South African Reserve Bank

Working Paper Series

WP/25/14

The impact of extreme weather events on the term structure of sovereign debt

Emanuel Moench and Robin Schaal

Authorised for publication by Konstantin Makrelov

25 August 2025

South African Reserve Bank

South African Reserve Bank Working Papers are written by staff members of the South African Reserve Bank and, on occasion, by consultants under the auspices of the South African Reserve Bank. The papers deal with topical issues and describe preliminary research findings and develop new analytical or empirical approaches in their analyses. They are solely intended to elicit comments and stimulate debate.

South African Reserve Bank Working Papers are externally refereed.

Information on South African Reserve Bank Working Papers can be found at
https://www.resbank.co.za/en/home/publications/Papers/working-papers.

Enquiries relating to the Working Paper Series can be addressed to:
Head: Economic Research Department
South African Reserve Bank
P O Box 427
Pretoria 0001

Tel. +27 12 313 3911

The impact of extreme weather events on the term structure of sovereign debt[*]

Emanuel Moench[†] and Robin Schaal[‡]

Abstract

This paper examines the impact of extreme weather events on the term structure of sovereign bond yields in a global panel. Using local projections to estimate the dynamic response of yields and their expected short rate and term premium components to such events, we uncover significant heterogeneity across countries. We show that differentiating between strong and weak fiscal regimes helps explain variations in both yield and inflation responses. Among advanced economies, countries with low debt levels experience a significant rise in short rate expectations as investors anticipate tighter monetary policy in response to inflationary pressures. Advanced economies with high levels of debt primarily exhibit a rise in term premiums, consistent with investors pricing in more issuance. While fiscally constrained emerging economies exhibit muted yield responses, their higher-rated peers experience a decline in expected short rates and an increase in term premiums, potentially suggesting that investors anticipate monetary easing and increased debt issuance following disasters.

JEL classification

E43, G15, H63, Q54

Keywords

Climate change, extreme weather events, sovereign debt, monetary policy

---

* We acknowledge financial support from the South African Reserve Bank (SARB) for this project. We thank Tobias Adrian and colleagues at the International Monetary Fund for providing us with international panel data for sovereign debt yields and their components. We thank Joe Feyertag (discussant) and seminar participants at the SARB for their helpful comments.

† Frankfurt School of Finance & Management, Germany. CEPR. Email: e.moench@fs.de.

‡ Frankfurt School of Finance & Management.

1. Introduction

The increasing frequency and severity of extreme weather events due to anthropogenic climate change (IPCC 2021) pose growing challenges for both fiscal and monetary authorities. Governments worldwide must respond to increasingly frequent and costly natural disasters, while financing the transition to a low-carbon economy. These pressures exacerbate existing fiscal constraints and the riskiness of sovereign debt. At the same time, extreme weather events influence macroeconomic conditions in ways that may prompt central banks to adjust their policy stance, thereby affecting expectations of future policy rates. Consequently, sovereign bond yields are likely to respond to climate-related shocks through multiple channels. Yet little is known about how extreme weather events affect the term structure of interest rates.

This paper seeks to fill this gap. Specifically, we study the effects of extreme weather events on sovereign debt yields. Using the approach of Adrian et al. (2013), we decompose yields into two components: the average expected future policy rate over the life of the bond and a term premium. The former characterises market expectations of monetary policy, while the latter is a measure of compensation for interest rate risk. Since both might be affected by physical climate risks, it is helpful to break down yield responses to extreme weather into the two components.

Extreme weather events occur infrequently. To increase the statistical power of our analysis, we jointly consider yields with different maturities across a broad panel of countries. This includes 15 advanced economies and nine leading emerging market economies. These countries are ideal because they have sufficiently well-developed financial markets, institutions and economies, but also allow us to compare countries with different exposures to climate change. Beyond this group of emerging economies we also separately consider a panel of 10 African economies to provide some initial evidence for this continent.

In line with Jordà (2005), we trace the dynamic effects of natural disasters on yields and their components using panel local projection methods. Our results show that for many countries in our sample the effects are economically and statistically significant and often more pronounced for larger events, as measured by their human impact. Yet sovereign debt yields experience varying effects following extreme weather events across countries. While term premiums tend to rise following natural disasters, the effects are comparably small and not always statistically significant. For the short rate path, however, we observe a considerable degree of heterogeneity across countries. In some countries, investors expect the central bank to raise rates substantially following disasters, while in others they anticipate a decline in policy rates.

We then study a range of potential state variables to shed light on the underlying drivers behind these heterogeneous responses. We find that a country's fiscal state best helps to differentiate between the observed country-level results. Specifically, for advanced economies we rely on the debt-to-GDP ratio as a sufficient statistic for a country's debt sustainability.[1] For emerging economies, we use the average sovereign credit rating across rating agencies as a proxy of fiscal health. Relying on a smooth state transition model in the spirit of Auerbach and Gorodnichenko (2012), we find that advanced economies with low levels of debt experience strong increases in the expected rate path following extreme weather events, while the term premium is the primary driver of the yield response in states with high debt. In fiscally strong emerging economies, there is a similar noticeable response in the expected rate path (although in this case rates are expected to fall). Economies in weaker fiscal states exhibit a relatively muted response, potentially due to fiscal constraints.

To shed light on this heterogeneity, we further examine how extreme weather events affect inflation, estimating state-dependent impulse responses for year-over-year inflation rates. Inflation tends to fall in countries with high debt or weak credit ratings following a disaster, while it tends to rise in low-debt advanced economies. In stronger-rated emerging markets, inflation remains broadly unchanged. Combined, our results suggest that countries with a strong fiscal position are better able to cushion the economic fallout from natural disasters. Central banks in these countries respond to the resulting inflationary pressure by raising policy rates. In countries with weaker fiscal fundamentals, the term premium is the main driver of the yield response, suggesting investor concerns about debt sustainability following disasters. Our results highlight the importance of fiscal capacity in shaping the macroeconomic and financial market

---

[1] See Ghosh et al. (2013) for a discussion and application of the debt-to-GDP ratio in a model of fiscal space and debt sustainability of advanced economies.

responses to climate-related shocks. These findings have implications for modelling the economic impacts of climate change, designing monetary and fiscal policies, and understanding investor expectations in relation to climate risk.

The remainder of the paper is structured as follows. Section 2 reviews the literature and outlines the transmission channels through which extreme weather events affect the term structure of interest rates. Section 3 describes the data and empirical methodology. Section 4 discusses our main results. Section 5 concludes.

2. Transmission channels and literature review

Our work contributes to the growing literature on the macroeconomic effects of physical climate risks. Like much of the existing research, we focus on extreme weather events that can generally be associated with anthropogenic climate change, but we do not attribute individual events to climate change.[2]

2.1 Transmission mechanisms

Standard neoclassical growth theory suggests that natural disasters can affect the macroeconomy through two primary channels. First, disasters such as storms and floods destroy physical capital, reducing an economy's productive capacity. This capital destruction initially lowers output, but subsequent investment may restore capital to its pre-shock level and bring the economy back to its steady state. Second, disasters such as droughts and heatwaves do not destroy capital but instead reduce productivity, effectively acting as a negative total factor productivity (TFP) shock. In this case, output remains below potential until productivity recovers.[3]

Empirical results by Felbermayr and Gröschl (2014) or Fomby, Ikeda and Loayza (2013), among others, confirm these predictions. Especially for disasters that destroy capital, Cantelmo (2022) posits that disasters reducing capital stock tend to be followed by an investment-driven recovery, whereas those that represent productivity shocks

---

[2] The literature on attribution science establishes links between climate change and extreme weather events. Notable contributions include Min et al. (2011), Trenberth, Fasullo and Shepherd (2015) and Stott et al. (2016).

[3] See Hallegatte and Przyluski (2010) for a broader discussion of how extreme weather events affect economic activity.

result in more prolonged economic contractions. These dynamics also have important implications for inflation. When disasters reduce supply by destroying capital, they can increase inflation by raising the marginal productivity of capital while compressing output. However, if extreme weather events increase uncertainty about future productivity and capital depreciation, risk-averse agents may shift toward precautionary savings, reducing investment and lowering aggregate demand. The net impact on inflation and output may vary based on whether supply- or demand-side effects dominate.[4]

2.2 Empirical evidence on climate shocks and macroeconomic outcomes

The literature on the economic impact of climate change can be broadly classified into two strands. The first examines the effect of extreme weather events on economic growth. Studies such as Lemoine and Kapnick (2016), Dell, Jones and Olken (2012), Burke and Tanutama (2019), Kahn et al. (2019), Kiley (2021), Acevedo et al. (2020), Noy (2009), Loyaza et al. (2012) and Kim, Matthes and Phan (2021) document how extreme weather events have negative effects on output growth, increasing the likelihood of economic contractions. Our work is particularly motivated by Fomby, Ikeda and Loayza (2013) and Felbermayr and Gröschl (2014), who not only document overall negative effects on growth but also highlight differences between advanced and emerging economies, as well as variations based on disaster magnitude. Although measured in different ways, both studies find stronger effects in developing economies, but also significant contractions in advanced economies, with larger shocks associated with more pronounced economic effects.

A second strand of research explores the relationship between extreme weather events and inflation. Beirne et al. (2022) find a significant positive link between natural disasters and headline inflation in the euro area, with heterogeneous responses across countries. Similar findings emerge for African economies in Kunawotor et al. (2022) and for heatwaves specifically in Faccia, Parker and Stracca (2021). Our study is particularly related to Parker (2018), who examines inflationary responses to natural disasters, distinguishing between country groups and disaster magnitudes. His

4 Cantelmo (2022) builds on seminal work on disaster-induced macroeconomic shocks, including Barro (2006), Gabaix (2011, 2012) and Gourio (2012).

findings suggest that severe disasters lead to stronger inflationary pressures, particularly in high-income countries. Chavleishvili and Moench (2025) focus on the impact of natural disasters on the conditional distribution of both output growth and inflation. They introduce quantile and moment impulse response functions for structural quantile vector autoregressive models and document that disasters strongly shift the forecast distribution, particularly on the tails. Disasters trigger an initial sharp increase of downside risk for growth, followed by a temporary rebound. They also lead to higher upside risk to inflation for a few months. As a result, natural disasters have a persistent impact on the conditional variance and skewness of macroeconomic aggregates. For a more comprehensive review of the rapidly growing literature on the impact of natural disasters on economic outcomes, see Tol (2018) or Botzen, Deschenes and Sanders (2019).

Overall, these studies suggest that investors are likely to incorporate macroeconomic risks from extreme weather events into sovereign debt pricing, particularly through their effects on growth, inflation, and subsequent monetary and fiscal policy responses.

2.3 Climate risk and sovereign debt markets

Recent research has examined how climate risks influence sovereign bond markets. Cevik and Jalles (2022) show that climate vulnerability significantly increases bond yields and spreads, particularly for developing countries. Similar effects on spreads and sovereign default premiums are documented by Klomp (2015) and Kling et al. (2018), while Painter (2020) finds comparable patterns for US municipal bonds. Lis and Nickel (2010) estimate that budgetary costs from extreme weather events range from 0.23% to 1.4% of GDP in developing economies. Using a panel of 115 countries from 1985–2010, Klomp (2017) finds that large-scale natural disasters increase the probability of sovereign default by about three percentage points. Malluci (2022) shows that in the Caribbean hurricane risk reduces governments' ability to issue debt, with adverse welfare effects. In addition, Bauer and Rudebusch (2023) argue that declines in the natural rate of interest amplify the social cost of carbon, supporting stronger climate mitigation policies. For a broader literature review on climate change and government debt, see Seghini (2024).

Despite this growing body of research, little is known about how extreme weather events affect the term structure of sovereign yields. While macroeconomic theory suggests that climate shocks could influence yields through expectations of monetary policy or shifts in risk perception, thus far these mechanisms remain largely unexplored in empirical work.

2.4 Yield curve decomposition and extreme weather events

To investigate how extreme weather events affect sovereign bond yields, we rely on the model of Adrian, Crump and Moench (2013), which expresses bond yields as the sum of expectations about future short-term interest rates and a term premium. Specifically, for a bond of maturity n, we decompose the observed yield $y_t^{(n)}$ as follows:

$$y_t^{(n)} = \tilde{y}_t^{(n)} + tp_t^{(n)} \tag{1}$$

Here, $\tilde{y}_t^{(n)}$represents the risk-neutral yield component (i.e. the expected average future short rate over the bond's life) and $tp_t^{(n)}$captures the term premium, which reflects compensation for interest rate risk. The term premium is thus mainly influenced by inflation uncertainty, supply-and-demand dynamics in sovereign debt markets and broader risk sentiment. Assuming that log bond prices are affine in their pricing factors, time-varying risk premiums can be estimated from market yields following the regression-based approach established by Adrian, Crump and Moench (2013).

Given the documented effects of extreme weather events on output, inflation and macroeconomic uncertainty, climate shocks could affect the yield curve through two main channels:

1. *Monetary policy expectations:* If investors anticipate that central banks will respond to an extreme weather event by adjusting policy rates, this should be reflected in the expected short rate path.
2. *Risk perceptions and term premiums:* If extreme weather events alter perceptions of inflation risks, fiscal sustainability or economic uncertainty, they may influence the term premium.

By applying this decomposition, we aim to understand how investors perceive the macroeconomic consequences of climate shocks and whether their pricing of sovereign debt aligns with macroeconomic theory. We also investigate which state variables shape the cross-sectional and time-series variation in yield responses, with a particular focus on fiscal capacity. Importantly, since we rely on local currency yields, our setting does not focus on the direct credit risk concerns of international investors. To the best of our knowledge, ours is the first study to examine the immediate impact of extreme weather events on the term structure of sovereign yields and its underlying components.

3. Data and empirical approach

3.1 Data

Extreme weather events

To identify extreme weather events and their magnitude, we rely on the EM-DAT database provided by the Centre for Research on the Epidemiology of Disasters at the Université Catholique de Louvain. EM-DAT systematically records country-level human and economic losses from disasters that meet at least one of the following criteria: (i) at least 10 fatalities, (ii) at least 100 affected individuals, (iii) an official declaration of a state of emergency or (iv) a call for international assistance. This dataset is widely used in cross-disciplinary research on disaster impacts.

We focus exclusively on extreme weather events that can be linked to climate change, categorised as follows:

1. *Meteorological events:* storms, extreme temperatures, fog.
2. *Hydrological events:* floods and landslides.
3. *Climatological events:* droughts, glacial lake outbursts, wildfires.

Other natural disasters in EM-DAT – such as earthquakes, tsunamis, volcanic eruptions and epidemics are excluded because they are less directly related to climate change. EM-DAT compiles its data from a wide range of sources, including government agencies, United Nations bodies, NGOs, international aid organisations, insurance firms, research institutes and the press (Centre for Research on the Epidemiology of Disasters 2025).

For our baseline analysis with daily data, we define the occurrence of an extreme weather event using an indicator variable equal to one on days when EM-DAT records a disaster in a given country. To distinguish between smaller and larger events, we measure the human impact as the sum of reported deaths, homeless individuals and those classified as affected by the event in the EM-DAT dataset. This is in line with much of the literature. Following previous works studying the macroeconomic effects of extreme weather events, we focus on larger events. Specifically, we compute the median human impact across all events of a given country in the EM-DAT database since its inception and then restrict our empirical analysis to the largest 50% of events that also coincide with our available yield data. This allows us to focus on the larger events per country while maintaining a sufficient panel across countries and time. That said, the absolute size of the impact varies strongly across countries.[5]

Yield curve data

To examine the impact of extreme weather events on sovereign debt yields, we use local-currency zero-coupon yields sourced from Bloomberg. Specifically, we use a dataset provided by the International Monetary Fund (IMF), which applies the methodology of Adrian, Crump and Moench (2013) to a large cross-country panel. This dataset has been employed in several studies, including Moench (2019) and Adrian et al. (2019), which analyse global bond yield co-movements, and more recently, Adrian et al. (2024), which examines the effects of US monetary policy shocks on global sovereign yields and their components.

Our main sample consists of 15 advanced economies and nine emerging markets – a panel well-suited to our research question. These countries feature developed financial markets and institutions but vary in their exposure to climate risks. In addition, we conduct a separate analysis on 10 African economies, nine of which are in sub-Saharan Africa, to provide supplementary evidence. However, due to data constraints,

---

5 The ultimate count of disasters in a given country can be more or less than 50% of the total number depending on the availability of yield curve data for the respective country.

the availability of sovereign yield data is more limited in this sample. For these countries we rely on par yield curves from Bloomberg's BVAL dataset, following Du and Schreger (2016), as proxies for market-based zero-coupon yield curves. An overview of all countries considered, data availability and the respective number of extreme weather events can be found in Table A.1.

Macroeconomic and financial data

We obtain additional macroeconomic and financial data from three primary sources. Exchange rates are obtained from Bloomberg. Macroeconomic data such as inflation rates, growth rates or debt ratios are obtained from the IMF Data Portal. We also use information on climate vulnerability from the IMF's Climate Change Indicators dataset. To study the fiscal state of emerging markets we rely on the World Bank database for fiscal space based on Kose et al. (2022) and specifically use the foreign currency long-term sovereign debt ratings index.

