DIMITRIOS (TAKIS) ANTONOPOULOS

Klingentalstrasse 88, Basel 4057, Switzerland | +41 77 997 2268 | tantonopoulos93@gmail.com

PROFESSIONAL SUMMARY

Financial economist with advanced quantitative skills and extensive experience at international organisations, specialising in macro-financial risk analysis, banking regulation, and global financial stability. Experienced in leading international policy workstreams and advising G20 authorities on systemic vulnerabilities.

WORK EXPERIENCE

Financial Stability Board (FSB) — **Basel, Switzerland**
Senior Financial Market Analyst — *03/2021 – Present*

- **Macro-financial monitoring**: Monitors global macro developments by maintaining and updating cross-market datasets, producing analytical inputs for the FSB's regular vulnerability assessments, and preparing data visualisations and briefing materials for senior management and G20 authorities.
- **FX derivatives**: Analysed the structure of the global FX derivatives market - currency composition, dealer concentration, maturity and rollover profiles, and sectoral net payment obligations - to assess how shocks propagate across jurisdictions and into core funding markets.
- **Climate risk**: Led climate risk analysis within the FSB, integrating climate and financial data to assess system-wide vulnerabilities. Published a key report identifying supervisory approaches for monitoring climate risks.
- **Bank Liquidity**: Led cross-country data collection and analysis of deposit run dynamics for the FSB depositor behaviour report, benchmarking the speed and scale of the March 2023 bank runs and inform policy options for liquidity regulation.
- **International Macroeconomics**: Co-authored an IMF–FSB analysis of macro-financial vulnerabilities in EMEs, building the underlying dataset from multiple international sources and conducting quantitative analysis of USD funding dependence, foreign-currency exposures, and cross-border spillover channels.
- **AI & Financial Stability**: Co-authored a report on the financial stability implications of AI, identifying key pressure points regarding third-party dependencies and model governance.

European Central Bank (ECB) — **Frankfurt, Germany**
Supervision Analyst – Single Supervisory Mechanism (SSM) — *01/2020 – 03/2021*

- **Bank supervision:** Assessed recovery plans, evaluating crisis preparedness and credibility of recovery options. Maintained credit and market risk monitoring dashboards for institutions under enhanced supervision.

Research Analyst – Financial Stability Directorate (DGMF) — *09/2018 – 12/2019*

- **Policy analysis:** Contributed to the quantitative impact evaluation of the too-big-to-fail post-crisis reforms, providing the evidence base used by the G20 to assess the credibility of global resolution regimes.

EDUCATION

Vrije Universiteit Amsterdam — **Amsterdam, Netherlands**
PhD in Finance (Part-time) — *02/2025 – Ongoing*

- **Topic:** *Climate-related risks in the financial system and the broader economy*

University of Chicago — **Chicago, USA**
M.A. in the Social Sciences (Economics Concentration) – 1st in class — *09/2017 – 06/2018*

Athens University of Economics and Business — **Athens, Greece**
M.Sc. in Business Mathematics – 1st in class — *09/2016 – 12/2017*

Athens University of Economics and Business — **Athens, Greece**
B.Sc. in Accounting & Finance (Finance Concentration) — *09/2011 – 06/2016*

TECHNICAL SKILLS & LANGUAGES

Programming & Data: Claude Code, Python, Stata, MATLAB, MS Excel | **Languages:** English, Greek

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

Takis Antonopoulos*

September 24, 2026

Abstract

We study how natural disasters affect the term structure of domestic sovereign borrowing costs in Africa, using instrument-level data on about 46,000 bonds and Treasury bills issued by 39 African countries over 2000–2025, of which the regressions use the subset with a measurable pre-disaster curve slope. Both floods and droughts steepen the domestic yield curve in proportion to the sovereign's debt burden: lightly indebted sovereigns show no steepening while the response rises steeply with debt, so that the market reprices longer-maturity debt most aggressively where fiscal space is thinnest. In high-debt sovereigns, a severe flood could widen the long-short spread by approximately 1.3 percentage points after one year, with droughts widening it by a comparable amount. The results indicate that as climate change intensifies, long-term borrowing stands to become disproportionately more expensive for fiscally vulnerable African sovereigns.

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

JEL Codes: F34, G12, H63, Q54

*Senior Financial Market Analyst, Financial Stability Board (FSB). PhD candidate, Vrije Universiteit Amsterdam. Email: takis.antonopoulos@fsb.org, d.antonopoulos@vu.nl.

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 flood and drought 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 46,000 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 and droughts, the two disaster categories that combine direct climate relevance with measurable exposure across the continent; storm exposure—small and confined to a few cyclone-exposed countries—enters the regressions as a control rather than as a treatment, for the reasons set out in Section 3.

Our main finding is that disasters steepen the yield curve in proportion to the sovereign's debt burden, so that longer-maturity instruments issued after a disaster clear auction at disproportionately higher yields precisely where fiscal space is thin. This debt gradient governs both shocks. For floods it builds over the year following the event, peaking around five quarters out, and sharpens with the debt burden; in the full sample, which pools sovereigns of very different debt positions, the flood steepening is modest and imprecisely estimated. For droughts there is both a positive pooled slope response and a

debt interaction that strengthens it, developing over subsequent quarters and remaining elevated at the two-year horizon.

We quantify this debt gradient directly by interacting each shock with the lagged debt ratio. The implied flood slope response is absent at low debt ratios and rises steadily with debt: at a debt ratio of 69.4 percent of GDP, a severe flood—one at the 90th percentile of sample floods—could widen the ten-year minus one-year spread by approximately 1.3 percentage points after one year. Droughts steepen the curve on average, and more so as debt rises. A complementary interaction with the fiscal balance shows that larger deficits amplify the flood steepening, while the corresponding drought evidence is weaker and less systematic.

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.

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, across disaster types, or across fiscal positions: both floods and droughts steepen the curve in proportion to the sovereign's debt burden—floods within a quarter or two of the event, droughts building over the two years that follow. Second, it contributes to the literature on the macroeconomic consequences of natural disasters, which has decomposed growth and fiscal responses by disaster type; we ask how those consequences show up along the maturity dimension of sovereign borrowing. Third, it relates to the asset-pricing literature on the term structure of sovereign credit risk, which has largely worked with external-market instruments and yield-component decompositions; we bring evidence from primary-market domestic issuance. 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, and Section 6 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*—has begun to be studied in global secondary-market panels, but remains open for African domestic primary markets, where issuance data allow the slope to be measured directly. 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 (2026) estimate state-dependent local projections for a global panel of sovereign yields, splitting the two-year yield into an expected policy path and a term premium. Their headline result concerns direction rather than size: severe weather events push yields down where fiscal space is tight and up where it is ample, a contrast that unconditional estimates average away. They attribute this to the fiscal reaction itself. Sovereigns with room to borrow raise expenditure after a disaster, while constrained ones barely move, and the two groups' inflation paths diverge accordingly. The channel also differs by country group. In advanced economies the expected policy path does most of the work: high-debt sovereigns see rate expectations fall

with no meaningful term-premium movement, consistent with markets anticipating monetary accommodation where fiscal support is unavailable. In emerging markets the term premium carries more weight, with lower-rated sovereigns experiencing yield declines and higher-rated ones increases in both components. On their evidence fiscal space governs not only how far yields move after a disaster, but in which direction and through which part of the curve.

