multi-quarter persistence of drought events. The contemporaneous slope coefficients are qualitatively and quantitatively unchanged; the only notable movement is that the drought-maturity coefficient becomes somewhat more significant, most visibly at $h = 0$ in the full sample (from $p < 0.10$ to $p < 0.05$).

Table 5: Yield at Issuance: Country×Quarter Fixed Effects (High-Debt Countries)

	$h=0$	$h=1$	$h=2$	$h=3$	$h=4$	$h=5$	$h=6$	$h=7$	$h=8$
Flood × maturity	0.165	0.208***	0.257**	0.326***	0.251*	0.214	0.081	0.182	0.167
	(0.110)	(0.063)	(0.128)	(0.106)	(0.139)	(0.140)	(0.132)	(0.148)	(0.137)
Storm × maturity	−0.048	−0.016	−0.080	−0.078	0.041	−0.231	−0.099	−0.075	−0.170*
	(0.078)	(0.173)	(0.069)	(0.091)	(0.207)	(0.178)	(0.088)	(0.070)	(0.094)
Drought × maturity	0.049***	0.050***	0.039***	0.045***	0.044***	0.038***	0.035*	0.041***	0.041**
	(0.006)	(0.012)	(0.009)	(0.013)	(0.013)	(0.010)	(0.018)	(0.015)	(0.019)
R^2_w	0.289	0.293	0.300	0.306	0.312	0.316	0.320	0.326	0.330
N	17,499	17,858	18,303	18,832	19,333	19,666	20,130	20,535	20,754
CQ cells	623	634	646	658	667	673	677	680	680

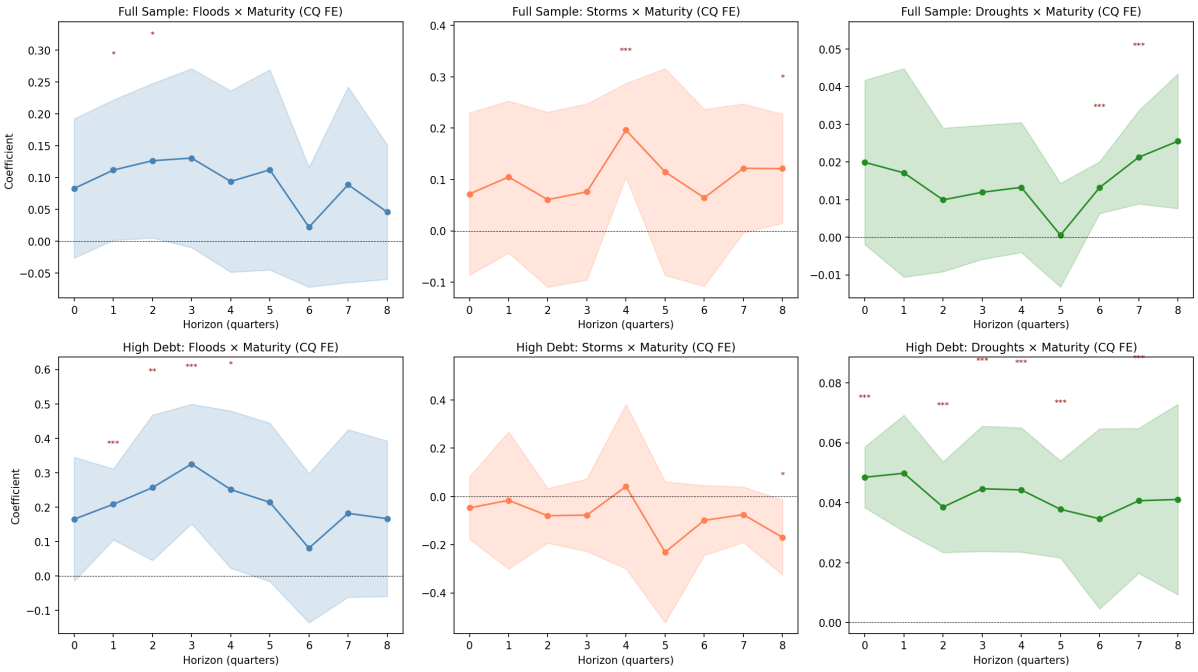


Figure 3: IRFs under Country×Quarter Fixed Effects

Notes: The figure plots the slope coefficients ($\hat{\beta}^h_{2,d}$) from Equation (1) with country×quarter fixed effects. Top row: full sample. Bottom row: high-debt subsample. The level coefficients are absorbed by the fixed effects. Shaded areas denote 90% confidence intervals based on country-clustered standard errors.