3.2 Baseline local projections

Our empirical strategy is based on local projections, a flexible methodology introduced by Jordà (2005). This approach allows us to estimate impulse response functions without imposing strong parametric restrictions, making it well-suited to capturing the dynamic effects of extreme weather events on bond yields. Under mild assumptions, local projections yield estimates consistent with traditional VAR models, as demonstrated by Plagborg-Møller and Wolf (2021). We estimate the following specification:

$$\Delta_{i,h} y_t^{(n)} = \beta_{0,h}^{(n)} + \beta_{1,h}^{(n)} \omega_{i,t} + X_{i,t} + \varepsilon_{i,h,t}^{(n)} \tag{2}$$

where

$$\Delta_{i,h} y_{i,t}^{(n)} = y_{i,t+h}^{(n)} - y_{i,t-1}^{(n)}$$

is the h-period cumulative change of a yield (component) of a bond with maturity n for country i. Then $\beta_{1,h}^{(n)}$ is the coefficient of interest measuring the cumulative yield (component) change following an extreme weather event. In our baseline specification based on daily data, $\omega_{i,t}$ is a dummy variable equal to one if an extreme weather event occurred in country i on day t. In our monthly regressions, $\omega_{i,t}$ measures the number of events occurring in country i in month t. As part of our vector of control variables X, we include three lags of the yield component $(y_{i,t-1}, y_{i,t-2}, y_{i,t-3})$ to account for potential serial yield correlations. We also control for lagged annual values of CPI inflation and GDP growth and country i's exchange rate in relation to the US dollar (and the euro in the case of the United States). Finally, we also include year fixed effects to account for low-frequency shifts in global yields unrelated to natural disasters. For individual country estimates, we report Newey-West standard errors (Newey and West 1987) to correct for autocorrelation and heteroskedasticity. In panel regressions, we compute Driscoll-Kraay standard errors (Driscoll and Kraay 1998) to account for cross-sectional dependence.

3.3 State-dependent impulse responses

As discussed in section 2, the economic consequences of extreme weather events may vary based on a country's fiscal position. High-debt economies might experience more pronounced yield responses due to increased sovereign risk, whereas economies with less fiscal constraints may exhibit greater resilience. To capture this heterogeneity, we estimate state-dependent impulse responses following Auerbach and Gorodnichenko (2012) and others.[6] Specifically, we modify equation 2 to allow for a smooth transition between high- and low-debt regimes:

$$\Delta_{i,h} y_t^{(n)} = \beta_{0,h}^{(n)} + \beta_{1,h}^{(n)} F(z_{i,t-1}) \omega_{i,t} + \beta_{2,h}^{(n)} \left(1 - F(z_{i,t-1})\right) \omega_{i,t} + X_{i,t} + \varepsilon_{i,h,t}^{(n)} \qquad (3)$$

where $z_{i,t-1}$ is the state variable capturing fiscal conditions. For advanced economies this is measured as net public debt as a percentage of GDP, while for emerging markets this is measured by the World Bank sovereign debt ratings index. The transition function is defined as

6 Works that have applied this approach to local projections include Tenreyro and Thwaites (2016) or Born, Müller and Pfeifer (2020).

$$F(z_{t-1}) = \frac{exp\left(\theta \frac{z_{t-1} - c}{\sigma_z}\right)}{1 + exp\left(\theta \frac{z_{t-1} - c}{\sigma_z}\right)} \tag{4}$$

where c and σ_z are the median and standard deviation of z_{t-1} across all countries in a given year. We set $\theta = 5$ to ensure a smooth yet meaningful separation between fiscal regimes.[7]

Finally, for estimating the state-dependent impulse response functions of the monthly year-over-year consumer price index, we simplify equation 3 to

$$\Delta_{i,h}\pi_t = \beta_{0,h} + \beta_{1,h}F\big(z_{i,t-1}\big)\omega_{i,t} + \beta_{2,h}\left(1 - F\big(z_{i,t-1}\big)\right)\omega_{i,t} + X_{i,t} + \varepsilon_{i,h,t}^{(n)} \tag{5}$$

where the control vector X only includes three lags of the consumer price index. Overall, our empirical approach leverages local projections to estimate the impact of extreme weather events on sovereign bond yields. The use of state-dependent impulse responses allows us to examine how these effects differ based on fiscal conditions, providing new evidence on the interaction between climate risk and sovereign credit markets. By applying a flexible econometric framework, we contribute to the growing literature on climate finance and sovereign debt sustainability.

4. Results

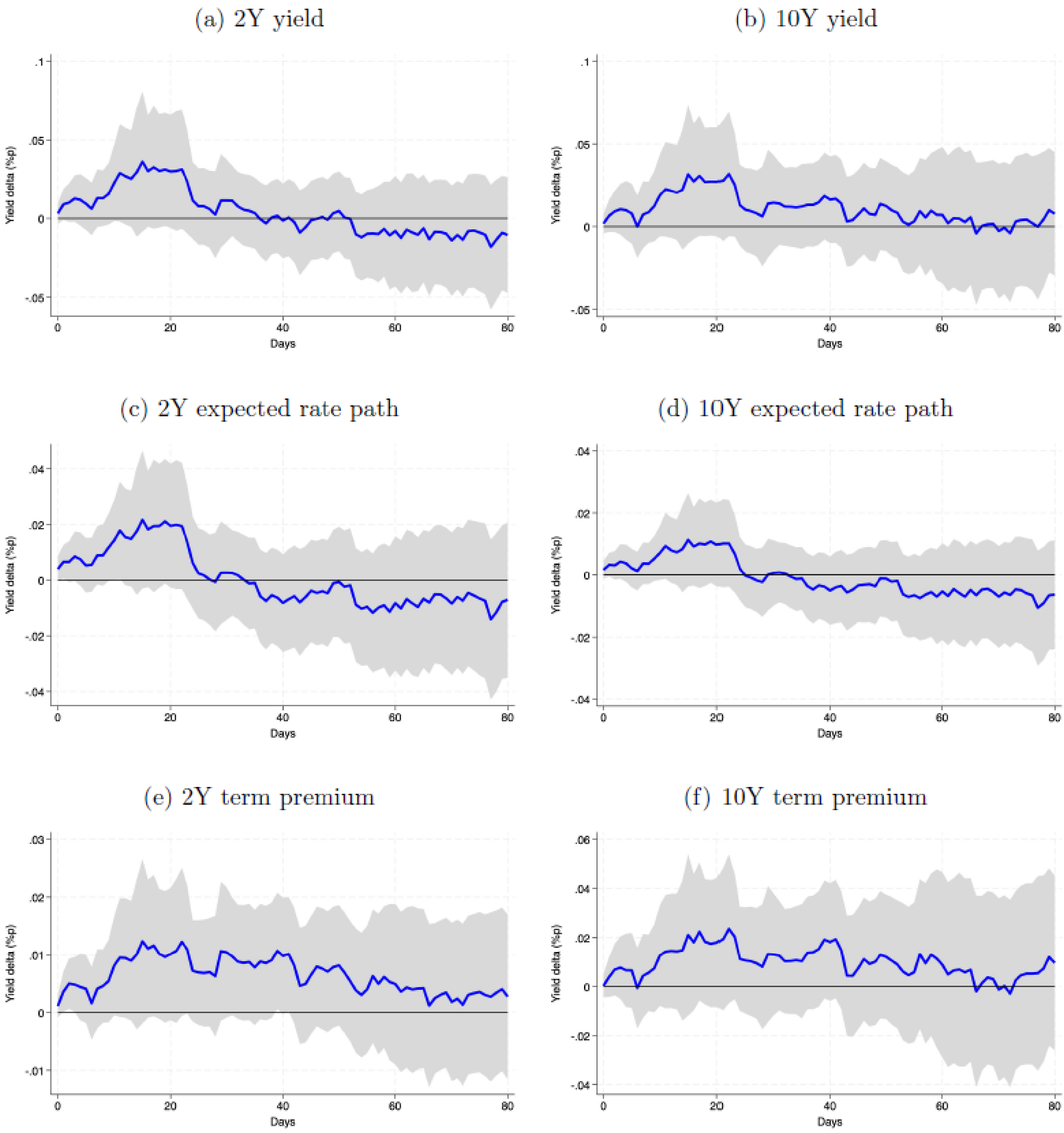
4.1 Basic yield responses

Estimating impulse response functions in line with equation 2 reveals distinct patterns across country groups. Figure 1 presents results for the two-year yield and its components (left panel) and 10-year yield and components (right panel) for advanced economies. The blue solid lines show the estimated $\beta_{1,h}$ coefficients, which provide the mean impulse response function. The grey shaded areas capture the 90% confidence band around these mean estimates.

---

[7] The estimated functions are shown in Annex B.

Figure 1: Panel impulse responses of advanced economies



Note: The figure shows impulse response functions of the daily two-year and 10-year yield and its expected short rate and term premium components to the largest 50% of extreme weather events, as specified in equation 2. The left panel shows the impulse responses of the two-year maturity and the right panel of the 10-year maturity. The sample period follows data availability and is summarised in Table A.1. We use Driscoll-Kraay standard errors and show confidence bands at the 90% level.

For both maturities, we see a small uptick in yields. This increase after a natural disaster is driven by growth in both the short rate component and the term premium. While the former rises particularly over the first 20 to 30 days after the event, the term premium increases more persistently. The corresponding results for the emerging market panel are provided in Figure C.15. Here, the responses are mixed and do not show a clear pattern. While two-year yields and their components appear to be little affected by disasters, 10-year yields tend to decline about two to three months after these events.

These initial findings motivate a separation of advanced and emerging economies, consistent with prior studies such as Felbermayr and Gröschl (2014). Structural differences – including institutional strength, fiscal and monetary policy frameworks, and access to liquid financial markets – could drive the observed divergence in yield responses across these groups. However, even within these broad categories, there is substantial cross-country heterogeneity, suggesting that aggregate results may obscure important underlying heterogeneity. To further explore this variation, we extend our analysis using state-dependent local projections, allowing us to assess how sovereign bond markets respond to disaster shocks under different fiscal conditions.[8]

4.2 State-dependent responses: advanced economies

To explore the heterogeneous yield responses observed in section 4.1, we estimate state-dependent local projections, using a country's fiscal position as the state variable. This approach is motivated by the transmission channels discussed in section 2 and aligns naturally with sovereign debt dynamics. Countries with high debt levels may experience stronger fiscal pressures following extreme weather events, as governments typically provide disaster relief and post-disaster economic support. Such responses can, in turn, influence growth and inflation expectations, shaping yield dynamics. Governments may also issue additional debt to finance these expenditures, affecting bond supply along the yield curve. Finally, in some cases, central banks may consider fiscal sustainability in their policy decisions, which could impose constraints on monetary policy.[9]

Short-term yield response

Figure 2 presents daily impulse response functions of yield components for high-debt countries (left panel) and low-debt countries (right panel), estimated with equation 3.

---

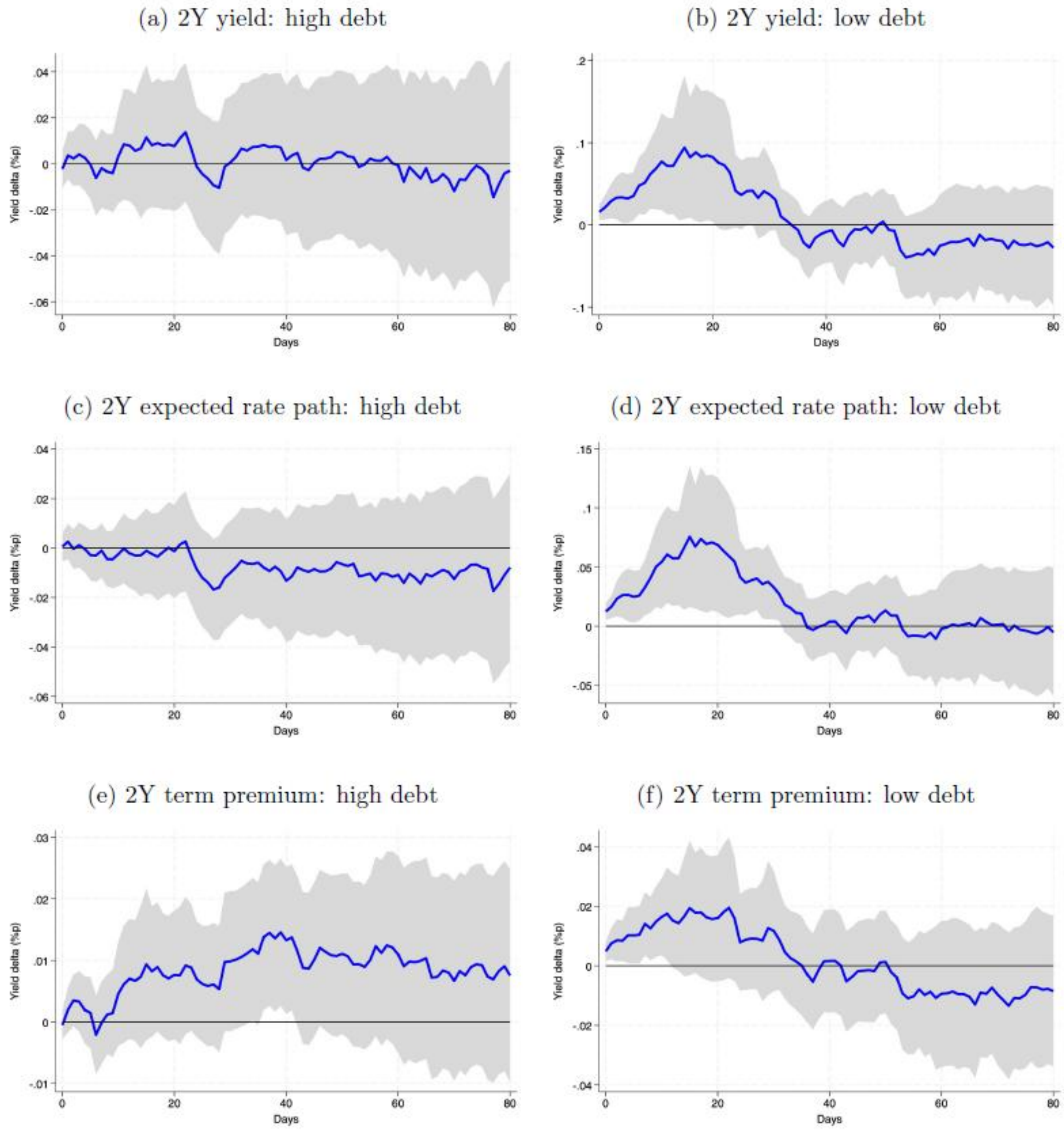
[8] Results for selected individual countries are presented in Figure C.16.

[9] We also considered other potential state variables, such as climate vulnerability or attention to climate change. However, we did not find much evidence suggesting that these variables help explain heterogeneity in the yield responses across countries.

The results suggest limited short-term effects for high-debt economies, with only the term premium exhibiting a positive drift that is borderline statistically significant. In contrast, low-debt economies show a statistically and economically significant increase in short rate expectations, which persists for approximately 40 days before reverting to pre-shock levels. The term premium, however, remains unchanged in this group. The results are similar at the longer end of the yield curve, although the magnitude of the response is slightly smaller for short rate expectations (see Figure C.18). This is plausible as policy rate adjustments in response to natural disasters should be temporary, rather than driving average short rate expectations over longer periods of time.

These initial findings suggest that investors price in higher interest rate risk in high-debt economies, whereas in low-debt economies they primarily adjust short rate expectations in response to the shock. However, both effects are transitory, reflecting a temporary increase in uncertainty surrounding extreme weather events. This is particularly relevant for disasters with delayed economic repercussions, where the full extent of damages and the policy responses to these events only become evident over time.