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 (2026)—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 estimate how disasters reshape the *term structure* of domestic borrowing costs. That disasters move the sovereign term structure, and that the response depends on fiscal position, is established in the global panel evidence of Moench and Schaal (2026); our contribution is to examine this in African domestic primary markets, where the instrument-level data allow the slope response to be measured directly from issuance rather than inferred from secondary-market curves. Second, the instrument-level data support a saturated specification in which the slope response is identified from bonds and bills issued by the same country in the same quarter, so that any disturbance common to that country-quarter is differenced out, and they allow the slope response to vary continuously with the sovereign's debt ratio. Third, 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, duplicate records, 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 instrument universe comprises approximately 46,000 instruments across 39 countries; the regressions use the smaller subset for which the pre-disaster slope control is defined (Section 4).

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 the affected population separately for *floods*, *storms*, and *droughts*—the three climate-related categories that together account for roughly 90% of the ∼1,590 African disaster events recorded in EM-DAT over 2000–2025 (approximately 1,010 flood, 250 storm, and 175

drought events). Floods and droughts are our two treatments: their frequency and severity are projected to intensify with climate change, and both expose a broad cross-section of countries to events large enough for markets to price. Storms fail this second requirement, and we do not report them as a treatment. African storm exposure is small and narrowly concentrated: the median storm quarter affects 0.04% of the population (against 0.09% for floods and 8.6% for droughts), and exposure is confined to a handful of cyclone-prone countries in the south-western Indian Ocean—Madagascar alone accounts for roughly 22% of non-zero storm quarters, and three countries supply over 90% of the variation that identifies storm coefficients in our interacted specifications. Estimates built on such thin, concentrated support hinge on single countries—dropping any one of the two or three exposed issuers overturns them—so we treat storms as unidentifiable in this design rather than as a third treatment. Because tropical cyclones also cause flooding, however, omitting storm exposure entirely could contaminate the flood estimates where the two co-occur; the storm measure (its level, maturity interaction, and two lags) therefore enters every specification as a control.[1] 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 are not included. Our treatment variables are the inverse hyperbolic sine transformations of the affected-population share for floods and droughts, as described in Section 4.[2] 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.

3.3 Macroeconomic Data

Macroeconomic and fiscal data are drawn from the Global Macro Database (GMD), as described in Müller et al. (2025); we use the July 2026 vintage. The GMD provides har-

[1]The flood and drought estimates are numerically insensitive to this choice: removing the storm terms from the specification entirely changes the reported coefficients by at most 0.006.

[2]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.

monised annual series compiled from major international databases (IMF, World Bank, OECD) and historical sources across 243 countries. We use five control variables: general government debt-to-GDP, the general government fiscal balance-to-GDP (a signed variable: negative values denote a deficit), real GDP growth, the current account balance-to-GDP, and CPI inflation.[3] 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 the instrument universe 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.

[3]We measure the debt burden with general rather than central government debt because the GMD's central-government series ends between 2018 and 2022 for most African countries, whereas the general-government series—sourced from the IMF World Economic Outlook—is complete for all 39 sample countries through 2025. General government debt is also the concept that matches the fiscal-balance control.

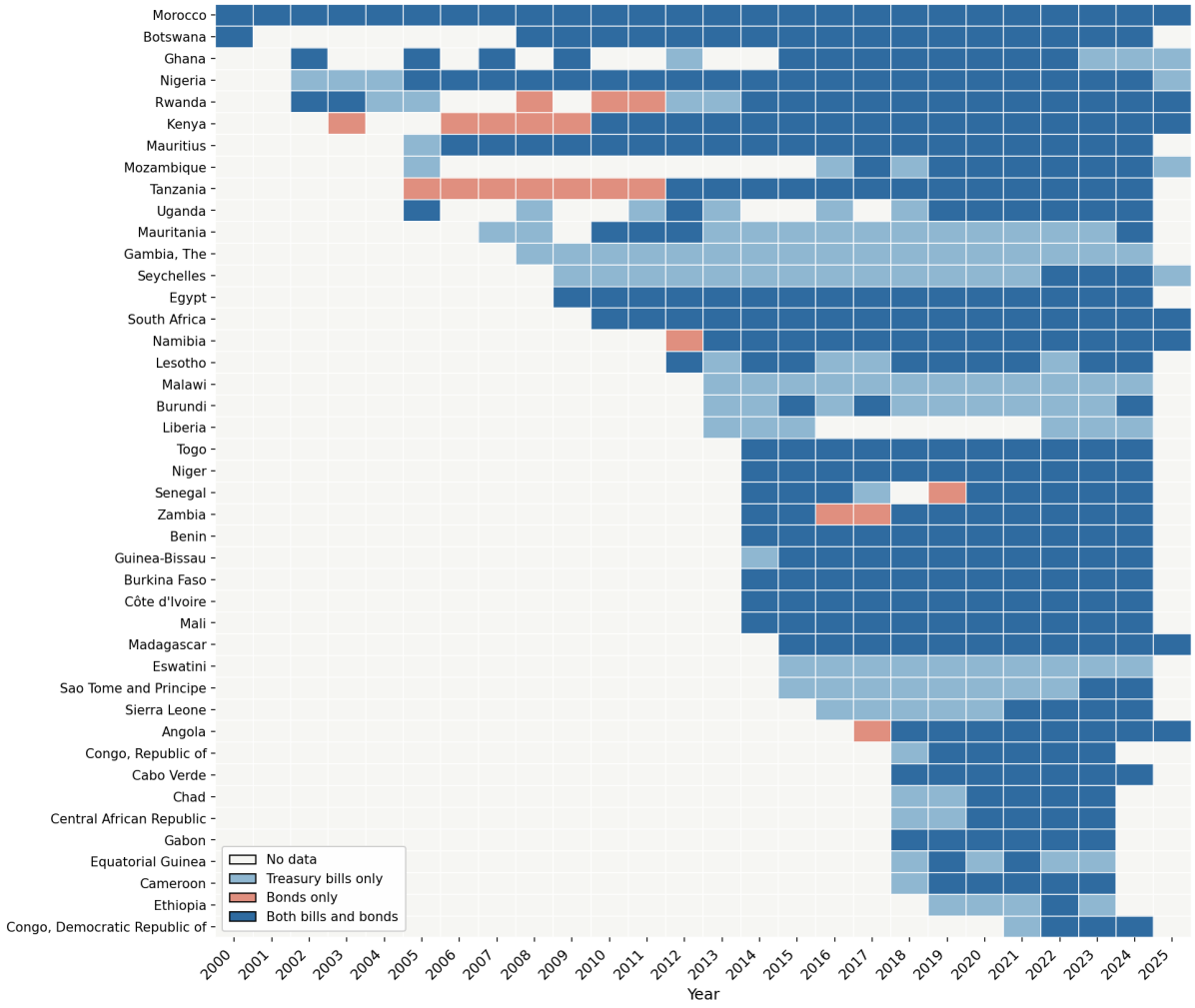


Figure 1: Country-Year Coverage of Domestic Debt Data

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. Four of the 43 countries shown (Central African Republic, Democratic Republic of the Congo, Ethiopia, Liberia) are dropped from the instrument universe for having fewer than 20 quarters of data, leaving 39.