6.2 Country-Quarters with Both Bills and Bonds Issued

Each observation in the baseline regression is an instrument that was actually issued at auction. Because governments choose which maturities to issue after a disaster and

investors choose whether to bid, the estimates reflect yields on issued instruments rather than a structural yield curve covering all possible tenors. The specific concern is that disasters may induce governments to shift their issuance mix toward Treasury bills and away from bonds. If so, the estimated slope would partly reflect this bill-versus-bond composition selection rather than pure investor repricing.

To neutralize this margin, we re-estimate the baseline specification on the subsample of country-quarters in which at least one Treasury bill and at least one bond are issued. In these country-quarters, by construction, the government chose to issue across both tenor classes, so the slope is identified without having to extrapolate to a tenor class the government avoided. The restriction retains about 71% of instruments and 59% of country-quarters, with 34 countries represented.

Table 6 reports the results for the high-debt subsample. The flood-maturity coefficient remains positive and statistically significant at the 1% level at $h = 1$ through $h = 3$ and $h = 5$, with magnitudes of roughly 0.33–0.37—modestly attenuated at the earlier horizons relative to the baseline but comparable at $h = 5$. The drought-maturity coefficient is statistically significant at conventional levels across all horizons from $h = 0$ through $h = 7$, with magnitudes in the 0.03–0.04 range. Storms remain noisy, as in the main specification. The attenuation of the flood slope is consistent with some role for issuance selection in the full-sample estimates,[7] but the qualitative pattern—sharp flood-induced steepening and persistent drought-induced steepening in high-debt countries—survives the restriction.

[7]In the full-sample regression, the flood-maturity coefficient remains positive and significant at the 5% level at $h = 1$ (0.174); it is attenuated and loses significance at $h = 0$ and $h = 2$, where the baseline was significant. The attenuation is therefore more pronounced in the full sample than in the high-debt subsample.

Table 6: Yield at Issuance: High-Debt Countries, Country-Quarters with Both Bills and Bonds

	$h=0$	$h=1$	$h=2$	$h=3$	$h=4$	$h=5$	$h=6$	$h=7$	$h=8$
Flood × maturity	0.236*	0.361***	0.336***	0.369***	0.308**	0.334***	0.071	0.122	0.096
	(0.128)	(0.089)	(0.128)	(0.113)	(0.132)	(0.124)	(0.134)	(0.150)	(0.140)
Storm × maturity	−0.061	−0.077	−0.081	−0.080	−0.072	−0.267*	−0.083	−0.082	−0.179*
	(0.056)	(0.145)	(0.057)	(0.072)	(0.123)	(0.140)	(0.067)	(0.073)	(0.100)
Drought × maturity	0.034***	0.032***	0.033***	0.045***	0.042***	0.039***	0.035**	0.039**	0.027
	(0.006)	(0.008)	(0.011)	(0.015)	(0.011)	(0.010)	(0.018)	(0.015)	(0.018)
R^2_{adj}	0.827	0.830	0.837	0.843	0.846	0.850	0.858	0.866	0.866
N	10,915	11,185	11,559	12,007	12,461	12,757	13,189	13,473	13,581
Countries	23	23	23	24	24	24	24	24	24

7 Conclusion

This paper studies how climate-related natural disasters reshape the domestic yield curve in African countries. Using instrument-level microdata on approximately 47,000 domestic sovereign instruments from the African Debt Database, combined with event-level disaster records for floods, storms, and droughts, we estimate local projections that identify the term-structure response from within-country-quarter variation in maturity.

The central finding is that *floods steepen the domestic yield curve*: long-maturity yields rise sharply after a flood while short-maturity yields move by less and, in high-debt countries, decline outright. The differential effect emerges on impact, peaks at one to two quarters, and fades by the fourth quarter. Storms, by contrast, produce no detectable steepening, a result we interpret with caution given the smaller scale of African storm events and their concentration in a handful of cyclone-prone countries. Droughts produce a smaller but precisely estimated steepening at impact, and a much larger and persistent effect in high-debt countries.