Figure 2: State-dependent panel impulse responses of advanced economies (daily)

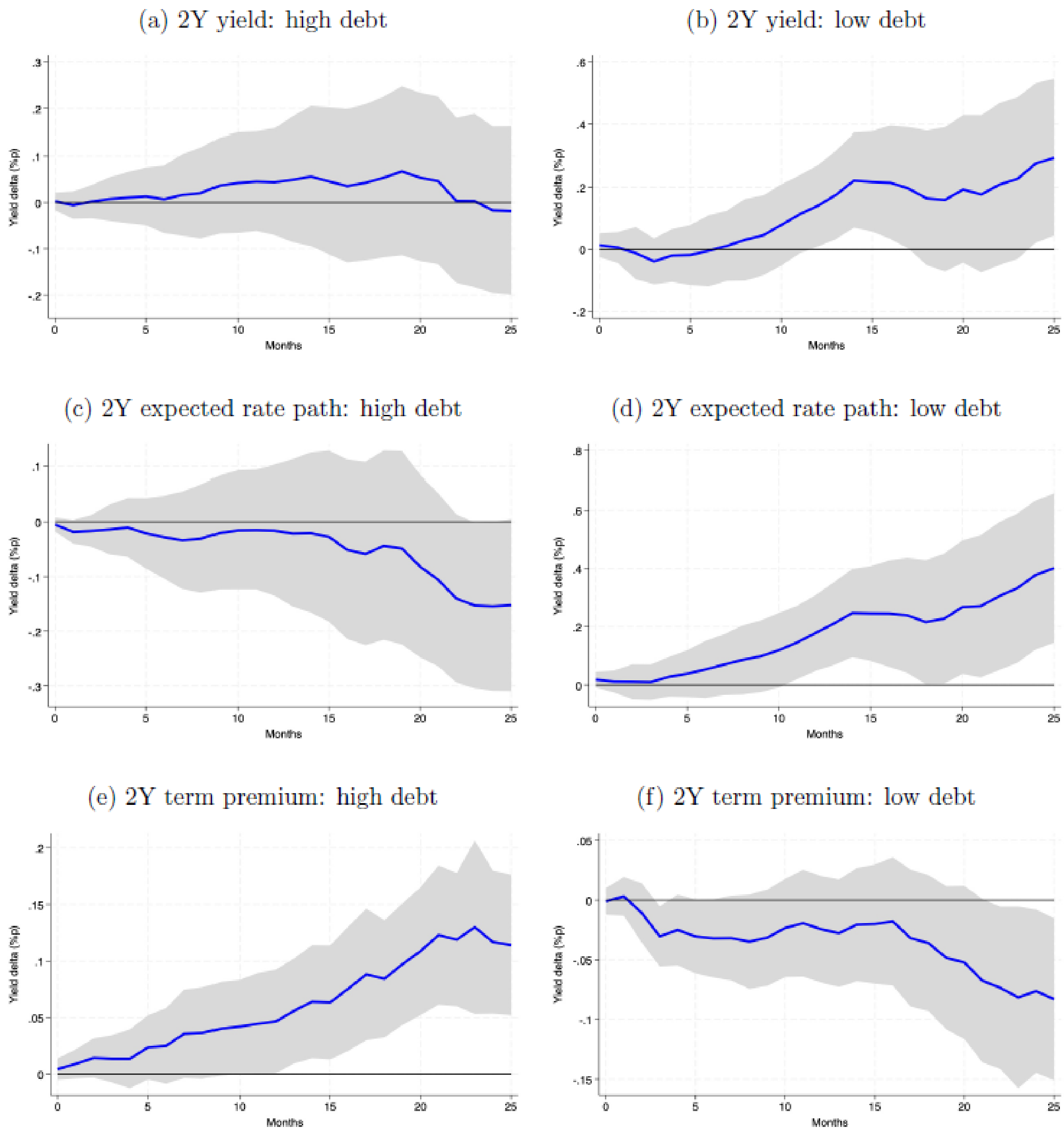


Note: The figure shows impulse response functions of the daily two-year yield and its expected short rate and term premium components to the largest 50% of extreme weather events, as specified in equation 3. The left panel shows the impulse responses of countries in a high debt-to-GDP state and the right panel in a low debt-to-GDP state. The sample period follows data availability and is summarised in Table A.1 We use Driscoll-Kraay standard errors and show confidence bands at the 90% level.

Longer-term yield response

To capture the longer-term dynamics, we estimate monthly impulse response functions, which provide a broader perspective once investors have more certainty about the economic and fiscal implications of the shock. The indicator variable in equation 3 captures the number of events per month. The results, shown in Figure 3, suggest that the short-term daily responses observed earlier serve as precursors to the longer-term effects: for high-debt economies, the term premium gradually rises, leading the overall yield response. For low-debt economies, short rate expectations increase, consistent with anticipated monetary policy tightening in response to inflationary pressures. Again there are similar impulse responses at the longer end of the yield curve, but in smaller magnitude in the short rate expectations (see Figure C.19).

Figure 3: State-dependent panel impulse responses of advanced economies (monthly)

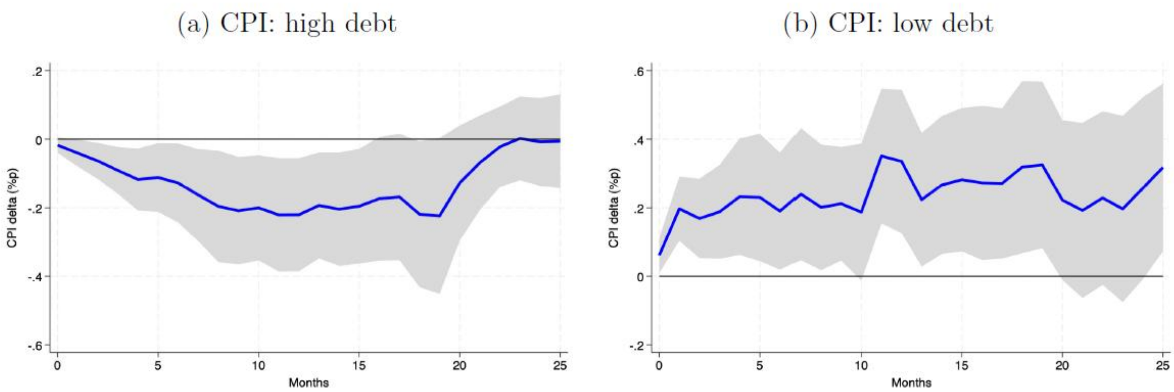


Note: The figure shows impulse response functions of the monthly two-year yield and its expected short rate and term premium components to the largest 50% of extreme weather events, as specified in equation 3. The left panel shows the impulse responses of countries in a high debt-to-GDP state and the right panel in a low debt-to-GDP state. The sample period follows data availability and is summarised in Table A.1. We use Driscoll-Kraay standard errors and show confidence bands at the 90% level.

State-dependent inflation response

To further explore these mechanisms, we estimate state-dependent impulse responses for year-over-year CPI inflation at a monthly frequency. The results, shown in Figure 4, highlight a striking asymmetry in the inflation response between high- and low-debt advanced economies. In highly indebted countries, inflation declines for approximately 18 months before gradually reverting to pre-shock levels. In low-debt economies, inflation rises immediately and remains persistently elevated over the two-year horizon.

Figure 4: State-dependent panel impulse responses of advanced economies (CPI)



Note: The figure shows impulse response functions of the monthly year-over-year consumer price index to the largest 50% of extreme weather events, as specified in equation 3. The exchange rate, CPI and GDP growth are omitted from the control variables in this specification. The left panel shows the impulse responses of countries in a high debt-to-GDP state and the right panel in a low debt-to-GDP state. The sample period follows data availability and is summarised in Table A.1. We use Driscoll-Kraay standard errors and show confidence bands at the 90% level.

These findings align with existing evidence on the growth-inflation nexus following extreme weather events. For high-debt economies, the initial decline in inflation is consistent with weaker growth (see, for example, Felbermayr and Gröschl (2014)), while the subsequent rebound coincides with a delayed increase in term premiums. Notably, the expected short-term rate path remains unchanged, potentially reflecting concerns over debt sustainability and the fiscal burden of higher interest rates. In contrast, inflationary pressures in low-debt economies emerge immediately after the event. This is in line with Parker (2018) and likely driven by stronger disaster relief spending and capital stock replenishment. This inflationary response coincides with a statistically significant rise in short rate expectations, suggesting that investors anticipate a monetary policy tightening to counteract rising prices.

4.3 State-dependent responses: emerging economies

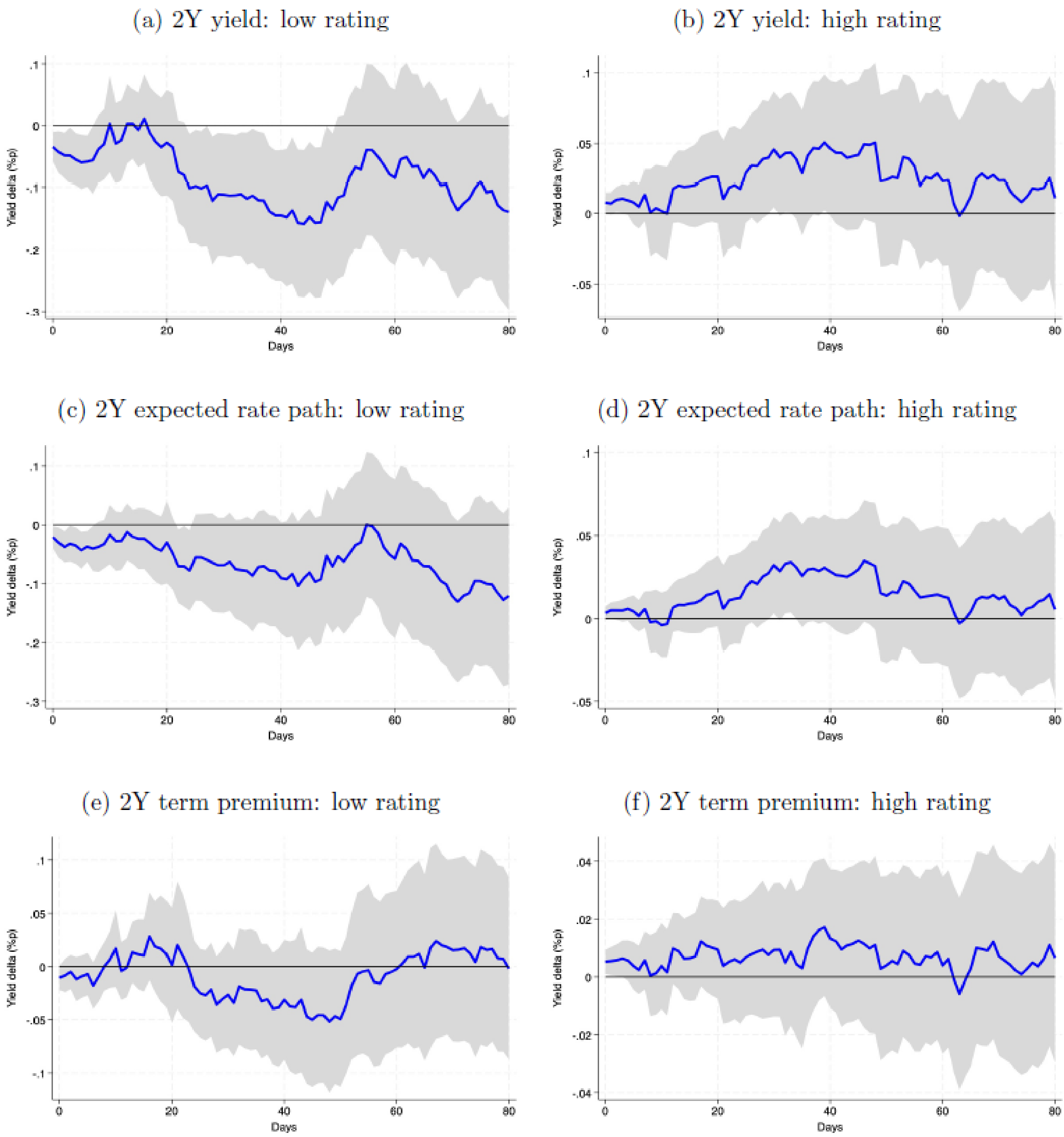
Following the analysis of advanced economies, we investigate state-dependent responses for emerging market economies. However, instead of using the debt-to-GDP ratio as the state variable, we rely on the World Bank's foreign currency long-term sovereign debt ratings index as a proxy for a country's fiscal health. This helps mitigate potential endogeneity concerns given that a low debt-to-GDP ratio may itself reflect limited access to financial markets, making it an unreliable indicator of fiscal strength. Since credit rating agencies incorporate these institutional and fiscal risks into their assessments, sovereign credit ratings should provide a more accurate proxy for fiscal conditions in emerging markets.

Short-term yield response

The daily impulse response functions for emerging markets reveal less pronounced patterns than those observed for advanced economies. In countries with weak credit ratings – indicating fragile fiscal conditions – both short rate expectations and the term premium decline temporarily. However, these responses exhibit weak statistical significance.

For higher-rated economies, the short-term response differs. We observe a weakly positive drift in short rate expectations, while the term premium remains unchanged. This pattern bears some similarity to the initial responses observed in our panel of advanced economies, where fiscally stronger countries exhibit a temporary rise in expected policy rates. The respective impulse response functions for emerging economies are presented in Figure 5. In line with advanced economies, the longer end of the yield curve responds similarly, with the response of short rate expectations being of a smaller magnitude (see Figure C.20).

Figure 5: State-dependent panel impulse responses of emerging markets (daily)

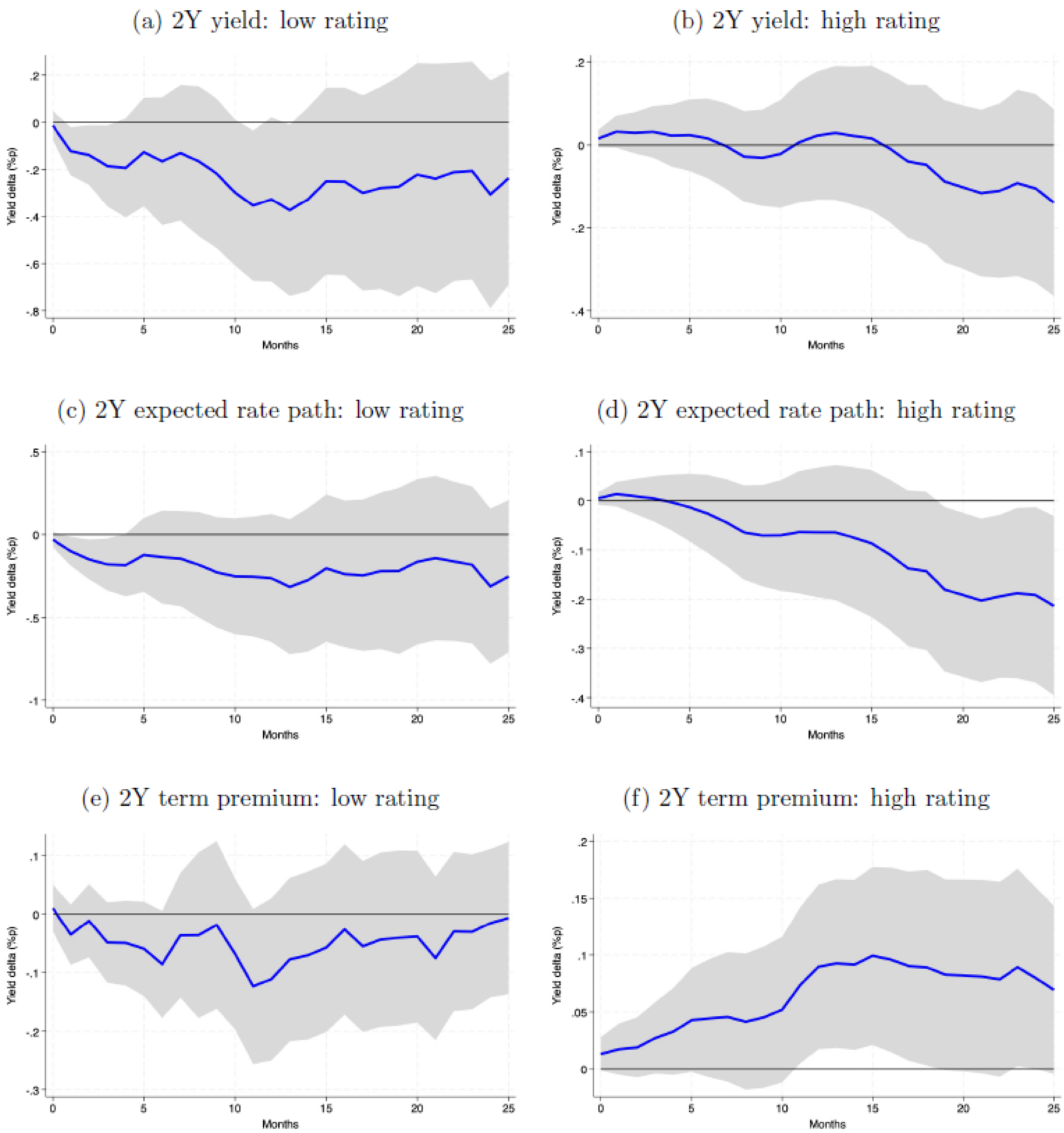


Note: The figure shows impulse response functions of the daily two-year yield and its expected short rate and term premium components to the largest 50% of extreme weather events, as specified in equation 3. The left panel shows the impulse responses of countries in a low rating state and the right panel in a high rating state. The sample period follows data availability and is summarised in Table A.1. We use Driscoll-Kraay standard errors and show confidence bands at the 90% level.

Long-term yield response

Unlike in advanced economies – where the short rate response provides useful insight into longer-term yield dynamics – the emerging market panel exhibits more divergent patterns over longer time periods (see Figure 6). In fiscally constrained economies, policy rate expectations remain largely unchanged, while the term premium exhibits a slight downward trend. This is, however, only weakly statistically significant. In higher-rated economies, the longer-term response is quite different from the short-term findings. We observe a statistically and economically significant decline in expected average short rates, suggesting that investors anticipate monetary policy easing in response to the economic shock. At the same time, the term premium rises, potentially reflecting increased inflation risk and expectations of higher government bond issuance – both of which contribute to declining bond prices and higher yields at longer maturities. This is again mirrored for longer maturity yields, as shown in Figure C.21.