Table 1 reports descriptive statistics for the instrument universe. 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 (%)	46,258	10.43	6.41	3.40	5.68	9.05	13.97	19.00
Maturity (years)	46,258	3.16	5.88	0.25	0.50	0.88	2.32	10.00
Treasury bills (N = 32,820; 70.9% of sample)								
Yield at issuance (%)	32,820	9.92	6.30	3.22	5.38	8.24	13.44	18.05
Maturity (years)	32,820	0.59	0.30	0.25	0.25	0.50	1.00	1.00
Bonds (N = 13,438; 29.1% of sample)								
Yield at issuance (%)	13,438	11.68	6.50	3.94	6.89	10.44	15.00	23.50
Maturity (years)	13,438	9.45	7.95	2.00	3.01	6.39	14.24	22.04
Panel B: Disaster shocks (IHS of affected population %, non-zero CQs)								
Floods	574	0.371	0.691	0.003	0.014	0.093	0.344	1.109
Storms	151	0.416	0.701	0.000	0.005	0.042	0.529	1.598
Droughts	123	2.783	1.183	1.205	1.976	2.850	3.728	4.222
Panel C: Macroeconomic controls (country-year)								
Govt. debt / GDP (%)	1,014	57.69	45.03	19.39	31.18	48.75	70.30	99.22
Fiscal balance / GDP (%)	999	−2.40	6.83	−7.54	−4.96	−2.91	−0.87	2.33
Real GDP growth (%)	975	4.24	4.70	0.00	2.39	4.31	6.22	8.14
Current account / GDP (%)	1,006	−5.32	9.35	−14.81	−9.25	−4.73	−1.13	4.79
Inflation (%)	1,014	7.42	15.53	0.58	2.24	4.95	8.82	14.34

Notes: 46,258 domestic-currency instruments issued by 39 African countries over 2000–2025, after the data-quality filters of Section 4. Panel B conditions on country-quarters with a non-zero shock; droughts affect far larger population shares per event than floods (median $\sinh(2.850) \approx 8.6\%$ vs $\sinh(0.093) \approx 0.09\%$). Panel C reports the lagged macroeconomic controls from the Global Macro Database (Müller et al., 2025).

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 and droughts enter the regression as separate shocks, together with their maturity interactions, so that each has its own level and slope coefficient; storm exposure enters as a control, as motivated in Section 3.

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 $d \in \{\text{Flood}, \text{Drought}\}$, 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 $h = 0, 1, \ldots, 8$:

$$
\begin{aligned}
y_{i,c,\tau} = \alpha_c + \delta_\tau &+ \sum_d \beta^h_{1,d}\, D^d_{c,\tau-h} + \sum_d \beta^h_{2,d}\, \left(D^d_{c,\tau-h} \times m_i\right) + \gamma_1\, m_i + \boldsymbol{\gamma}' \mathbf{X}_{c,\tau-h} \\
&+ \eta_1\, \mathbf{1}_{\text{bond},i} + \eta_2\, \left(\mathbf{1}_{\text{bond},i} \times m_i\right) + \boldsymbol{\theta}' \mathbf{S}_{c,\tau-h} \\
&+ \psi_1\, \bar{s}_{c,\, y(\tau-h)-1} + \psi_2\, \left(\bar{s}_{c,\, y(\tau-h)-1} \times m_i\right) \\
&+ \sum_d \phi^d_1\, D^d_{c,\tau-h-1} + \sum_d \phi^d_2\, D^d_{c,\tau-h-2} + \varepsilon_{i,c,\tau}
\end{aligned} \tag{1}
$$

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. The vector $\mathbf{S}_{c,\tau-h}$ collects the storm controls: the con-

temporaneous storm shock, its maturity interaction, and its first two lags. 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 term $\bar{s}_{c,\,y(\tau-h)-1}$ is the sovereign's *pre-disaster curve slope*, entering both on its own and interacted with maturity. In a country-quarter that contains both bonds and bills we take the difference between the mean bond and mean bill issuance yield and divide it by the corresponding difference in mean maturities, keeping quarters in which those maturities are at least a year apart. This yields a slope per year of maturity.[4] Conditioning on how steep each sovereign's curve already was addresses the concern that persistent cross-country differences in curve steepness, rather than the disasters themselves, drive the slope coefficients.

The coefficients of interest are $\{\beta^h_{2,d}\}_{d=\text{Flood,Drought}}$. 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 five lagged macroeconomic controls: general government debt-to-GDP, the general government fiscal balance-to-GDP (signed; negative values denote a deficit), real GDP growth, the current account balance-to-GDP, and CPI inflation. The identifying assumption is that, conditional on country and quarter fixed effects, the macroeconomic and storm controls, and the lags of both shocks, the disaster shocks are orthogonal to unobserved determinants of instrument-level borrowing costs. 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; in that specification, the level coefficients $\{\beta^h_{1,d}\}$ and the level of the pre-disaster slope control are absorbed—within an issuance cell every instrument shares the same shock quarter, so only its maturity interaction is identified—and the slope coefficients are identified exclusively from within-country-quarter variation in maturity—comparing instruments of different tenors issued

[4]For a shock in calendar year y the control is the equally weighted average of the eligible quarterly slopes of year $y-1$, requiring at least two such quarters. It is dated relative to the *shock* quarter $\tau-h$ rather than the issuance quarter τ, so the same pre-disaster value applies at every horizon.

by the same country in the same quarter. This saturated specification absorbs any time-varying country-level shock whose effect is common to all instruments issued in that cell; a shock whose effect varies with maturity is not absorbed, and we report it alongside the baseline throughout (Panel B of Table 3).[5]

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. Events with a missing start month—about a fifth of drought records, whose slow onset EM-DAT often leaves undated—are assigned the modal onset quarter of dated events of the same type in the same country, with the Africa-wide modal quarter for the type as a fallback.[6] A shock value of one—equivalently, an increase from zero to one—corresponds to a disaster affecting approximately 1.2% of the population; because the transformation is concave, the population share implied by a further one-unit increase depends on the starting value. Event sizes differ sharply across disaster types, which matters when translating coefficients into yield magnitudes. The median flood in the instrument universe affects 0.09 percent of the population (0.09 units), and only 13 percent of floods reach one percent of

[5]Standard errors are clustered at the country level throughout, and we report statistical significance at the 10%, 5%, and 1% levels.