The yield curve steepening is concentrated in *fiscally vulnerable economies*. Splitting the sample at the median government debt-to-GDP ratio, we find that the flood-maturity interaction is roughly twice as large in high-debt countries as in the full sample, and that

the drought steepening is statistically significant across six consecutive horizons in high-debt countries but not in low-debt ones. A complementary split by the fiscal balance yields the same pattern, indicating that both debt stock and fiscal flow matter. This heterogeneity is consistent with a fiscal-risk pricing mechanism: when fiscal space is thin, the market reprices longer-maturity debt more aggressively in response to disaster-induced fiscal deterioration. The pattern is robust to saturating the specification with country-by-quarter fixed effects, which identify the slope coefficients exclusively from within-country-quarter maturity variation.

These findings carry implications for fiscal policy and climate adaptation in disaster-prone economies. Under most projections, climate change will intensify the frequency and severity of both floods and droughts in Africa. Our results imply that this intensification will translate into persistently higher long-term borrowing costs for African sovereigns, disproportionately so for those already carrying elevated debt stocks. A government facing a steeper yield curve after a flood confronts an uncomfortable choice: borrow long at elevated rates, or substitute toward shorter-maturity instruments that carry rollover risk. Either response degrades the sovereign's debt profile. Pre-positioned contingent financing—catastrophe bonds, parametric insurance, or pre-approved credit lines triggered by disaster events—could attenuate this channel by reducing the need for emergency domestic issuance at the worst possible moment. Our heterogeneity results reinforce this point: the steepening is concentrated among high-debt countries, suggesting that contingent financing would be most valuable precisely where fiscal buffers are thinnest.

More broadly, our results suggest that standard debt sustainability analyses, which typically model disaster risk as a uniform shock to the level of borrowing costs, understate the fiscal implications by ignoring the maturity dimension. Incorporating the term-structure dimension into climate-augmented debt sustainability frameworks would provide a more complete picture of the fiscal risks that disaster-prone African sovereigns face.

Several limitations point toward future work. Our evidence on storms should be inter-

preted with caution: storm events in Africa affect a much smaller share of the population than floods or droughts, and exposure is concentrated in a handful of cyclone-prone countries. The null result likely reflects low statistical power as much as an economically zero effect. A richer structural model of investor behaviour—distinguishing credit risk, liquidity risk, and inflation expectations at different horizons—would deepen the understanding of the mechanism. Finally, the instrument-level within-country-quarter identification strategy we adopt here is not available for the comparatively thin African Eurobond market; extending the analysis to external bonds would require a different design but could usefully test whether the steepening patterns we document for domestic markets spill over into external borrowing costs.

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Appendix

A.1 Placebo Test

As a placebo test, we assign to each country the disaster shock observed two quarters *after* issuance and re-estimate Equation (1) at $h = 0$. If the yield curve steepening we document reflected pre-existing trends rather than a causal disaster effect, this future shock should predict the yield curve slope. In the full sample, the placebo flood-maturity coefficient is 0.125 (p = 0.13), placebo storm is 0.001 (p = 1.00), and placebo drought is 0.019 (p = 0.02).[8] The placebo flood and storm coefficients are not significant at the 10% level, consistent with no pre-existing flood- or storm-related steepening trend. The small but non-zero placebo drought coefficient reflects the persistence of drought events: because droughts typically extend over multiple quarters, a "future" drought is often already being experienced at the nominal placebo quarter.

A.2 Supply- and Demand-Side Decomposition

Tables 7 and 8 report the coupon and price regressions in high-debt countries referenced in Section 5.2. Both specifications replicate the baseline regression from the main text, replacing the issuance yield with the coupon rate (Table 7) and the issue price (Table 8) as the dependent variable. The coupon regression is restricted to domestic bonds with a positive coupon; zero-coupon bills are therefore excluded, which reduces the cluster count to 10–14 countries depending on the horizon.

[8] We use $h = -2$ rather than $h = -1$ because the two shock lags included in the specification create a mechanical link between the $h = -1$ placebo shock and the contemporaneous disaster.