Figure 6: State-dependent panel impulse responses of emerging markets (monthly)

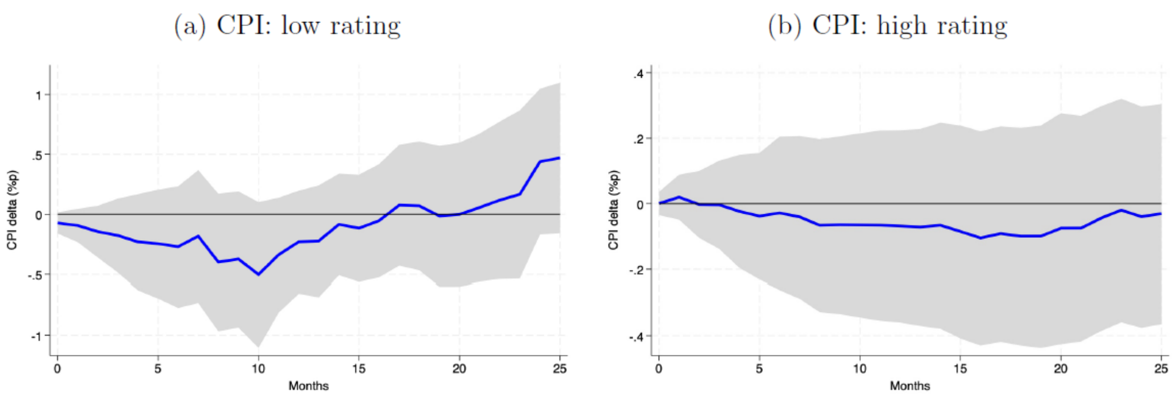


Note: The figure shows impulse response functions of the monthly two-year yield and its expected short rate and term premium components to the largest 50% of extreme weather events, as specified in equation 3. The left panel shows the impulse responses of countries in a low rating state and the right panel in a high rating state. The sample period follows data availability and is summarised in Table A.1. We use Driscoll-Kraay standard errors and show confidence bands at the 90% level.

State-dependent inflation response

The inflation responses in emerging markets are similar to those observed in advanced economies, particularly among fiscally weaker countries. As presented in Figure 7, inflation declines in the aftermath of extreme weather events, followed by a gradual return to the pre-shock level. The larger magnitude of this effect in comparison to advanced economies is consistent with the substantially more negative impact of extreme weather events on growth documented in Fomby, Ikeda and Loayza (2013) or Felbermayr and Gröschl (2014).

Figure 7: State-dependent panel impulse responses of emerging markets (CPI)



Note: The figure shows impulse response functions of the monthly year-over-year consumer price index to the largest 50% of extreme weather events, as specified in equation 3. The exchange rate, CPI and GDP growth are omitted from the control variables in this specification. The left panel shows the impulse responses of countries in a low rating state and the right panel in a high rating state. The sample period follows data availability and is summarised in Table A.1. We use Driscoll-Kraay standard errors and show confidence bands at the 90% level.

However, for higher-rated emerging market economies, inflation remains largely unchanged, unlike the persistent inflationary pressures observed in their advanced economy counterparts. This could suggest that in emerging markets the opposing forces of economic contraction from the shock and government-led recovery efforts largely offset each other, resulting in a muted overall inflation response.

Taken together, these findings highlight important differences between the responses of advanced and emerging economies: in fiscally constrained emerging markets, inflation and short rate expectations behave similarly to their advanced economy counterparts, with initial declines followed by a reversion to the mean. In higher-rated emerging markets, inflation remains unchanged, possibly due to offsetting effects between the economic shock and subsequent disaster recovery efforts. Unlike in advanced economies, investors appear to anticipate monetary policy easing in response to the shock, leading to declining short rate expectations. In addition, expectations of increased government borrowing may contribute to a higher term premium. These results underscore key differences in how sovereign debt markets adjust to extreme weather shocks, shaped by both institutional capacity and monetary-fiscal interactions. They also underline the importance of accounting for state dependencies in the transmission of natural disaster shocks on the macroeconomy and sovereign debt markets, which the existing literature has not yet considered.

4.4 Indicative evidence: African countries

Beyond our analysis of advanced and emerging economies, we also examine a panel of African countries, including Botswana, Egypt, Ghana, Kenya, Mauritius, Namibia, Nigeria, South Africa, Uganda and Zambia. Since we do not have a yield decomposition for these countries and given the smaller sample size, these findings should be interpreted as indicative rather than conclusive evidence.

Despite these limitations, the estimated impulse response functions reveal notable insights. The figures are shown in Annex D to conserve space. First, the economic magnitude of yield responses in African markets is substantially larger than in advanced or emerging economies. However, the broad responses align closely with our findings for emerging markets: in fiscally constrained African countries (proxied by weaker sovereign ratings), yields initially decline, followed by no clear directional response – mirroring patterns observed in weaker-rated emerging markets. In fiscally stronger African countries, yields show a persistent downward trend in line with higher-rated emerging markets. The impulse responses of yields (Figure D.23) closely resemble the state-dependent response of inflation, but with a substantially larger magnitude for lower-rated countries and a smaller magnitude for higher-rated countries.

These findings suggest that sovereign bond markets in African economies respond similarly to those in other emerging markets, albeit with amplified magnitudes. While the underlying mechanisms require further investigation, these results highlight the heightened sensitivity of African bond yields to extreme weather shocks, potentially reflecting lower market depth, higher risk premiums and more volatile investor expectations.

5. Conclusion

This paper has examined the impact of extreme weather events on the term structure of sovereign bond yields, applying the yield decomposition framework of Adrian, Crump and Moench (2013) and using state-dependent local projections to capture heterogeneity across countries. Using a broad panel of advanced, emerging and African economies, our results provide novel evidence of how fiscal capacity influences the transmission of climate shocks to sovereign debt markets.

Our findings indicate that extreme weather events affect sovereign bond yields through distinct channels, with heterogeneous responses across groups of countries. Among advanced economies, low-debt countries experience a significant rise in the expected short rate path, consistent with investors anticipating a monetary tightening in response to inflationary pressures following such events. In contrast, high-debt countries primarily exhibit a rise in term premiums, suggesting that investors price in higher interest rate risk rather than a policy rate adjustment.

In emerging markets, the responses are more nuanced. Fiscally constrained economies have muted yield responses, potentially reflecting limited fiscal space to respond to climate shocks. In contrast, emerging markets with a better credit rating experience a decline in short rates and a rise in term premiums, suggesting that investors anticipate monetary easing and increased debt issuance following disasters. These results highlight the role of institutional strength and policy credibility in shaping financial market reactions to climate risk.

Our indicative evidence for African economies suggests that bond markets in these countries exhibit amplified yield responses compared to other emerging markets. Fiscally constrained countries show initial declines in yields, while countries with higher credit ratings exhibit persistent downward trends, mirroring patterns observed in other emerging economies. These findings suggest that lower market depth and heightened risk premiums may amplify the financial effects of climate shocks in African economies.

Policy and research implications

Our results underscore the critical role of fiscal capacity in shaping the macroeconomic and financial consequences of extreme weather events. Policymakers should consider fiscal sustainability as a key factor in climate risk mitigation, as countries with higher debt burdens appear more vulnerable to financial market disruptions following extreme weather events. Similarly, central banks must carefully balance monetary policy trade-offs, as climate shocks can generate both inflationary pressures and financial stability concerns depending on a country's fiscal position.

From a research perspective, future work could explore broader state dependencies in financial spillovers, including the impact of fiscal constraints on private sector borrowing costs, corporate bond markets and financial stability risks following extreme weather events. Further investigation into the interaction between climate shocks, fiscal policy and central bank responses would provide deeper insights into the macroeconomic management of climate risks.

Final remarks

As climate change continues to make extreme weather events more frequent and severe, it is becoming increasingly important to understand the impact of these events on sovereign debt markets. Our findings contribute to the growing literature on climate finance by demonstrating how fiscal constraints and investor expectations shape sovereign yield responses to climate shocks. Future research on the long-term implications of climate risk for debt sustainability and monetary-fiscal coordination will be essential for designing resilient economic policies in an era of increasing environmental uncertainty.

Annexures

Annex A: Data availability

Table A.1 presents data availability by country as well as the country group composition used in our three panels. The start date is determined by the availability of yield data. The number of events corresponds to all events from that start date until the end of our sample. The number of large events corresponds to the largest 50% of events, as measured by the human impact over the entirety of events in the EM-DAT database for a given country. This allows us to capture longer-term trends in the intensity of extreme weather events despite the comparably short sample period of our yield data. Thus, the ultimate count of large disasters in a given country can be more or less than 50% of the total number depending on the availability of yield curve data for the respective country. Table A.2 presents an overview of large events by disaster type and country.

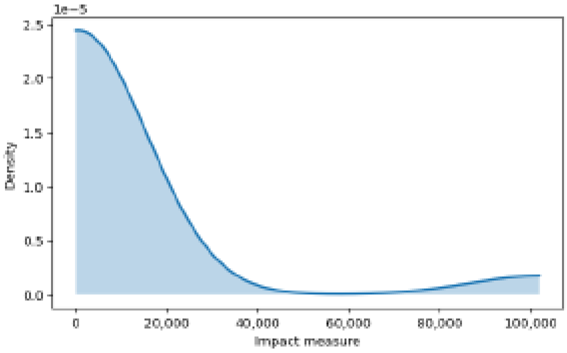
Table A.1: Summary of country-specific sample characteristics

Country	Start date	End date	Events	Large events	Country group
Belgium	2000-02-01	2023-03-03	32	15	Advanced economies
Canada	2000-02-01	2023-03-03	67	34	Advanced economies
Denmark	2000-02-01	2023-03-03	8	3	Advanced economies
France	2000-02-01	2023-03-03	99	60	Advanced economies
Germany	2000-02-01	2023-03-03	53	25	Advanced economies
Ireland	2000-02-01	2023-03-03	12	5	Advanced economies
Israel	2005-03-31	2023-03-03	8	4	Advanced economies
Italy	2000-02-01	2023-03-03	67	30	Advanced economies
Netherlands	2000-02-01	2023-03-03	20	12	Advanced economies
Portugal	2000-02-01	2023-03-03	23	11	Advanced economies
Spain	2000-02-01	2023-03-03	51	24	Advanced economies
Sweden	2000-02-01	2023-03-03	7	4	Advanced economies
Switzerland	2000-02-01	2023-03-03	28	16	Advanced economies
United Kingdom	2000-02-01	2023-03-03	53	31	Advanced economies
United States	2000-02-01	2023-03-03	523	284	Advanced economies
Brazil	2007-03-27	2023-03-03	81	45	Emerging markets
China	2004-04-28	2023-03-03	394	216	Emerging markets
Colombia	2006-04-28	2023-03-03	76	44	Emerging markets
Czech Republic	2000-12-15	2023-03-03	25	12	Emerging markets
Hungary	2001-03-16	2023-03-03	16	8	Emerging markets
Peru	2006-05-01	2023-03-03	44	24	Emerging markets
Poland	2000-12-15	2023-03-03	39	20	Emerging markets
Russia	2005-03-29	2022-03-31	46	30	Emerging markets
South Africa	2000-02-01	2023-03-03	60	31	Emerging markets
Botswana	2014-07-30	2023-03-03	2	1	African markets
Egypt	2011-10-10	2023-03-03	6	4	African markets
Ghana	2014-07-15	2023-03-03	12	3	African markets
Kenya	2011-11-09	2023-03-03	17	10	African markets
Mauritius	2018-06-04	2023-03-03	2	0	African markets
Namibia	2014-07-10	2023-03-03	3	0	African markets
Nigeria	2011-11-07	2023-03-03	19	14	African markets
South Africa	2000-02-01	2023-03-03	60	31	African markets
Uganda	2020-11-24	2023-03-03	7	3	African markets
Zambia	2015-12-03	2023-03-03	6	2	African markets

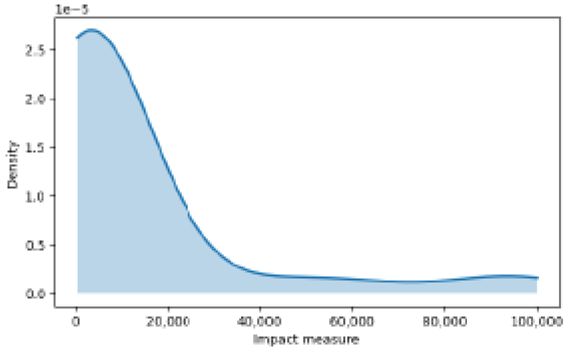
Table A.2: Number of large events by country and disaster category

Country	Storms	Extreme temperature	Floods	Droughts	Wildfires	Mass movement (wet)
Belgium	2	7	6	0	0	0
Canada	4	1	24	0	5	0
Denmark	2	1	0	0	0	0
France	18	8	32	0	2	0
Germany	14	4	7	0	0	0
Ireland	1	1	3	0	0	0
Israel	2	0	0	0	2	0
Italy	5	2	20	0	1	2
Netherlands	7	5	0	0	0	0
Portugal	1	2	3	0	5	0
Spain	2	2	17	0	3	0
Sweden	2	1	1	0	0	0
Switzerland	8	2	3	0	0	3
United Kingdom	6	3	22	0	0	0
United States	143	3	81	0	55	2
Brazil	2	0	42	1	0	0
China	88	3	120	2	0	3
Colombia	3	0	37	0	0	4
Czech Republic	2	3	7	0	0	0
Hungary	2	0	6	0	0	0
Peru	0	2	20	0	0	2
Poland	8	4	8	0	0	0
Russia	0	1	26	0	2	1
South Africa	10	0	18	1	2	0
Botswana	0	0	1	0	0	0
Egypt	1	1	2	0	0	0
Ghana	0	0	3	0	0	0
Kenya	0	0	10	0	0	0
Mauritius	0	0	0	0	0	0
Namibia	0	0	0	0	0	0
Nigeria	1	0	13	0	0	0
South Africa	10	0	18	1	2	0
Uganda	0	0	3	0	0	0
Zambia	0	0	2	0	0	0

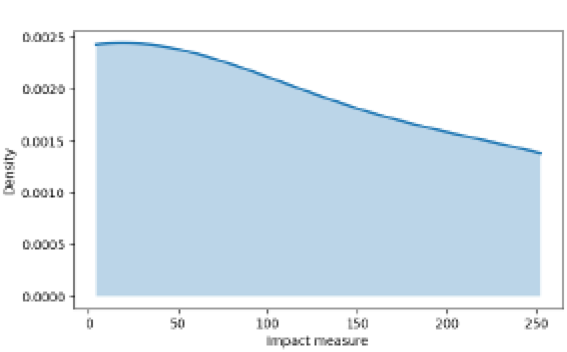
Figure A.8: Distribution (kernel density estimation) of impact measures by country (page 1)



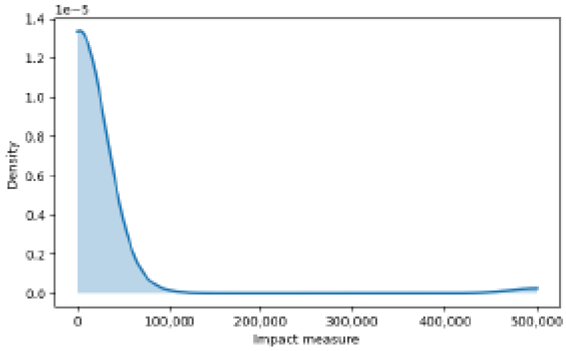
(a) Belgium



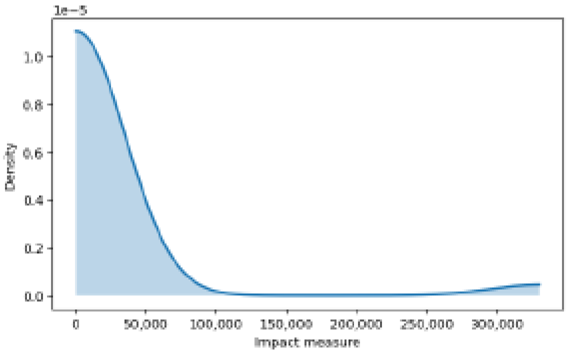
(b) Canada



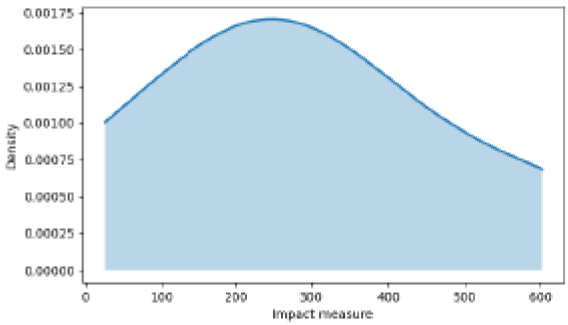
(c) Denmark



(d) France

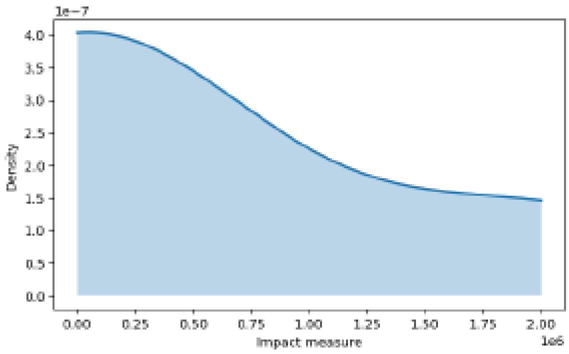


(e) Germany

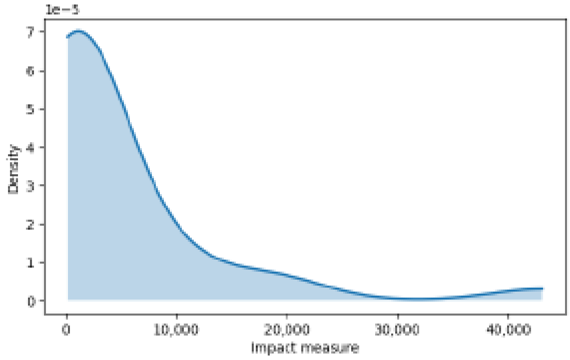


(f) Ireland

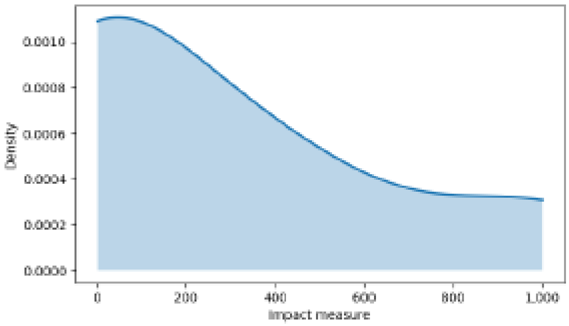
Figure A.9: Distribution (kernel density estimation) of impact measures by country (page 2)