[6]This affects 36 of the roughly 1,430 flood, storm, and drought events, almost all of them droughts. Dropping undated events instead leaves the flood and storm estimates almost unchanged; the drought estimates move modestly and in both directions.

the population; the median drought affects 8.6 percent (2.85 units), reflecting the scale of the drought episodes that clear EM-DAT's reporting threshold. When we convert coefficients into yield effects in the text, we use a reference event of each type, chosen to be severe but still plausible for illustration (Panel B of Table 1). For floods this is the 90th percentile of the non-zero shock distribution, an event affecting about 1.4 percent of the population (1.11 units). For droughts we use the 75th percentile, which already affects 20.8 percent of the population (3.73 units); the drought distribution is compact at the top, so its 90th percentile corresponds to an event reaching a third of the population, which is a national-scale catastrophe rather than a useful illustrative benchmark. Tables and figures report coefficients per unit of the transformed shock, with two exceptions: Figure 4 and Table 4, whose entries are percentage-point yield changes for the reference shocks defined above.

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 and Namibian inflation-linked bonds, which carry real coupons of 2–5% and would be compared within the same country-quarter to nominal bonds with coupons of 8–12%, conflating the inflation-linked/nominal distinction with the maturity dimension.[7] Second, we exclude foreign-currency-denominated domestic instruments (primarily Angolan USD-denominated bonds). Third, we drop a small number of duplicate records that appear twice with identical country, issue date, terms, and amount, reflecting overlapping source files. Fourth, we exclude a small number of coupon outliers exceeding 20%, which are likely data errors. Fifth, 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. Sixth, we exclude instruments with yields below zero or above 50%, which are data errors arising from the price anomalies described above. Seventh, we drop instruments with a recorded

[7] We identify these as South African domestic bonds with a coupon below 4% and Namibian domestic bonds with a coupon of at most 5%, which correspond to the known sets of inflation-linked government bonds in the two countries. Nominal Namibian bond coupons start at 7%, so the Namibian cutoff is not sensitive to its exact placement.

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 instrument universe comprises 46,258 instruments across 39 countries over 2000–2025 (104 quarters).

One timing adjustment applies at $h = 0$, where the shock and issuance quarters coincide: an instrument sold in January cannot be responding to a flood whose onset was in March. In country-quarters with positive flood exposure and a recorded onset month we therefore drop issuances dated before that month, keeping those in the onset month and later. Excluded issuances are dropped rather than recoded as unexposed. The slope control is built from the full issuance data before this restriction, and the minimum of two observations per country×quarter cell is re-imposed after it. The adjustment removes 2,064 instruments, 4.5 percent of the instrument universe, in 138 country-quarters

The resulting regression sample is 27,070 instruments across 32 countries at $h = 0$, and 23,368 across 31 countries at $h = 8$, against an instrument universe of 46,258 across 39 countries.[8] 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.

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).

[8]Estimation samples shrink at longer horizons both because shock quarters before 2000 are unobserved for instruments issued early in the sample, and because the two lags of each shock carry forward any quarter in which a disaster's human impact went unrecorded.

5.1 Full-Sample Estimates

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

The flood–maturity interaction is positive but statistically insignificant on impact and builds to a peak five quarters out (0.169), where it is significant at the 10 percent level; it is also significant at $h = 3$ and $h = 4$, and statistically indistinguishable from zero elsewhere. Taken at face value the peak estimate is not trivial—a severe flood, one at the 90th percentile of sample floods and affecting about 1.4 percent of the population, would raise the yield on a 10-year bond by roughly 1.7 percentage points more than on a 1-year bill—but with significance only at the 10 percent level and only at three horizons, we read the pooled flood response as suggestive rather than as establishing an average effect.

Droughts show a clearer average response, significant at seven of the nine horizons. Because they affect far larger population shares than floods, these coefficients translate into economically meaningful differentials: at the peak, a drought at the 75th percentile—affecting about a fifth of the population—raises 10-year yields by roughly 1.4 percentage points relative to 1-year yields. The profile is consistent with the slow onset of drought damage, building over the first year. As the next subsection shows, both responses are strongly concentrated among high-debt sovereigns.

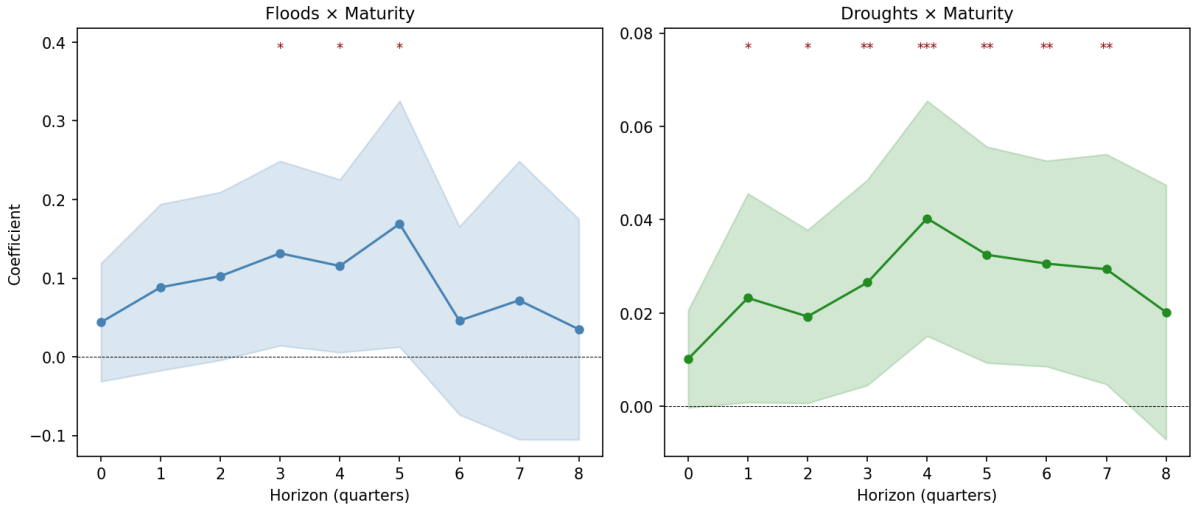


Figure 2: Impulse Response Functions: Floods and Droughts (Full Sample)

Notes: The figure plots the slope coefficients ($\hat{\beta}^h_{2,d}$, $d \times$ maturity) from Equation (1) for floods and droughts, for horizons $h = 0, \ldots, 8$ quarters. Coefficients are in percentage points of yield per additional year of maturity, per one-unit increase in the IHS-transformed shock; the reference flood is 1.109 IHS units (90th percentile) and the reference drought 3.728 (75th percentile; Table 1). Shaded areas denote 90% confidence intervals based on country-clustered standard errors. (Section 4). Stars: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 2: Yield at Issuance: Flood 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	0.044	0.088	0.103	0.132*	0.115*	0.169*	0.046	0.072	0.035
	(0.046)	(0.064)	(0.065)	(0.071)	(0.067)	(0.095)	(0.073)	(0.108)	(0.085)
Drought × maturity	0.010	0.023*	0.019*	0.027**	0.040***	0.032**	0.031**	0.029**	0.020
	(0.006)	(0.014)	(0.011)	(0.013)	(0.015)	(0.014)	(0.013)	(0.015)	(0.017)
R^2_{adj}	0.833	0.822	0.811	0.801	0.795	0.792	0.792	0.797	0.801
N	27,070	28,010	27,404	26,661	26,112	25,659	25,006	24,269	23,368
Countries	32	32	32	32	32	32	32	32	31

Notes: Slope coefficients $\hat{\beta}^h_{2,d}$ from Equation (1). Standard errors clustered at the country level in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

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 how the yield curve response varies with the sovereign's debt burden by letting the slope response vary continuously with the debt ratio; a complementary interaction with the fiscal balance, reported below, examines the flow dimension of fiscal space.