Table 7: Coupon at Issuance: Flood, Storm, and Drought Shocks (High-Debt Countries, Bonds Only)

	$h=0$	$h=1$	$h=2$	$h=3$	$h=4$	$h=5$	$h=6$	$h=7$	$h=8$
Flood × maturity	0.048	0.134***	0.140***	0.139***	0.137*	0.127***	0.085***	0.070	0.104***
	(0.037)	(0.019)	(0.028)	(0.032)	(0.073)	(0.034)	(0.025)	(0.051)	(0.028)
Storm × maturity	−0.106	0.216**	0.003	−0.019	0.127	−0.171	0.010	−0.142	−0.273
	(0.167)	(0.088)	(0.043)	(0.066)	(0.095)	(0.238)	(0.060)	(0.180)	(0.264)
Drought × maturity	−0.004	−0.014*	−0.002	0.000	−0.013	−0.004	−0.005	0.007	0.021*
	(0.009)	(0.008)	(0.009)	(0.006)	(0.012)	(0.005)	(0.008)	(0.012)	(0.012)
R^2_{adj}	0.899	0.899	0.899	0.897	0.895	0.894	0.892	0.891	0.890
N	3,511	3,545	3,491	3,529	3,565	3,589	3,616	3,637	3,648
Countries	10	10	10	12	12	14	14	14	14

Table 8: Price at Issuance: Flood, Storm, and Drought Shocks (High-Debt Countries)

	$h=0$	$h=1$	$h=2$	$h=3$	$h=4$	$h=5$	$h=6$	$h=7$	$h=8$
Flood × maturity	−1.005***	−0.973***	−1.072**	−1.112***	−1.010**	−0.965**	−0.645*	−0.429	−0.613*
	(0.292)	(0.346)	(0.429)	(0.377)	(0.433)	(0.397)	(0.350)	(0.371)	(0.314)
Storm × maturity	0.744**	1.622**	0.428*	0.463**	1.166***	1.038***	0.371	0.450	0.774*
	(0.291)	(0.653)	(0.229)	(0.231)	(0.395)	(0.311)	(0.267)	(0.312)	(0.403)
Drought × maturity	−0.119***	−0.112***	−0.075**	−0.108***	−0.096***	−0.124***	−0.185***	−0.189***	−0.168*
	(0.034)	(0.029)	(0.034)	(0.040)	(0.035)	(0.033)	(0.034)	(0.050)	(0.094)
R^2_{adj}	0.480	0.482	0.488	0.486	0.478	0.480	0.471	0.475	0.474
N	16,823	17,107	17,416	17,816	18,159	18,348	18,485	18,664	18,808
Countries	31	31	31	31	31	31	31	31	31

A.3 Fiscal-Flow Heterogeneity

Table 9 reports the baseline yield regression restricted to the high-deficit subsample referenced in Section 5.2. "High deficit" is defined as a lagged general-government fiscal balance-to-GDP ratio at or below the sample median (−2.6%), i.e., observations in the larger-deficit half of the distribution. All other aspects of the specification follow the baseline in the main text.

Table 9: Yield at Issuance: Flood, Storm, and Drought Shocks (High-Deficit Countries)

	$h = 0$	$h = 1$	$h = 2$	$h = 3$	$h = 4$	$h = 5$	$h = 6$	$h = 7$	$h = 8$
Flood × maturity	0.227***	0.318***	0.393***	0.330**	0.128	0.168	0.042	0.023	−0.031
	(0.062)	(0.081)	(0.122)	(0.128)	(0.114)	(0.130)	(0.101)	(0.118)	(0.097)
Storm × maturity	−0.068	0.015	−0.104	−0.150	−0.002	−0.443***	−0.281**	−0.096	−0.088
	(0.121)	(0.219)	(0.190)	(0.305)	(0.266)	(0.150)	(0.131)	(0.120)	(0.115)
Drought × maturity	0.026*	0.017	−0.003	−0.007	0.002	−0.021	−0.016	0.001	0.005
	(0.015)	(0.011)	(0.013)	(0.014)	(0.012)	(0.016)	(0.015)	(0.007)	(0.007)
R^2_{adj}	0.775	0.771	0.765	0.759	0.748	0.746	0.748	0.752	0.757
N	20,903	21,513	22,164	22,859	23,525	23,924	24,380	24,752	24,806
Countries	34	37	37	37	37	38	38	38	38