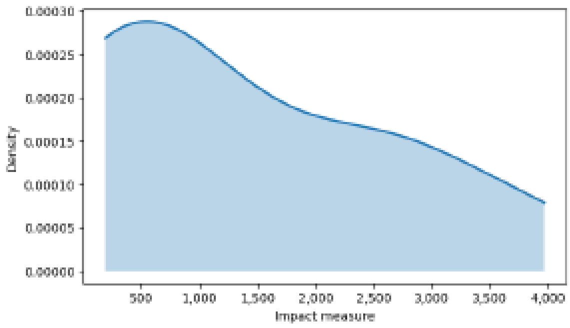
(a) Israel



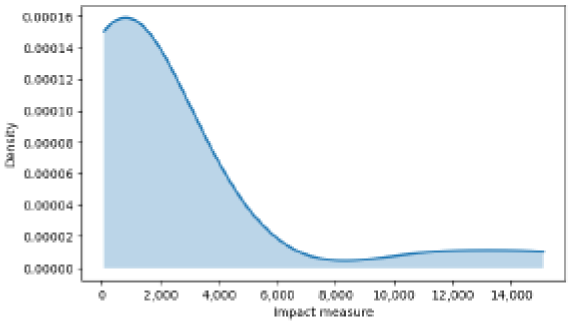
(b) Italy



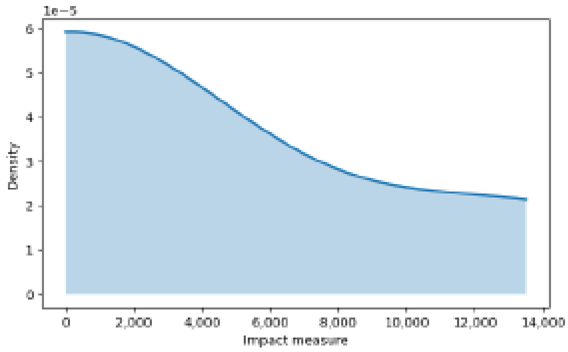
(c) Netherlands



(d) Portugal

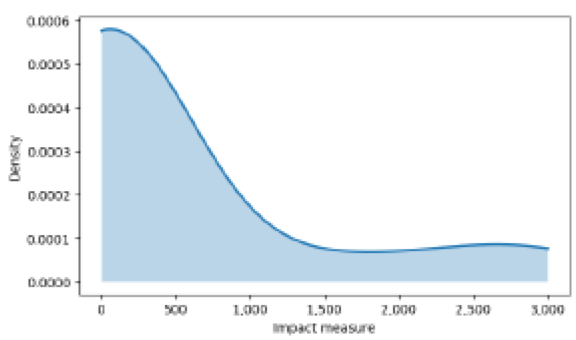


(e) Spain

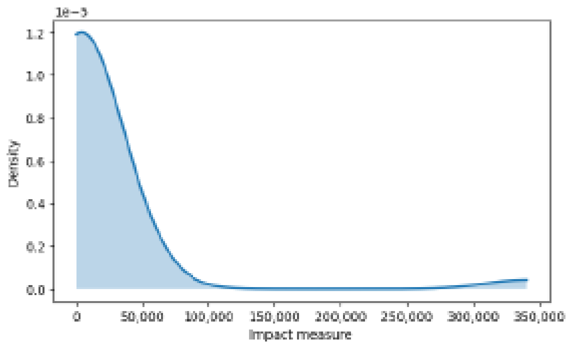


(f) Sweden

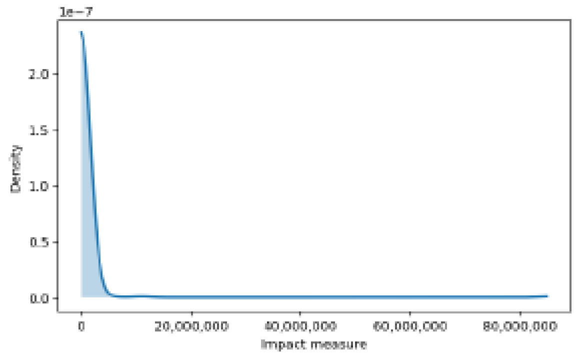
Figure A.10: Distribution (kernel density estimation) of impact measures by country (page 3)



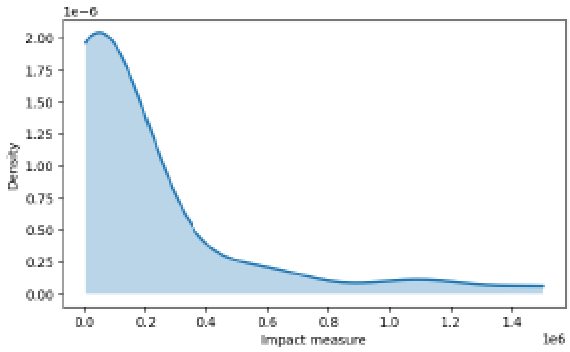
(a) Switzerland



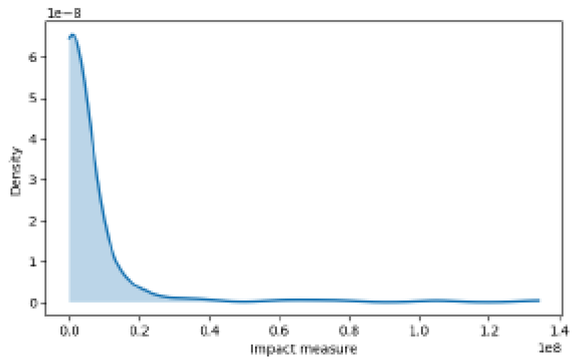
(b) United Kingdom



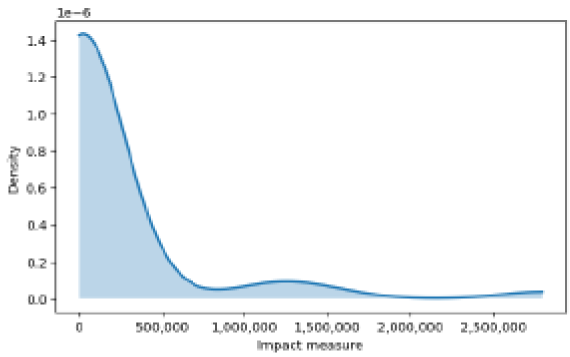
(c) United States



(d) Brazil

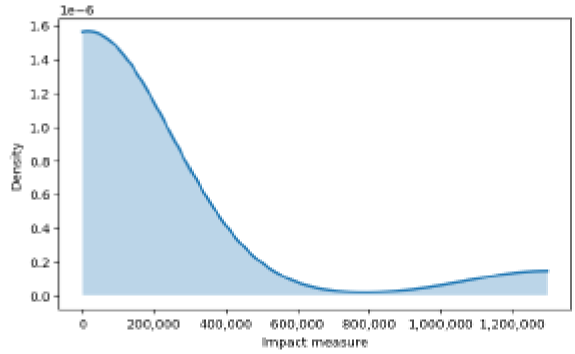


(e) China

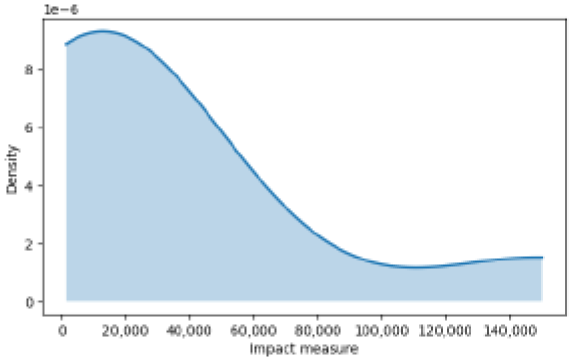


(f) Colombia

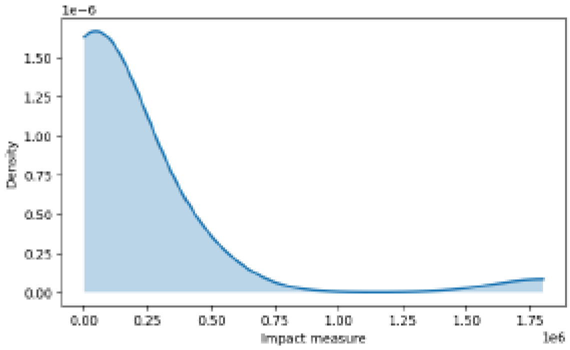
Figure A.11: Distribution (kernel density estimation) of impact measures by country (page 4)



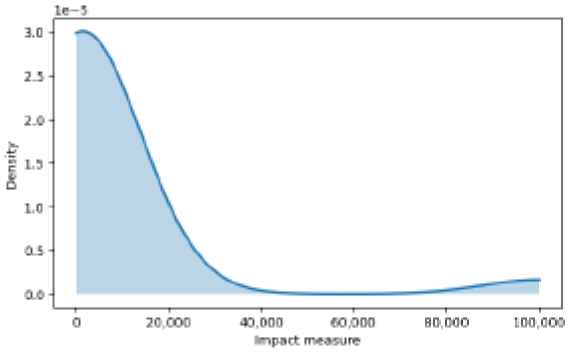
(a) Czech Republic



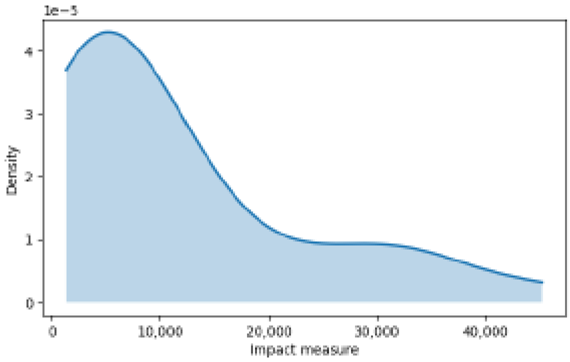
(b) Hungary



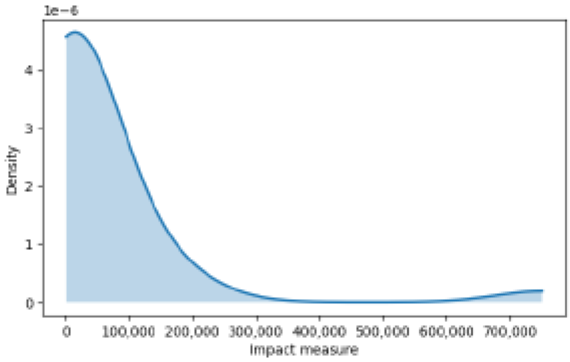
(c) Peru



(d) Poland

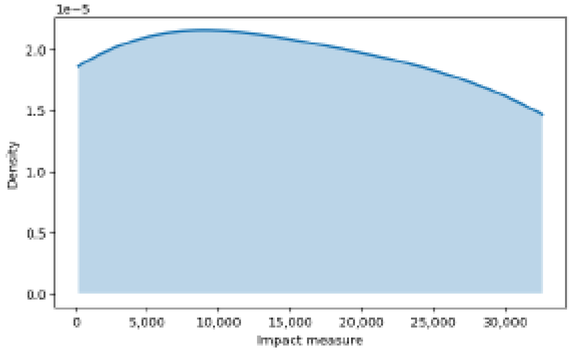


(e) Russia

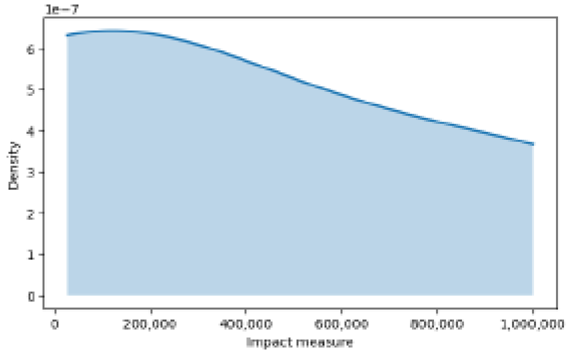


(f) South Africa

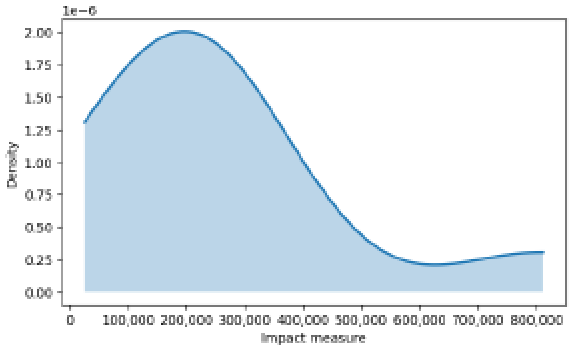
Figure A.12: Distribution (kernel density estimation) of impact measures by country (page 5)