The debt gradient

Because the debt burden is a continuous state variable, our primary heterogeneity specification lets the slope response vary with the debt ratio itself. We augment Equation (1) with interactions between each disaster shock and the lagged general-government debt ratio $B_{c,\tau-h}$:

$$y_{i,c,\tau} = \ldots + \sum_{d} \left[\beta^{h}_{3,d}\left(D^{d}_{c,\tau-h} \times B_{c,\tau-h}\right) + \beta^{h}_{4,d}\left(D^{d}_{c,\tau-h} \times m_i \times B_{c,\tau-h}\right)\right] + \gamma_2\left(m_i \times B_{c,\tau-h}\right) + \varepsilon_{i,c,\tau}, \tag{3}$$

where the omitted terms are exactly those of Equation (1), including the debt ratio itself among the controls. The sum over d runs over all three hazards, so the storm×debt and storm×maturity×debt terms enter as controls alongside the flood and drought interactions, as storm exposure does elsewhere. The coefficient of interest is $\beta^{h}_{4,d}$, the *debt gradient*: how much the disaster-induced maturity slope changes per percentage point of the lagged debt ratio. The debt-dependent slope response itself is $\beta^{h}_{2,d} + \beta^{h}_{4,d}B$, which we evaluate at a representative high-debt ratio in Figure 4. The specification imposes that the slope response is linear in the debt ratio.

Table 3 and Figure 3 show that the yield curve response varies systematically with the sovereign's debt burden. For both floods and droughts the debt gradient is positive at every horizon. The flood gradient is significant at every horizon in both specifications. The drought gradient is significant at most horizons but not all: it is indistinguishable

from zero on impact and at $h = 2$ in both specifications, and also at $h = 6$ under country×quarter fixed effects. Its strongest point estimate comes at the end of the two-year window. A positive debt gradient means that the slope response becomes more positive as debt rises; it is a statement about how the response varies with debt, not about whether the curve steepens significantly at any particular debt ratio, which is what Figure 4 reports. The pooled estimates therefore conceal substantial heterogeneity across fiscal positions.

The two hazards display somewhat different response profiles. Flood steepening emerges in the quarters following the shock, while the drought response tends to be larger at longer horizons. This difference may reflect the nature of the events: floods often cause immediate physical damage, whereas droughts develop and persist over extended periods. Their economic and fiscal costs may accumulate over time, as agricultural losses, revenue shortfalls and relief spending materialise. Investors may consequently adjust the relative pricing of short- and long-maturity debt as the drought evolves and its financing implications become clearer.

Table 3: The Debt Gradient of the Yield Curve Response

	$h=0$	$h=1$	$h=2$	$h=3$	$h=4$	$h=5$	$h=6$	$h=7$	$h=8$
Panel A: Baseline (country + quarter fixed effects)									
Flood × mat. × debt	0.274**	0.332**	0.418**	0.515***	0.545***	0.659***	0.506***	0.649***	0.563***
	(0.138)	(0.156)	(0.185)	(0.162)	(0.141)	(0.163)	(0.182)	(0.179)	(0.145)
Drought × mat. × debt	0.003	0.090**	0.072	0.165**	0.170***	0.175***	0.114*	0.161**	0.194***
	(0.040)	(0.043)	(0.066)	(0.067)	(0.062)	(0.054)	(0.060)	(0.067)	(0.070)
N	27,070	28,010	27,404	26,661	26,112	25,659	25,006	24,269	23,368
Countries	32	32	32	32	32	32	32	32	31
Panel B: Country×quarter fixed effects									
Flood × mat. × debt	0.163*	0.188***	0.230*	0.356***	0.420***	0.352***	0.189**	0.272*	0.281***
	(0.087)	(0.067)	(0.120)	(0.077)	(0.099)	(0.081)	(0.085)	(0.145)	(0.093)
Drought × mat. × debt	0.036	0.061***	0.015	0.095***	0.109**	0.106***	0.048	0.091*	0.110***
	(0.025)	(0.020)	(0.044)	(0.031)	(0.050)	(0.028)	(0.043)	(0.049)	(0.039)
N	28,395	29,408	28,838	28,131	27,598	27,048	26,434	25,774	24,826
Countries	32	31	31	31	31	31	31	31	30

Notes: Triple-interaction coefficients $\hat{\beta}^h_{4,d}$ from Equation (3). Coefficients and standard errors are multiplied by 100 for readability; the debt ratio itself enters in percentage points, so the unscaled coefficient is already the change in the disaster–maturity slope per percentage point of debt/GDP. Figure 3 plots these coefficients. The implied slope response at debt ratio B is $\hat{\beta}^h_{2,d} + \hat{\beta}^h_{4,d} B$, computed with unscaled coefficients; Figure 4 reports it at the median debt ratio of the high-debt group. Panel A augments the baseline specification of Equation (1); Panel B its country×quarter fixed-effects version, in which the shock levels, the debt level, the shock×debt terms, and the level of the pre-disaster slope control are absorbed. Standard errors clustered at the country level in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