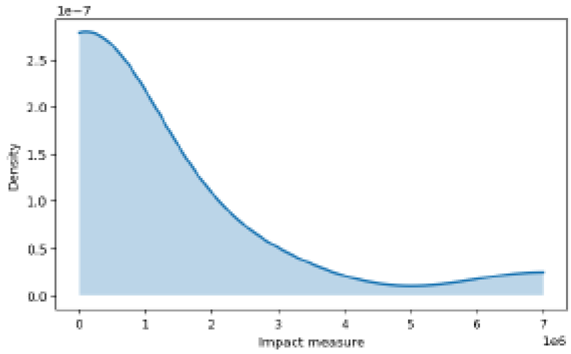
(a) Egypt



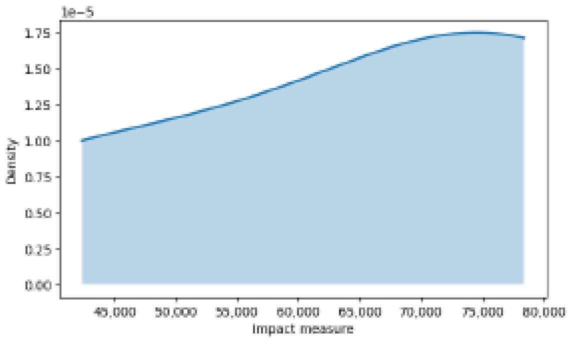
(b) Ghana



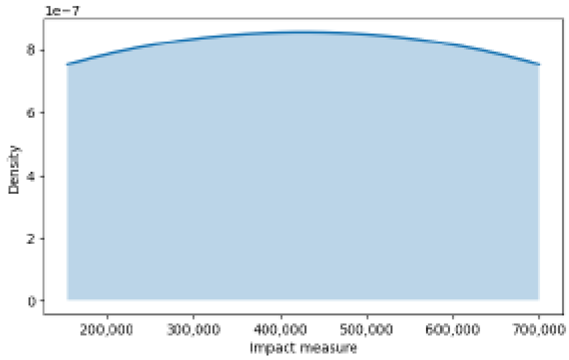
(c) Kenya



(d) Nigeria



(e) Uganda

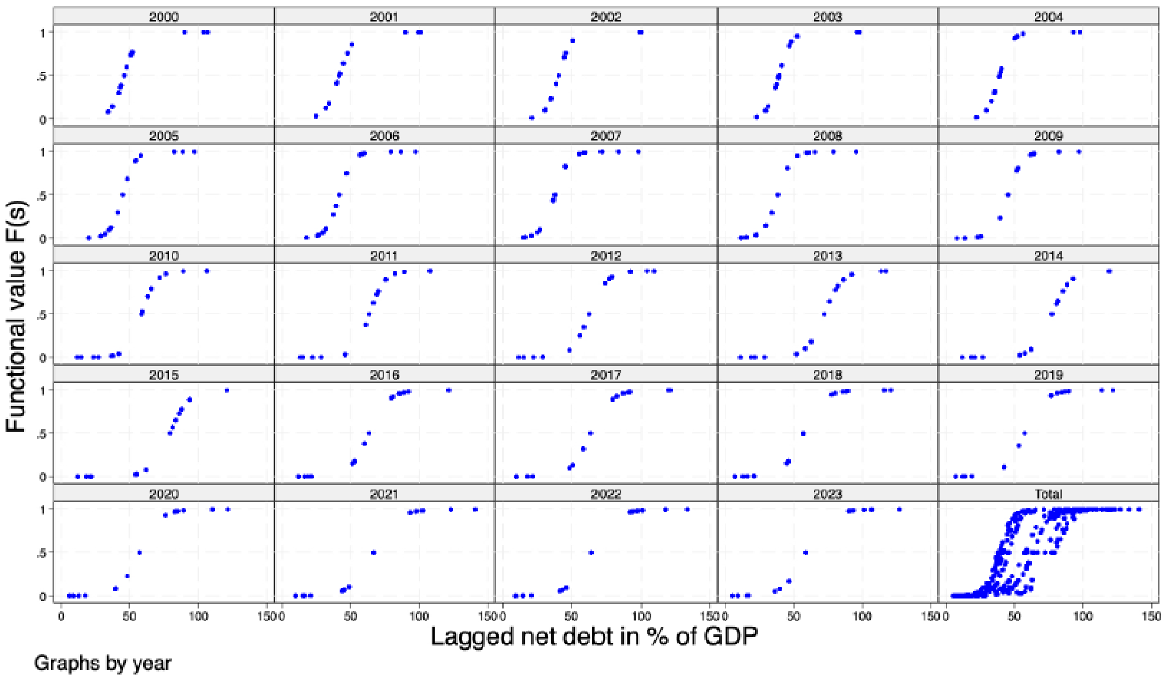


(f) Zambia

Annex B: State transition function

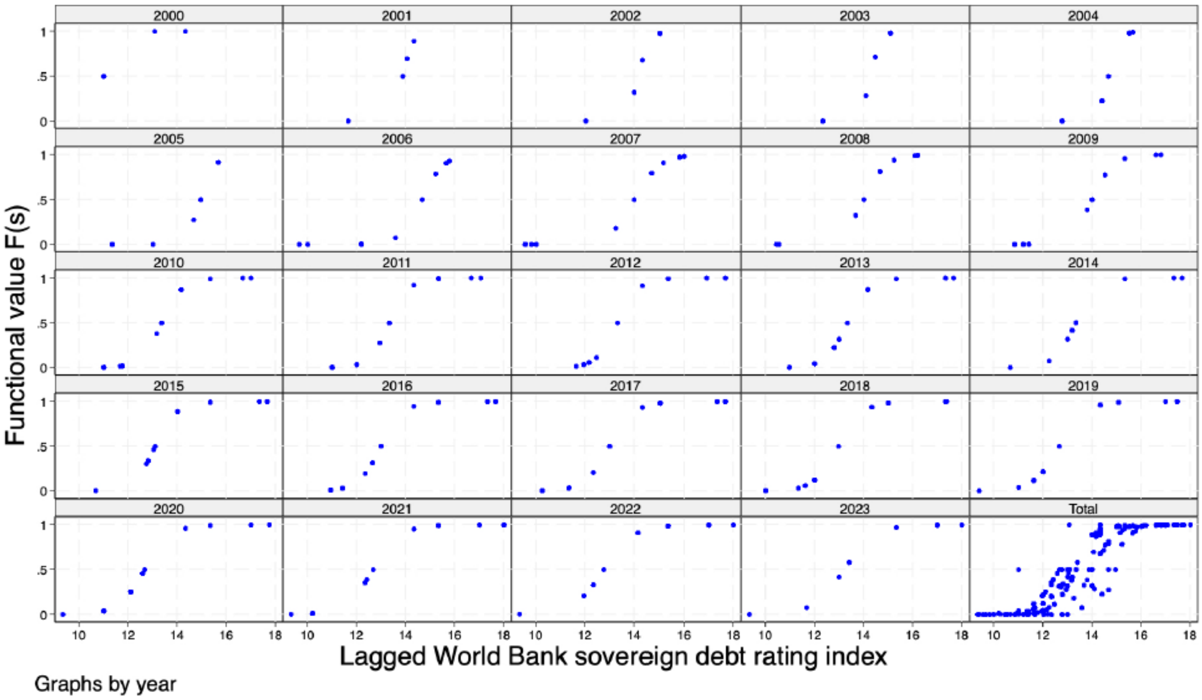
We use smooth transition functions to estimate state-dependent impulse response functions, as outlined in section 3.3. Figures B.13, B.14 and B.15 illustrate the functional forms per year for the three country panels. As discussed in Annex A, data availability constraints mean that not all countries in the sample have observations starting in 2000. Consequently, the limited number of available countries in earlier years may reduce the reliability of the transition functions. To account for this, we use these plots to determine the appropriate start year for each panel. Based on data coverage and transition function behaviour, we retain 2000 as the start year for advanced economies, while setting 2005 for emerging markets and 2014 for African economies.

Figure B.13: Smooth state transition function: advanced economies



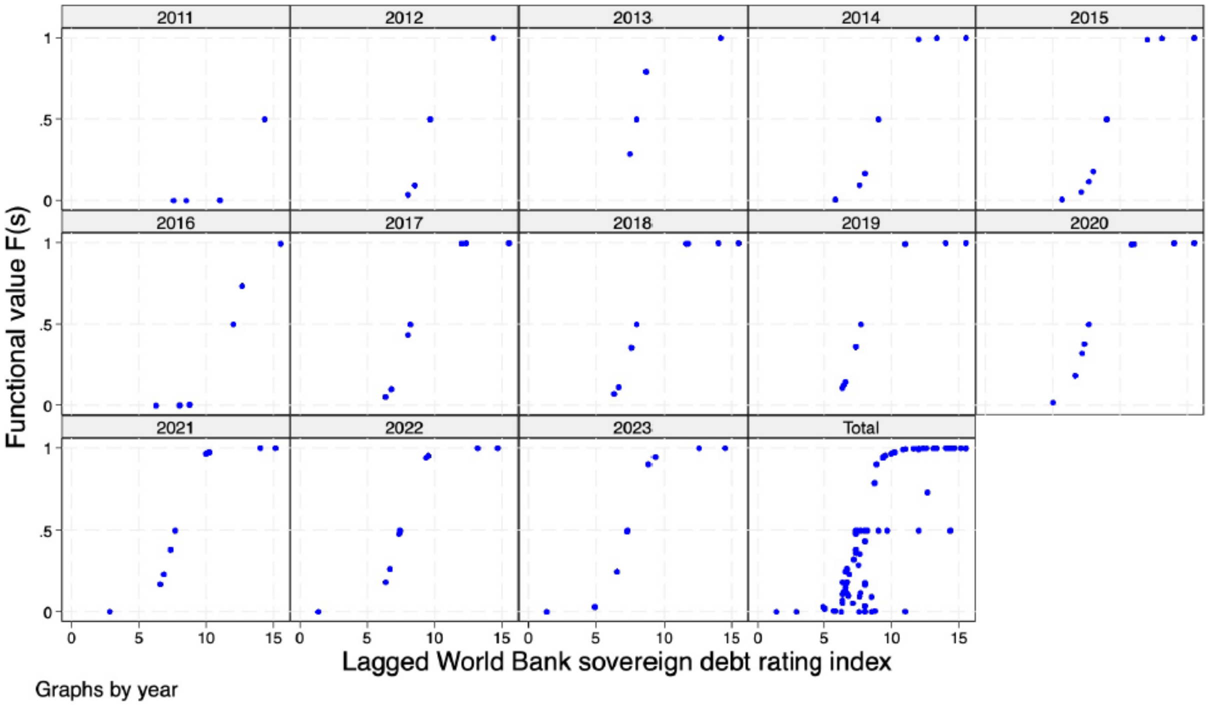
Note: The figure shows the estimated smooth state transition function, as specified in equation 4. We estimate a new transition function across countries for each year. The state variable for advanced economies is the lagged net debt in % of GDP. The sample period follows data availability and is described in Table A.1.

Figure B.14: Smooth state transition function: emerging markets



Note: The figure shows the estimated smooth state transition function, as specified in equation 4. We estimate a new transition function across countries for each year. The state variable for emerging markets is the lagged World Bank foreign currency long-term sovereign debt ratings index. The sample period follows data availability and is described in Table A.1.

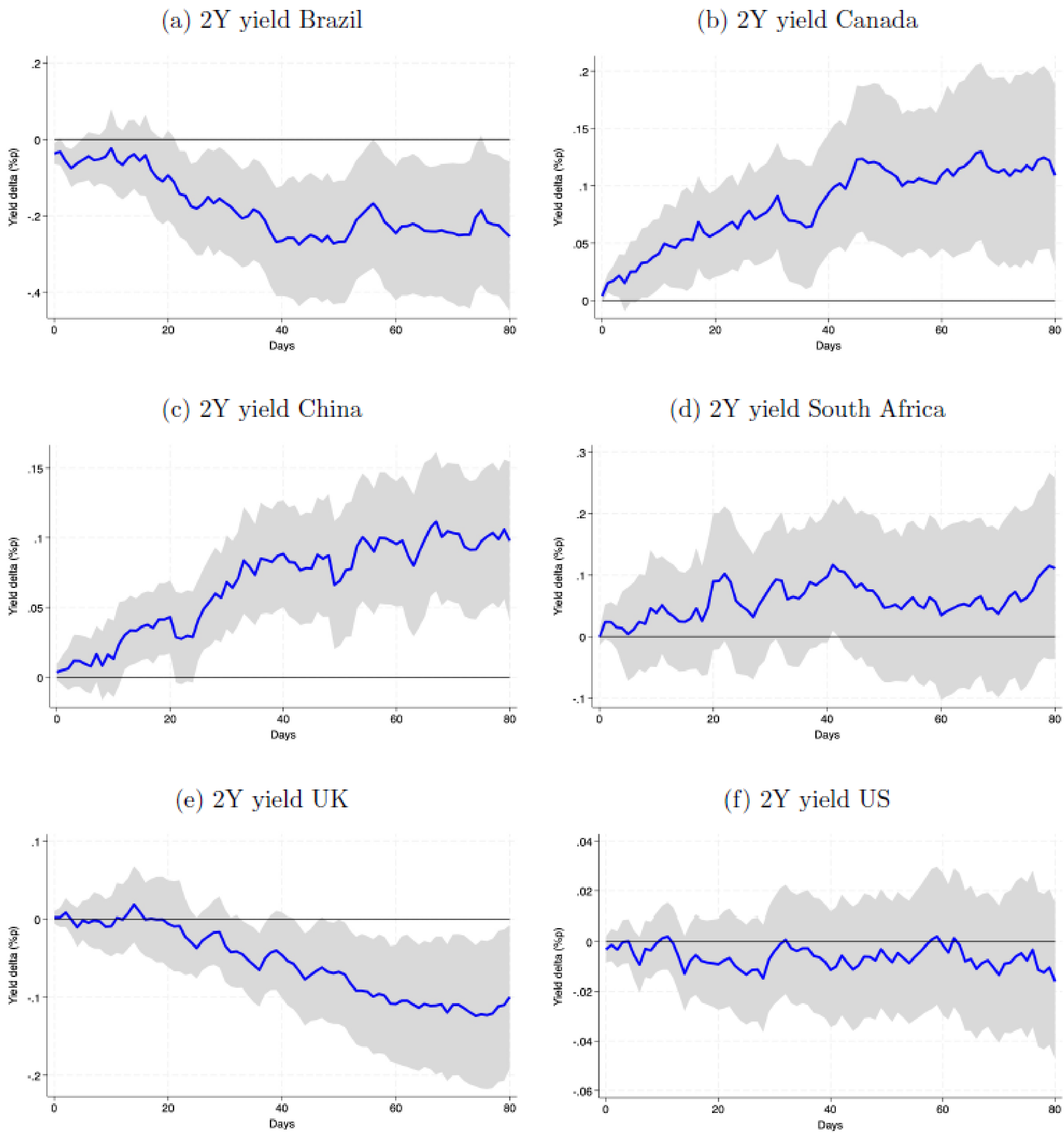
Figure B.15: Smooth state transition function: African markets



Note: The figure shows the estimated smooth state transition function, as specified in equation 4. We estimate a new transition function across countries for each year. The state variable for African markets is the lagged World Bank foreign currency long-term sovereign debt ratings index. The sample period follows data availability and is described in Table A.1.

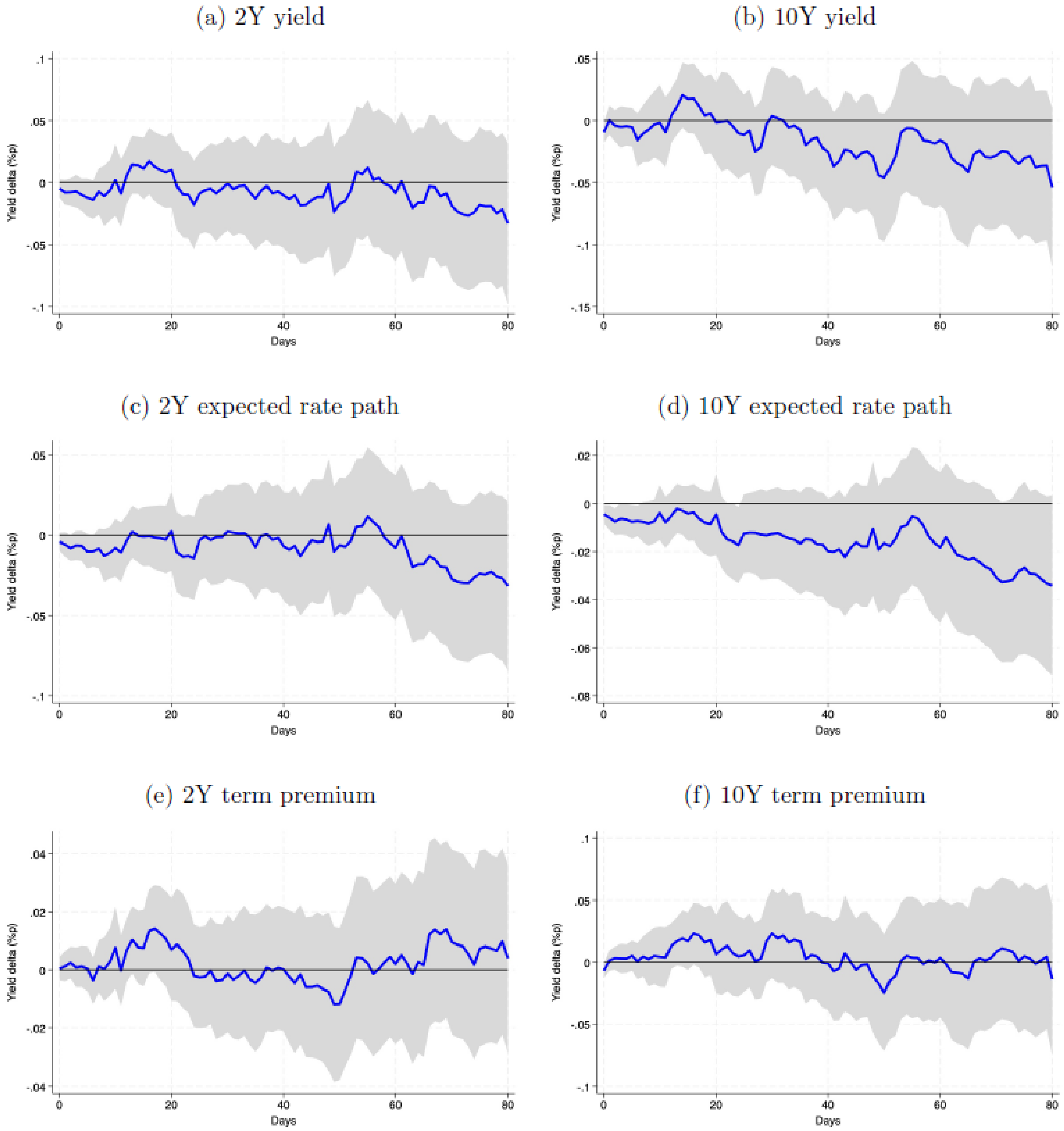
Annex C: Additional results

Figure C.16: Panel impulse responses of selected countries



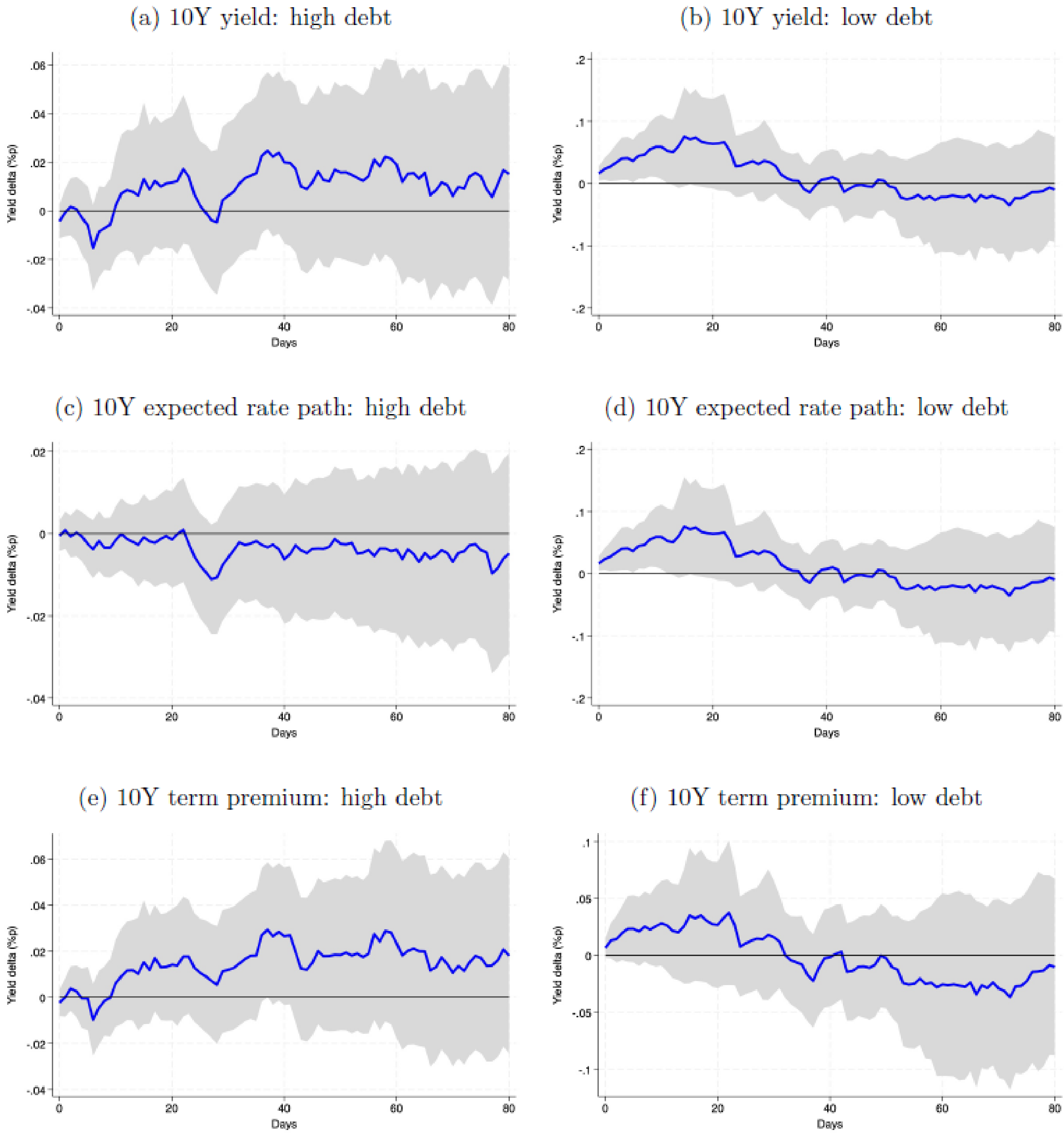
Note: The figure shows impulse response functions of the daily two-year yields to the largest 50% of extreme weather events, as specified in equation 2. The sample period follows data availability and is described in Table A.1. We use Newey-West standard errors and show confidence bands at the 90% level.

Figure C.17: Panel impulse responses of emerging markets



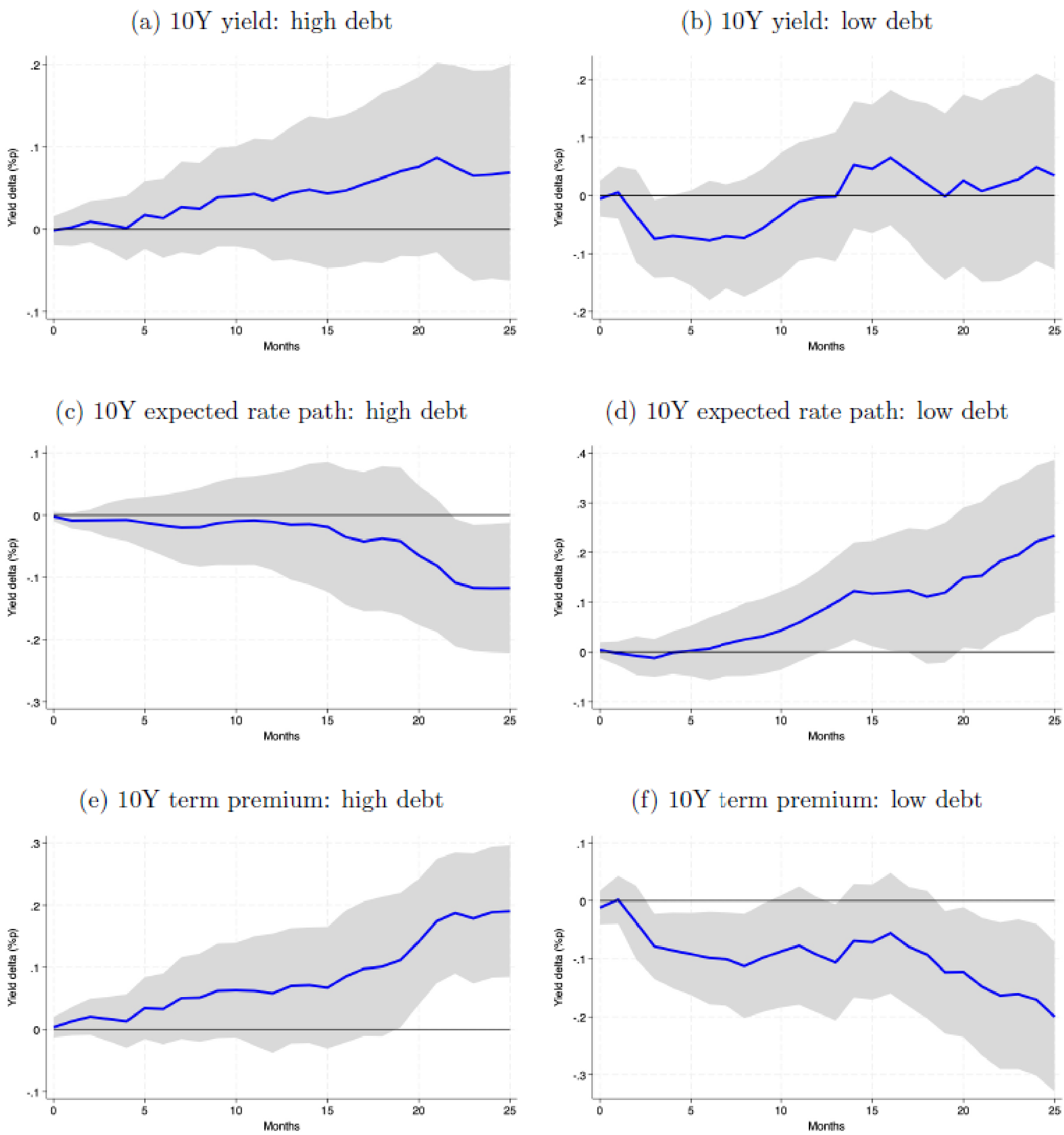
Note: The figure shows impulse response functions of the daily two-year and 10-year yield and its expected short rate and term premium components to the largest 50% of extreme weather events, as specified in equation 2. The left panel shows the impulse responses of two-year maturity and the right panel of 10-year maturity. The sample period follows data availability and is described in Table A.1. We use Driscoll-Kraay standard errors and show confidence bands at the 90% level.

Figure C.18: State-dependent panel impulse responses of advanced economies (daily)



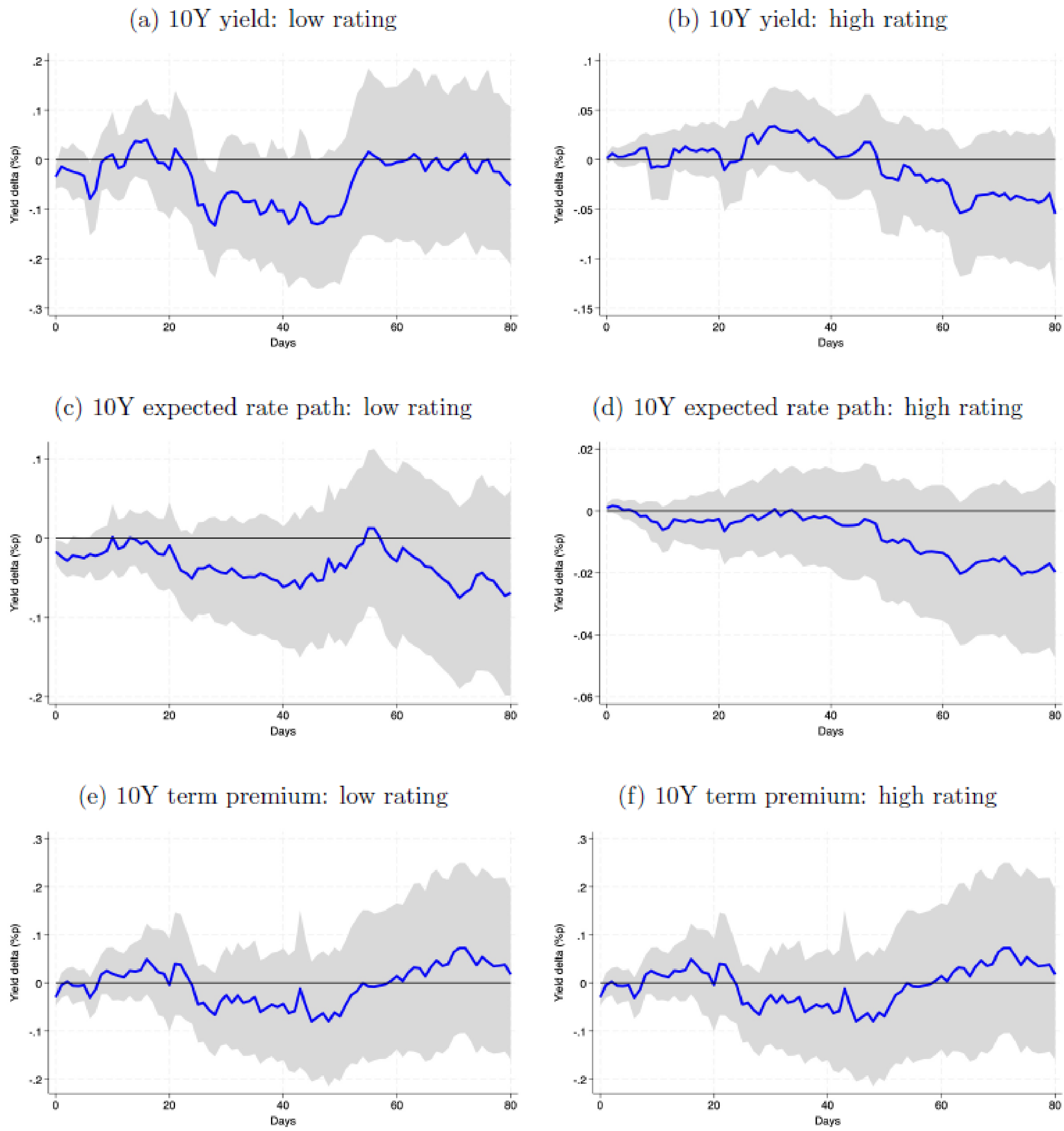
Note: The figure shows impulse response functions of the daily 10-year yield and its expected short rate and term premium components to the largest 50% of extreme weather events, as specified in equation 3. The left panel shows the impulse responses of countries in a high debt-to-GDP state and the right panel in a low debt-to-GDP state. The sample period follows data availability and is described in Table A.1. We use Driscoll-Kraay standard errors and show confidence bands at the 90% level.

Figure C.19: State-dependent panel impulse responses of advanced economies (monthly)



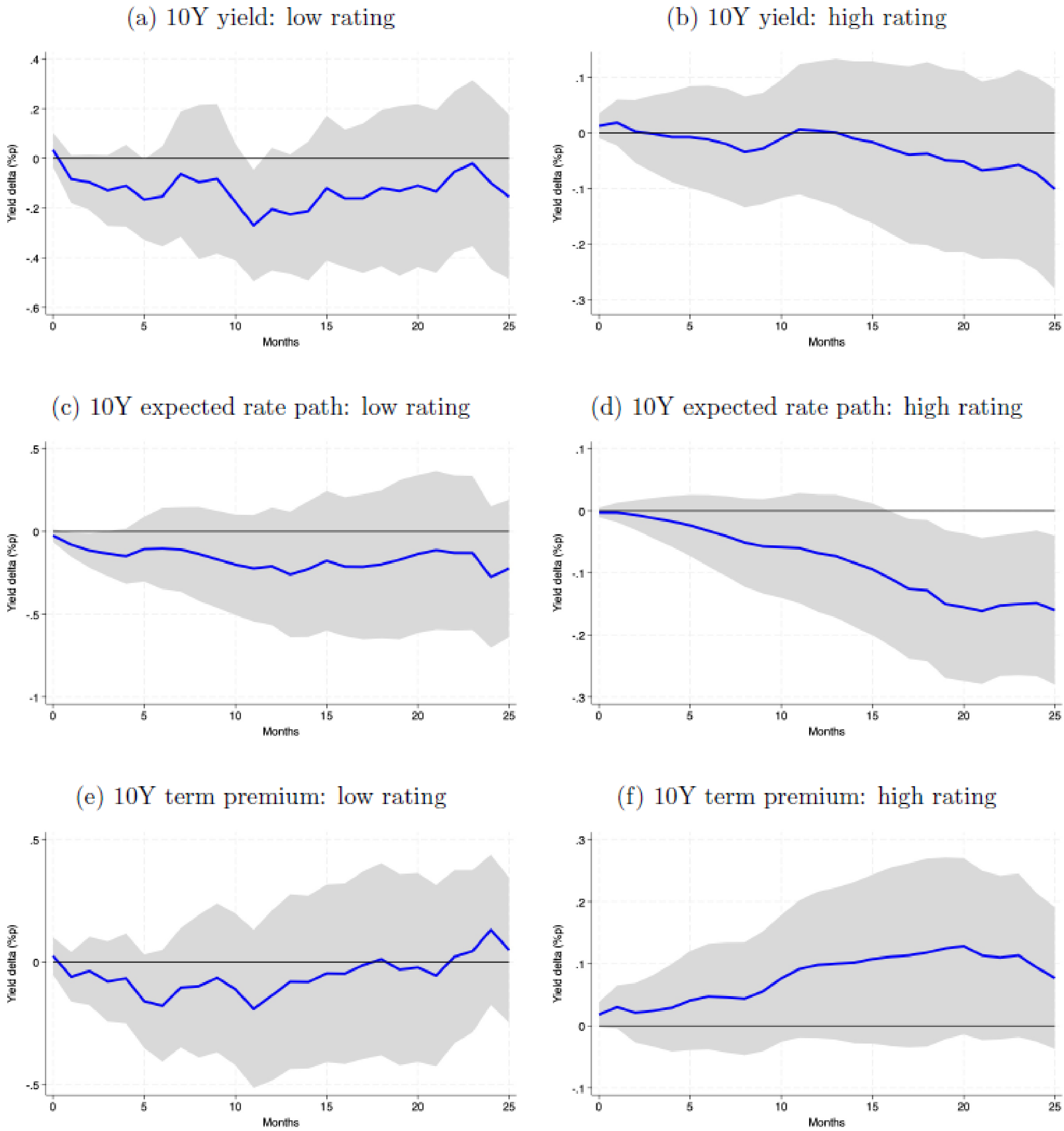
Note: The figure shows impulse response functions of the daily 10-year yield and its expected short rate and term premium components to the largest 50% of extreme weather events, as specified in equation 3. The left panel shows the impulse responses of countries in a high debt-to-GDP state and the right panel in a low debt-to-GDP state. The sample period follows data availability and is described in Table A.1. We use Driscoll-Kraay standard errors and show confidence bands at the 90% level.

Figure C.20: State-dependent impulse responses of emerging markets (daily)



Note: The figure shows impulse response functions of the daily 10-year yield and its expected short rate and term premium components to the largest 50% of extreme weather events, as specified in equation 3. The left panel shows the impulse responses of countries in a low rating state and the right panel in a high rating state. The sample period follows data availability and is described in Table A.1. We use Driscoll-Kraay standard errors and show confidence bands at the 90% level.

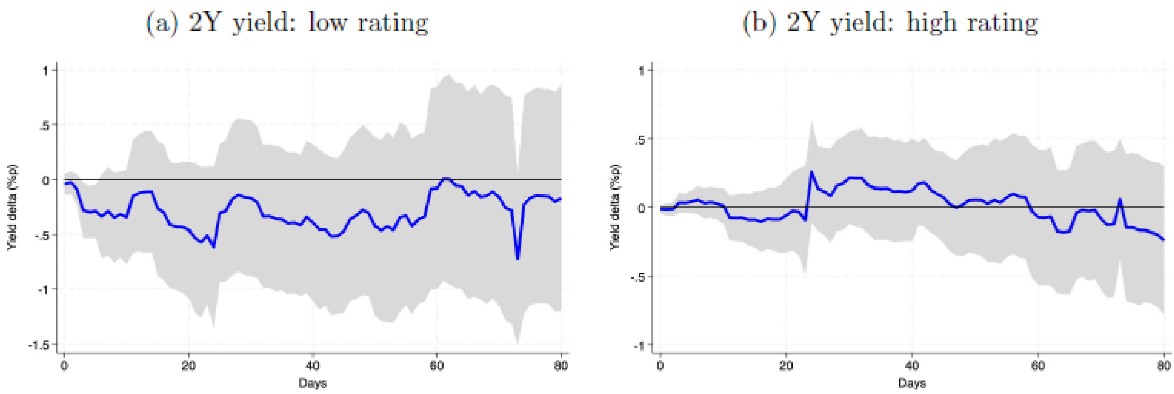
Figure C.21: State-dependent panel impulses of emerging markets (monthly)



Note: The figure shows impulse response functions of the monthly 10-year yield and its expected short rate and term premium components to the largest 50% of extreme weather events, as specified in equation 3. The left panel shows the impulse responses of countries in a low rating state and the right panel in a high rating state. The sample period follows data availability and is described in Table A.1. We use Driscoll-Kraay standard errors and show confidence bands at the 90% level.