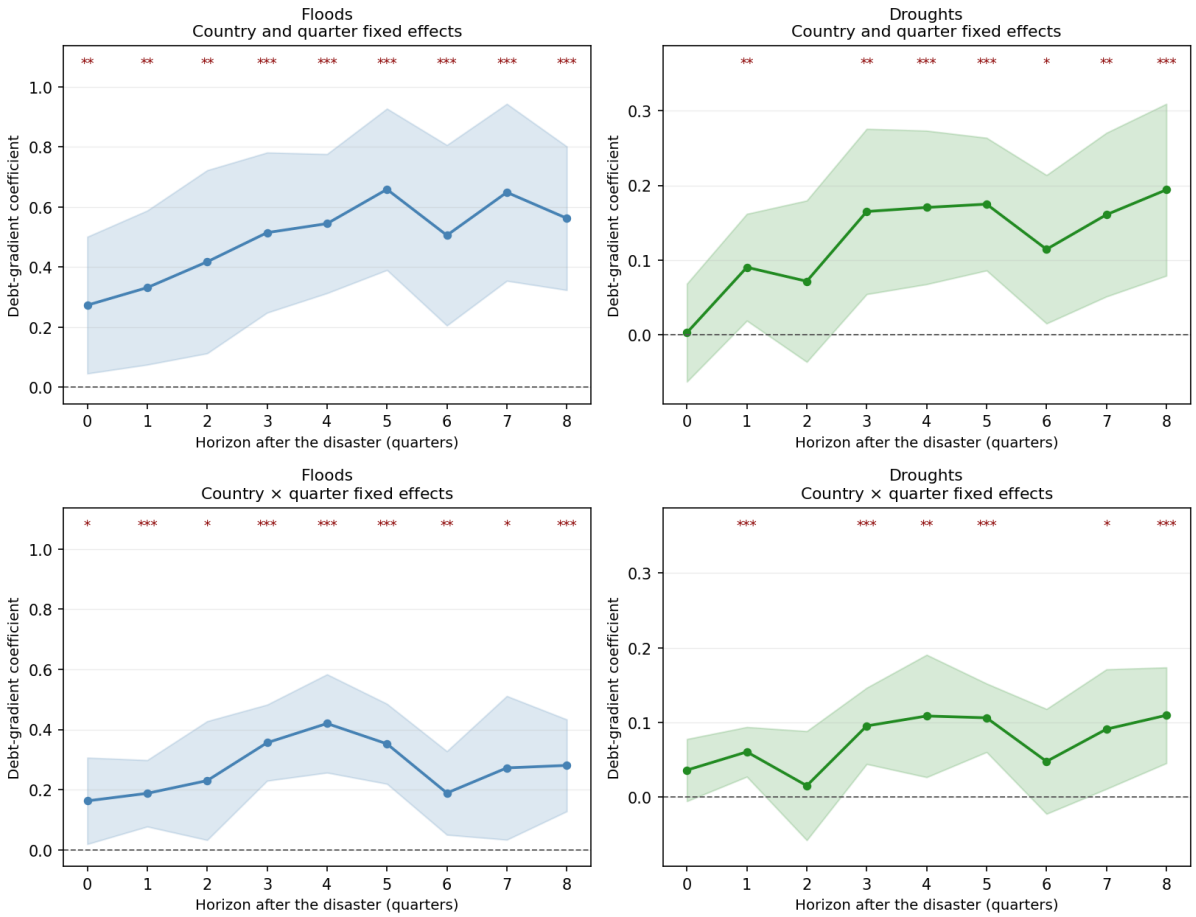


Figure 3: Debt Gradients of the Yield-Curve Response

Notes: The figure plots the triple-interaction coefficients $\hat{\beta}^h_{4,d}$ from Equation (3), multiplied by 100 to match Table 3, for horizons $h = 0, \ldots, 8$ quarters. Each coefficient measures how the disaster-induced maturity slope changes with the lagged debt-to-GDP ratio; positive values indicate a more positive slope response at higher debt levels. The top row uses separate country and calendar-quarter fixed effects, the bottom row country×calendar-quarter fixed effects. Shaded areas denote 90% confidence intervals based on country-clustered standard errors, and stars above each panel mark the significance of the coefficient at that horizon. Specifications, controls and the impact-horizon timing adjustment follow Table 3. Stars: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Figure 4 translates the continuous-debt estimates into implied term-spread responses at a representative high-debt ratio. We define the high-debt group as country-quarters whose lagged debt ratio is at or above the within-year median across the 39 eligible countries, and take as the representative ratio the median within that group, 69.4 percent of GDP. For each horizon we evaluate the implied slope at that single debt level and multiply by the reference event of each type and by the nine-year gap between a ten-year

bond and a one-year bill. In the baseline specification the flood response peaks at 2.47 percentage points five quarters after the shock, while the drought response peaks at 2.32 points at $h = 4$ and stands at 1.88 points at the two-year horizon. Under country×quarter fixed effects both are smaller: drought widening is about 1.20 points at $h = 4$ and 1.21 at $h = 8$, and the flood response is roughly half its baseline size. Droughts develop and persist over time, and their economic and fiscal costs may accumulate as the event unfolds, so investors may revise the relative pricing of short- and long-dated debt as it does; the estimates are consistent with that reading without identifying it. We should note though that such movements are sizeable but not unprecedented in these markets: the ten-year-minus-one-year spread widens by at least 2 percentage points in approximately 18% of available one-year comparisons, while increases of at least 2.3 percentage points occur in approximately 25% of two-year comparisons. The estimated responses are therefore economically substantial but within the observed range of term-spread movements.[9].

[9]These descriptive comparisons use country-quarter average issuance yields for instruments with maturities of 0.95–1.05 years and 9.5–10.5 years, requiring observations at both ends of the curve in both comparison quarters. There are 159 one-year comparisons across 14 countries and 130 two-year comparisons across 12 countries.

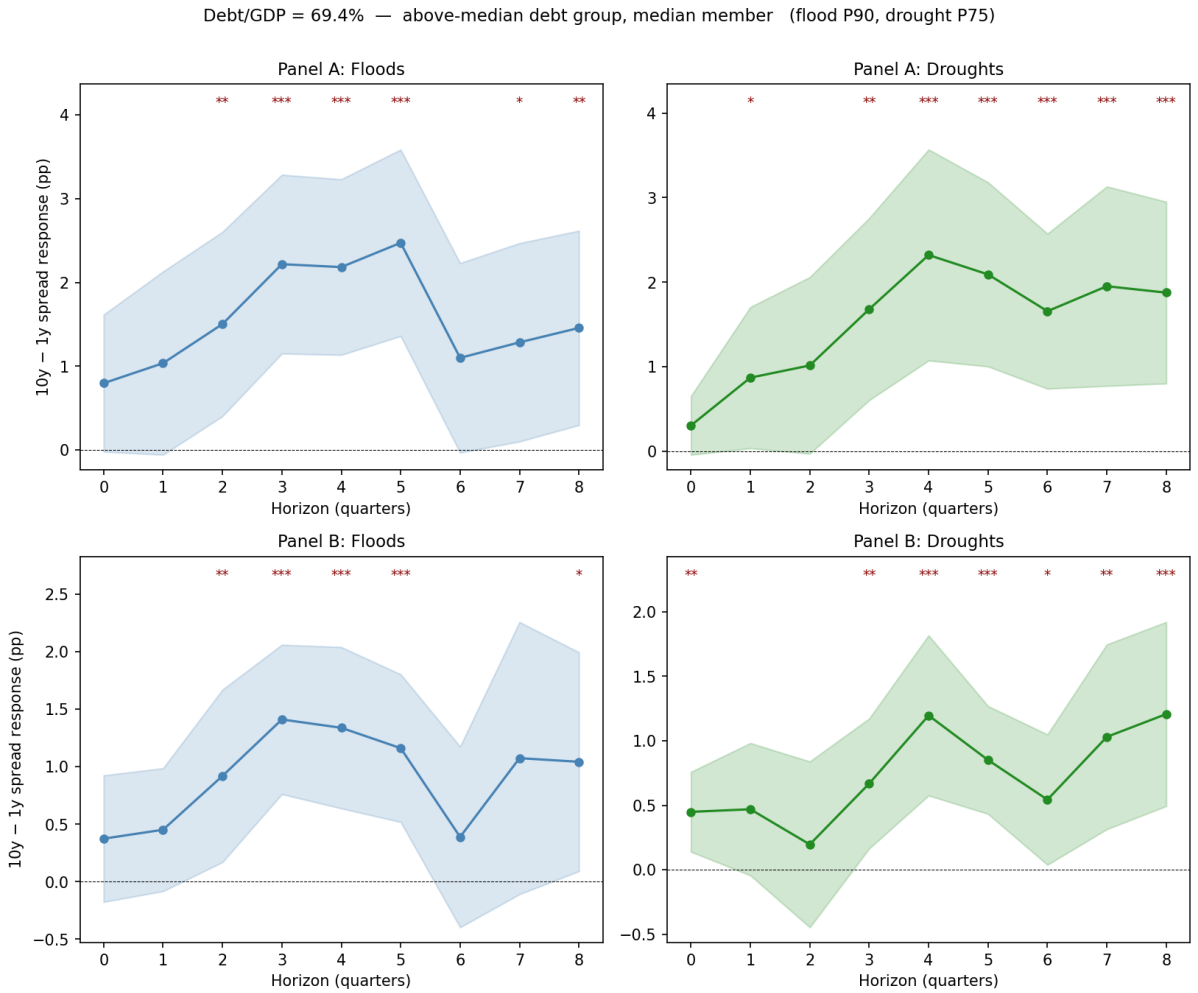


Figure 4: Implied Response of the 10-Year Minus 1-Year Spread, High-Debt Sovereigns

Notes: The figure plots $9 \times (\text{event size}) \times [\hat{\beta}^h_{2,d} + \hat{\beta}^h_{4,d}\bar{B}]$ from Equation (3), the implied change in the ten-year minus one-year yield spread, in percentage points, for horizons $h = 0, \ldots, 8$ quarters. $\bar{B} = 69.4$ is the median lagged debt ratio among high-debt country-quarters, as classified in Section 5.2; the estimates come from the same full-sample regressions as Table 3, re-expressed with the debt ratio centered at $\bar{B}$. Event sizes are the reference events of Section 4: 1.109 IHS units for floods and 3.728 for droughts. Panel A: country and quarter fixed effects. Panel B: country×quarter fixed effects. Shaded areas denote 90% confidence intervals based on country-clustered standard errors. Stars: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Which end of the curve moves though? Appendix Table 4 decomposes the spread responses in Figure 4 into changes in one-year and ten-year yields, evaluated at the same representative debt ratio for high-debt sovereigns. For floods, the clearest evidence is an increase in long-dated yields, while movements at the short end are less precisely estimated. For droughts, the evidence is stronger for a decline in one-year yields, although

the later point estimates indicate that both lower short-term yields and higher long-term yields contribute to the widening. The spread response can be estimated more precisely than either endpoint; an individually insignificant endpoint therefore need not make a negligible contribution.

We further test whether fiscal flow conditions matter, using the same triple-interaction design as the debt gradient. We interact each shock's maturity slope with an indicator for the larger-deficit half of the sample, defined by the sample-median lagged general-government fiscal balance-to-GDP ratio (-2.9%), and estimate on the full sample so that the coefficient of interest is the *difference* in slope between the two halves (appendix Table 5). For floods the difference is positive at every horizon and significant on impact and at $h = 3$ through $h = 5$: there is clear evidence that larger deficits amplify the flood steepening. For droughts the evidence is weaker and less systematic—the difference changes sign across horizons and is significant only at $h = 5$, where it is negative.

Taken together, both interactions point to fiscal vulnerability shaping the term-structure response, with clearer evidence for floods along the flow margin than for droughts. The two classifications overlap substantially—roughly three-quarters of above-median-debt observations also fall in the larger-deficit half—so we treat them as two views of the same vulnerability rather than as separate channels. Both are 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.

6 Conclusion

This paper studies how climate-related natural disasters reshape the domestic yield curve in African countries. Using an instrument universe of approximately 46,000 domestic sovereign instruments from the African Debt Database, combined with event-level disaster records for floods and droughts, we estimate local projections that identify the term-structure response from within-country-quarter variation in maturity.

The central finding is that disasters steepen the yield curve in proportion to the

sovereign's debt burden. In the most indebted sovereigns a severe flood widens the gap between long- and short-dated yields by roughly 1.3 percentage points within a year, and a severe drought by a similar amount—visible from the quarter of the event and still present two years later. The pooled estimates conceal substantial heterogeneity across debt positions, and the average flood evidence is less precise. In the baseline decomposition, the clearest evidence is of higher ten-year yields after floods and lower one-year yields after droughts, although movements at both ends contribute to the widening in the point estimates.

Letting the response vary with the debt ratio makes the gradient explicit: for both hazards the steepening is muted where debt is low and grows with the debt burden, and for droughts it reaches its largest values at the longer horizons. Splitting instead by the fiscal balance points the same way for floods, where larger deficits amplify the steepening; the drought evidence along that margin is weaker. The two measures of fiscal space overlap heavily, so we read them as two views of the same vulnerability rather than as separate channels. The pattern 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.

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 more expensive long-dated borrowing relative to short-dated borrowing disproportionately so for sovereigns 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 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.

Several limitations point toward future work. First, EM-DAT dates slow-onset droughts imprecisely—one in five drought records lacks a start month—and reported impacts depend on state capacity; replacing reported events with objective climatological indices such as the standardised precipitation-evapotranspiration index would sharpen the timing analysis. 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.

References

Acevedo, Sebastian, "Debt, Growth and Natural Disasters: A Caribbean Trilogy," IMF Working Paper 14/125, International Monetary Fund 2014.

Anyfantaki, Sofia, Marianna Blix Grimaldi, Carlos Madeira, Simona Malovana, and Georgios Papadopoulos, "Decoding Climate-related Risks in Sovereign Bond Pricing: A Global Perspective," Working Paper Series 3135, European Central Bank October 2025.

Augustin, Patrick, "The Term Structure of CDS Spreads and Sovereign Credit Risk," *Journal of Monetary Economics*, 2018, *96*, 53–76.

Barro, Robert J., "Rare Disasters and Asset Markets in the Twentieth Century," *Quarterly Journal of Economics*, 2006, *121* (3), 823–866.

Beirne, John, Nuobu Renzhi, and Ulrich Volz, "Feeling the Heat: Climate Risks and the Cost of Sovereign Borrowing," *International Review of Economics and Finance*, 2021, *76*, 920–936.

Borensztein, Eduardo, Eduardo Cavallo, and Patricio Valenzuela, "Debt Sustainability under Catastrophic Risk: The Case for Government Budget Insurance," *Risk Management and Insurance Review*, 2009, *12* (2), 273–294.

Burbidge, John B., Lonnie Magee, and A. Leslie Robb, "Alternative Transformations to Handle Extreme Values of the Dependent Variable," *Journal of the American Statistical Association*, 1988, *83* (401), 123–127.

Çevik, Serhan and João Tovar Jalles, "This Changes Everything: Climate Shocks and Sovereign Bonds," *Energy Economics*, 2022, *107*, 105856.

Kling, Gerhard, Yuen C. Lo, Victor Murinde, and Ulrich Volz, "Climate Vulnerability and the Cost of Debt," *Oxford Open Economics*, 2025, *4*.

Klomp, Jeroen, "Flooded with Debt," *Journal of International Money and Finance*, 2017, *73*, 93–103.