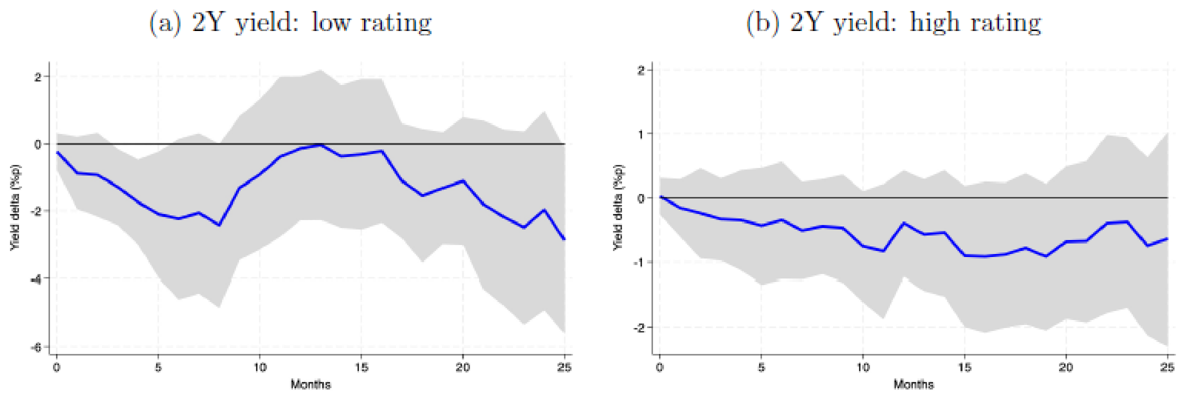
Annex D: Additional results: African countries

Figure D.22: State-dependent panel impulse responses of African markets (daily)



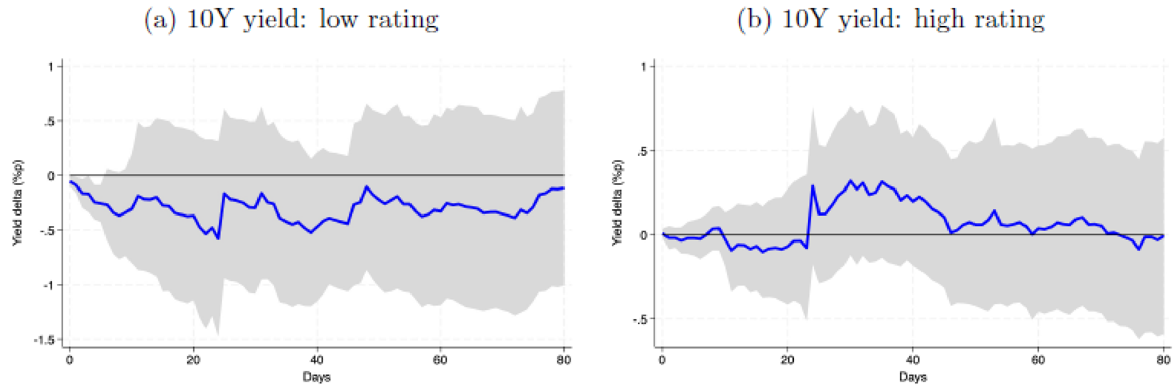
Note: The figure shows impulse response functions of the daily two-year yield and its expected short rate and term premium components to the largest 50% of extreme weather events, as specified in equation 3. The left panel shows the impulse responses of countries in a low rating state and the right panel in a high rating state. The sample period follows data availability and is described in Table A.1. We use Driscoll-Kraay standard errors and show confidence bands at the 90% level.

Figure D.23: State-dependent panel impulse responses of African markets (monthly)



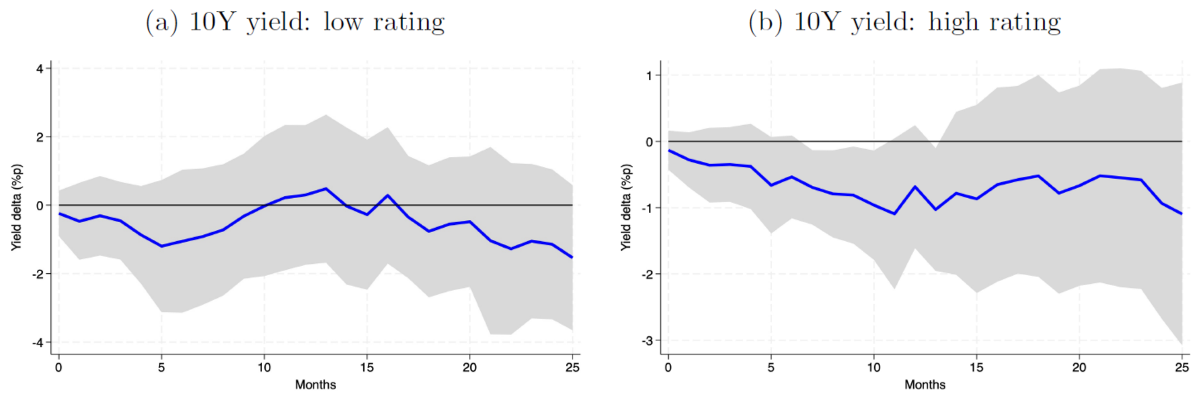
Note: The figure shows impulse response functions of the monthly two-year yield and its expected short rate and term premium components to the largest 50% of extreme weather events, as specified in equation 3. The left panel shows the impulse responses of countries in a low rating state and the right panel in a high rating state. The sample period follows data availability and is described in Table A.1. We use Driscoll-Kraay standard errors and show confidence bands at the 90% level.

Figure D.24: State-dependent panel impulse responses of African markets (daily)



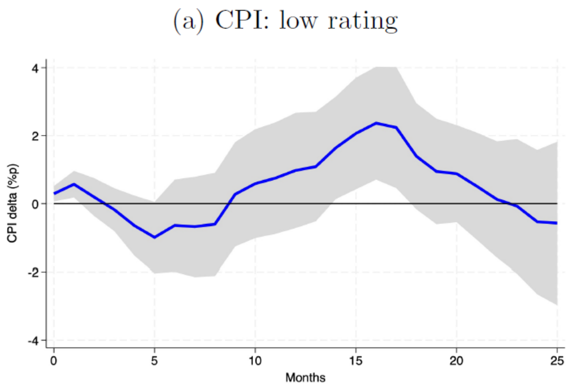
Note: The figure shows impulse response functions of the daily 10-year yield and its expected short rate and term premium components to the largest 50% of extreme weather events, as specified in equation (3). The left panel shows the impulse responses of countries in a low rating state and the right panel in a high rating state. The sample period follows data availability and is described in Table A.1. We use Driscoll-Kraay standard errors and show confidence bands at the 90% level.

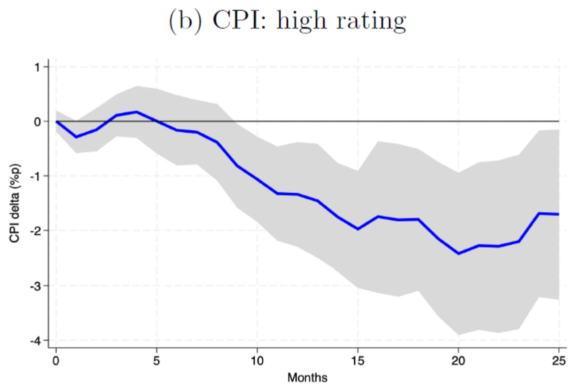
Figure D.25: State-dependent panel impulse responses of African markets (monthly)



The figure shows impulse response functions of the monthly 10-year yield and its expected short rate and term premium components to the largest 50% of extreme weather events, as specified in equation (3). The left panel shows the impulse responses of countries in a low rating state and the right panel in a high rating state. The sample period follows data availability and is described in Table A.1. We use Driscoll-Kraay standard errors and show confidence bands at the 90% level.

Figure D.26: State-dependent panel impulse responses of African markets (CPI)





Note: The figure shows impulse response functions of the monthly year-over-year consumer price index to the largest 50% of extreme weather events, as specified in equation (3). The exchange rate, CPI and GDP growth are omitted from the control variables in this specification. The left panel shows the impulse responses of countries in a low rating state and the right panel in a high rating state. The sample period follows data availability and is described in Table A.1. We use Driscoll-Kraay standard errors and show confidence bands at the 90% level.

References

Acevedo, S, Mrkaic, M, Novta, N, Pugacheva, E and Topalova, P. 2020. 'The effects of weather shocks on economic activity: what are the channels of impact?' *Journal of Macroeconomics* 65: 1–21.

Adrian, T, Crump, R, Durham, B and Moench, E. 2019. 'Sovereign yield co-movement'. Unpublished working paper.

Adrian, T, Crump, R and Moench, E. 2013. 'Pricing the term structure with linear regressions'. *Journal of Financial Economics* 110: 110–138.

Adrian, T, Gelos, G, Lamersdorf, N and Moench, E. 2024. 'The asymmetric and persistent effects of fed policy on global bond yields'. BIS Working Paper No. 1195.

Auerbach, A and Gorodnichenko, Y. 2012. 'Measuring the output responses to fiscal policy'. *American Economic Journal: Economic Policy* 4: 1–27.

Barro, R. 2006. 'Rare disasters, the natural interest rate and monetary policy'. *The Quarterly Journal of Economics* 121: 823–866.

Bauer, M D and Rudebusch, G D. 2023. 'The rising cost of climate change: evidence from the bond market'. *Review of Economics and Statistics* 105.

Beirne, J, Dafermos, Y, Kriwoluzky, A, Renzhi, N, Volz, U and Wittich, J. 2022. 'Natural disasters and inflation in the euro area'. Beiträge zur Jahrestagung des Vereins für Socialpolitik 2022: Big Data in Economics.

Born, B, Müller, G and Pfeifer, J. 2020. 'Does austerity pay off?' *The Review of Economics and Statistics* 102: 323–338.

Botzen, W, Deschenes, O and Sanders, M. 2019. 'The economic impacts of natural disasters: a review of models and empirical studies'. *Review of Environmental Economics and Policy* 13: 167–188.

Burke, M and Tanutama, V. 2019. ‘Climatic constraints on aggregate economic output’. NBER Working Paper No. 25779 .

Cantelmo, A. 2022. ‘Rare disasters and asset markets in the twentieth century’. *Oxford Bulletin of Economics and Statistics* 84: 473–496.

Centre for Research on the Epidemiology of Disasters. 2025. EM-DAT. https://www.emdat.be/

Cevik, S and Jalles, J. 2022. ‘This changes everything: climate shocks and sovereign bonds’. *Energy Economics* 107.

Chavleishvili, S and Moench, E. 2025. ‘Natural disasters as macroeconomic tail risks’. *Journal of Econometrics* 247.

Dell, M, Jones, B and Olken, B. 2012. ‘Temperature shocks and economic growth: evidence from the last half century’. *Nature Climate Change* 4: 66–95.

Driscoll, J and Kraay, A. 1998. ‘Consistent covariance matrix estimation with spatially dependent panel data’. *Review of Economics and Statistics* 80: 549–560.

Du, W and Schreger, J. 2016. ‘Local currency sovereign risk’. *The Journal of Finance* 71: 1027–1070.

Faccia, D, Parker, M and Stracca, L. 2021. ‘Feeling the heat: extreme temperatures and price stability’. ECB Working Paper No. 2626.

Felbermayr, G and Gröschl, J. 2014. ‘Naturally negative: the growth effects of natural disasters’. *Journal of Development Economics* 111: 92–106.

Fomby, T, Ikeda, Y and Loayza, N. 2013. ‘The growth aftermath of natural disasters’. *Journal of Applied Econometrics* 28: 412–434.

Gabaix, X. 2011. 'Disasterization: a simple way to fix the asset pricing properties of macroeconomic models'. *American Economic Review* 101: 406–409.

Gabaix, X. 2012. 'Variable rare disasters: an exactly solved framework for ten puzzles in macro-finance'. *The Quarterly Journal of Economics* 127: 645–700.

Ghosh, A, Kim, J, Mendoza, E, Ostry, J and Qureshi, M. 2013. 'Fiscal fatigue, fiscal space and debt sustainability in advanced economies'. *The Economic Journal* 123: F4–F30.

Gourio, F. 2012. 'Disaster risk and business cycles'. *American Economic Review* 102: 2734–2766.

Hallegatte, S and Przyluski, V. 2010. 'The impact of disasters on inflation'. World Bank Policy Research Working Paper No. 5507.

Intergovernmental Panel on Climate Change. 2021. 'Weather and climate extreme events in a changing climate'. *Climate Change 2021: The Physical Science Basis.* Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.

Jordà, O. 2005. 'Estimation and inference of impulse responses by local projections'. *American Economic Review* 95: 161–182.

Kahn, M, Mohaddes, K, Ng, R, Pesaran, M H, Raissi, M and Yang, J C. 2019. 'Long-term macroeconomic effects of climate change: a cross-country analysis'. *Energy Economics* 104.

Kiley, M. 2021. 'Growth at risk from climate change'. *Economic Inquiry* 62: 1134–1151.

Kim, H S, Matthes, C and Phan, T. 2021. 'Extreme weather and the macroeconomy'. Federal Reserve Bank of Richmond Working Paper 21-14.

Kling, G, Lo, Y, Murinde, V and Volz, U. 2018. *Climate vulnerability and the cost of debt.* SOAS University of London: Mimeo.

Klomp, J. 2015. 'Sovereign risk and natural disasters in emerging markets'. *Emerging Markets Finance and Trade* 51: 1326–1341.

Klomp, J. 2017. 'Flooded with debt'. *Journal of International Money and Finance* 73: 93–103.

Kose, A, Kurlat, S, Ohnsorge, F and Sugawara, N. 2022. 'A cross-country database of fiscal space'. *Journal of International Money and Finance* 128: 102682.

Kunawotor, M, Bopkin, G, Asuming, P and Amoateng, K. 2022. 'The impacts of extreme weather events on inflation and the implications for monetary policy in Africa'. *Progress in Development Studies* 22(2): 130–148.

Lemoine, D and Kapnick, S. 2016. 'A top-down approach to projecting market impacts of climate change'. *Nature Climate Change* 6: 51–55.

Lis, E and Nickel, C. 2010. 'The impact of extreme weather events on budget balances'. *International Tax and Public Finance* 17: 378–399.

Loayza, N, Olaberria, E, Rigolini, J and Christiaensen, L. 2012. 'Natural disasters and growth: going beyond the averages'. *World Development* 40: 1317–1336.

Malluci, E. 2022. 'Natural disasters, climate change and sovereign risk'. *Journal of International Economics* 139.

Min, S K, Zhang, X, Zwiers, F and Hegerl, G. 2011. 'Human contribution to more intense precipitation extremes'. *Nature* 470: 378–381.

Moench, E. 2019. 'The term structures of global yields'. BIS Papers No. 102 (keynote).

Newey, W and West, K. 1987. ‘A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix’. *Econometrica* 55: 703–708.

Noy, I. 2009. ‘The macroeconomic consequences of disasters’. *Journal of Development Economics* 88: 221–231.

Painter, M. 2020. ‘An inconvenient cost: the effects of climate change on municipal bonds’. *Journal of Financial Economics* 135: 468–482.

Parker, M. 2018. ‘The impact of disasters on inflation’. *Economics of Disasters and Climate Change* 2: 21–48.

Plagborg-Møller, M and Wolf, C. 2021. ‘Local projections and VARs estimate the same impulse responses’. *Econometrica* 89: 955–980.

Seghini, C. 2024. ‘Climate and sovereign debt sustainability: a literature review’. Swiss Finance Institute, Université de Genève. Unpublished.

Stott, P, Christidis, N, Otto, F, Sun, Y, Vanderlinden, J P, van Oldenborgh, G, Vautard, R, von Storch, H, Walton, P, Yiou, P and Zwiers, F. 2016. ‘Attribution of extreme weather and climate-related events’. *WIREs Climate Change* 7: 23–41.

Tenreyro, S and Thwaites, G. 2016. ‘Pushing on a string: US monetary policy is less powerful in recessions’. *American Economic Journal: Macroeconomics* 8: 42–74.

Tol, R. 2018. ‘The economic impacts of climate change’. *Review of Environmental Economics and Policy* 12(1): 4–25.

Trenberth, K, Fasullo, J and Shepherd, T. 2015. ‘Attribution of climate extreme events’. *Nature: Climate Change* 5: 725–730.