Loayza, Norman V., Eduardo Olaberría, Jamele Rigolini, and Luc Christiaensen, "Natural Disasters and Growth: Going Beyond the Averages," *World Development*, 2012, *40* (7), 1317–1336.

Mallucci, Enrico, "Natural Disasters, Climate Change, and Sovereign Risk," *Journal of International Economics*, 2022, *139*, 103672.

Manger, Mark S., David Mihalyi, Ugo Panizza, Nicolas Rescia, Christoph Trebesch, and Kay L. Wong, "Africa's Domestic Debt Boom: Evidence from the African Debt Database," CEPR Discussion Paper 20747, Centre for Economic Policy Research (CEPR) 2025.

Moench, Emanuel and Robin Schaal, "Extreme Weather Events, Fiscal Space, and the Term Structure of Sovereign Debt," CEPR Discussion Paper DP21479, Centre for Economic Policy Research May 2026. Earlier version issued as South African Reserve Bank Working Paper WP/25/14.

Müller, Karsten, Chenzi Xu, Mohamed Lehbib, and Ziliang Chen, "The Global Macro Database: A New International Macroeconomic Dataset," Working Paper 33714, National Bureau of Economic Research 2025.

Noy, Ilan, "The Macroeconomic Consequences of Disasters," *Journal of Development Economics*, 2009, *88* (2), 221–231.

Noy, Ilan and Aekkanush Nualsri, "Fiscal Storms: Public Spending and Revenues in the Aftermath of Natural Disasters," *Environment and Development Economics*, 2011, *16* (1), 113–128.

Òscar Jordà, "Estimation and Inference of Impulse Responses by Local Projections," *American Economic Review*, 2005, *95* (1), 161–182.

Presbitero, Andrea F., Dhaneshwar Ghura, Olumuyiwa S. Adedeji, and Lamin Njie, "Sovereign Bonds in Developing Countries: Drivers of Issuance and Spreads," *Review of Development Finance*, 2016, *6* (1), 1–15.

Raddatz, Claudio, "The Wrath of God: Macroeconomic Costs of Natural Disasters," Policy Research Working Paper 5039, World Bank 2009.

Appendix

A.1 Placebo Test

As a placebo test, we examine whether disaster exposure two quarters ahead predicts the current yield-curve slope. We retain the baseline controls, including the annual slope control and its maturity interaction, and control for disaster exposure in the issuance quarter and the intervening quarter. Neither hazard's lead is statistically significant, in the full sample or in the high-debt subsample. These results provide no evidence of anticipatory steepening at the tested horizon, but do not establish the absence of anticipation or pre-trends.

A.2 One-Year and Ten-Year Endpoint Responses

Table 4 decomposes the spread responses of Figure 4 into the implied movement in the one-year and ten-year yields, referenced in Section 5.2. Both endpoints come from the same full-sample continuous-debt regression, evaluated at $B = 69.4\%$ of GDP.

Table 4: Implied One-Year and Ten-Year Yield Responses at $B = 69.4\%$ of GDP

	$h=0$	$h=1$	$h=2$	$h=3$	$h=4$	$h=5$	$h=6$	$h=7$	$h=8$
Panel A: Floods									
One-year yield	−0.14	−0.02	−0.40	−0.58	−0.66	−1.00	−0.38	−1.04	−0.77
	(0.76)	(0.84)	(0.69)	(0.70)	(0.70)	(0.85)	(0.84)	(0.69)	(0.79)
Ten-year yield	0.66	1.02**	1.11**	1.64***	1.53**	1.47*	0.72	0.24	0.69
	(0.53)	(0.44)	(0.51)	(0.56)	(0.75)	(0.86)	(0.85)	(0.95)	(0.98)
Ten-year − one-year	0.80	1.04	1.50**	2.22***	2.18***	2.47***	1.10	1.29*	1.46**
	(0.50)	(0.66)	(0.67)	(0.65)	(0.64)	(0.68)	(0.69)	(0.72)	(0.71)
Panel B: Droughts									
One-year yield	−1.31*	−2.02**	−1.04	−1.19	−1.22*	−1.48*	−1.26*	−1.10*	−0.86
	(0.68)	(0.83)	(0.76)	(0.75)	(0.67)	(0.79)	(0.68)	(0.60)	(0.63)
Ten-year yield	−1.01*	−1.15	−0.02	0.50	1.10	0.61	0.40	0.85	1.02
	(0.59)	(0.89)	(0.96)	(0.86)	(0.92)	(0.85)	(0.62)	(0.65)	(0.64)
Ten-year − one-year	0.31	0.87*	1.02	1.68**	2.32***	2.09***	1.66***	1.95***	1.88***
	(0.21)	(0.51)	(0.63)	(0.65)	(0.76)	(0.66)	(0.56)	(0.72)	(0.65)
N	27,070	28,010	27,404	26,661	26,112	25,659	25,006	24,269	23,368
Countries	32	32	32	32	32	32	32	32	31

Notes: Implied yield changes at one-year and ten-year maturities from the continuous-debt specification of Equation (3), the same full-sample regression that produces Table 3 and Figure 4, with the debt ratio centered at $B = 69.4\%$ of GDP. Only the baseline specification is reported: country×quarter fixed effects absorb the shock level and so identify the slope but neither endpoint separately. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

A.3 Fiscal-Flow Heterogeneity

Table 5 reports the fiscal-flow interaction 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 (−2.9%), i.e., the larger-deficit half of the distribution. Rather than splitting the sample, the specification interacts each shock's maturity slope with that indicator on the full sample, so the reported coefficient is the difference in slope between the two halves.

All other aspects follow the baseline in the main text.

Table 5: The Fiscal-Flow Interaction: Slope Difference in High-Deficit Country-Quarters

	$h=0$	$h=1$	$h=2$	$h=3$	$h=4$	$h=5$	$h=6$	$h=7$	$h=8$
Flood × mat. × high-deficit	0.272^{**}	0.089	0.141	0.144^{**}	0.143^{**}	0.184^{**}	0.120	0.132	0.105
	(0.133)	(0.101)	(0.086)	(0.067)	(0.073)	(0.093)	(0.091)	(0.125)	(0.108)
Drought × mat. × high-deficit	0.114	0.019	−0.100	−0.090	−0.011	-0.068^{***}	0.024	−0.017	−0.004
	(0.087)	(0.032)	(0.079)	(0.078)	(0.079)	(0.023)	(0.067)	(0.090)	(0.102)
R^2_{adj}	0.836	0.824	0.813	0.803	0.796	0.794	0.793	0.798	0.802
N	27,070	28,010	27,404	26,661	26,112	25,659	25,006	24,269	23,368
Countries	32	32	32	32	32	32	32	32	31

Notes: Triple-interaction coefficients from Equation (1) augmented with an indicator for the high-deficit half of the sample (lagged general-government fiscal balance-to-GDP at or below the sample median of −2.9%). Each coefficient is the *difference* in the shock–maturity slope between high- and low-deficit country-quarters; the specification is estimated on the full sample and includes the indicator and its maturity and shock interactions, so the reported term is net of any level shift. Standard errors clustered at the country level in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.