The estimates and projections are based on statistical information available through April 14, 2025, but may not reflect the latest published data in all cases.

Online Annexes

Online Annex 1.1. Data and Methodology on the Effect of Expected Public Debt on the United States' Forward Interest Rates[1]

This online annex describes the data, methodology and additional results of the analysis presented in Figure 1.7. This exercise revisits Laubach (2009) estimations of the impact of 5-years ahead forecasts for debt and deficits on long-term interest rates. Furceri, Gonçalves, and Li (2025) provide a comprehensive discussion of the methods employed and sub-samples results.

Data

The main sources of the data it the CBO GitHub website (https://github.com/us-cbo), which is complemented with additional information from CBO documents regarding U.S. Treasury bonds. The dataset comprises 81 observations from 1976 to 2024.

Methodology

The empirical model estimated is the following:

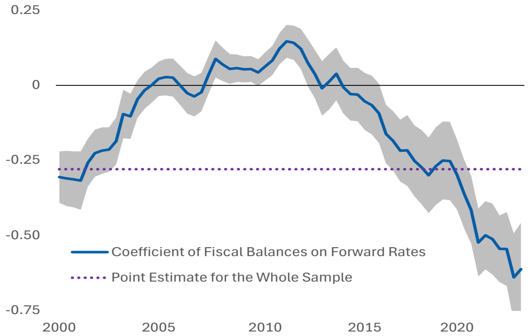
Rate = β1*Fiscal Variable + β2*Controls +error term (Eq.1.1.1)

where *Rate* denotes either the Forward rate or the 10-year Treasury; the baseline set of controls include: (i) a linear-quadratic time trend, (ii) 3-month US treasury bill (Tbill3m) or expected inflation, and (iii) a constant. The results presented in the chapter are obtained by estimating Eq.1.1.1 on a 40-observations rolling window.

Results

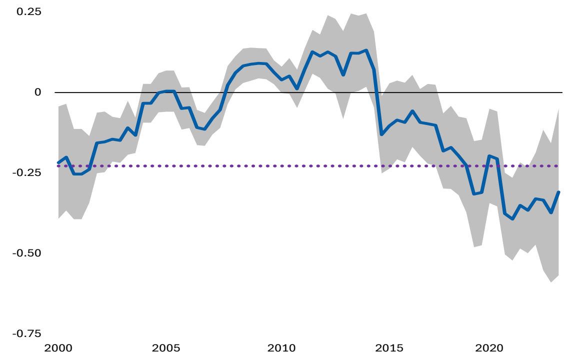
Similar messages to Figure 1.7 are obtained when using expected fiscal balances instead of debt (Online Annex Figure 1.1.1). Finally, the results are robust when using the 10 years term premium as the dependent variable and fiscal balances as the main fiscal regressor (Online Annex Figure 1.1.2).

Online Annex Figure 1.1.1. Time-Varying Impact of Fiscal Balances on Forward Rates
(Basis points; monthly)



Sources: Federal Reserve, Congressional Budget Office Reports.

Online Annex Figure 1.1.2. Time-Varying Impact of Fiscal Balances on Term Premium
(Basis points; monthly)



Sources: Federal Reserve, Congressional Budget Office Reports.

[1] Prepared by Carlos Eduardo Gonçalves.

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Methodology

The empirical model estimated is the following:

$$\text{Rate} = \beta 1 * \text{Fiscal Variable} + \beta 2 * \text{Controls} + \text{error term} \qquad \text{(Eq.1.1.1)}$$

where *Rate* denotes either the Forward rate or the 10-year Treasury; the baseline set of controls include: (i) a linear-quadratic time trend, (ii) 3-month US treasury bill (Tbill3m) or expected inflation, and (iii) a constant. The results presented in the chapter are obtained by estimating Eq.1.1.1 on a 40-observations rolling window.

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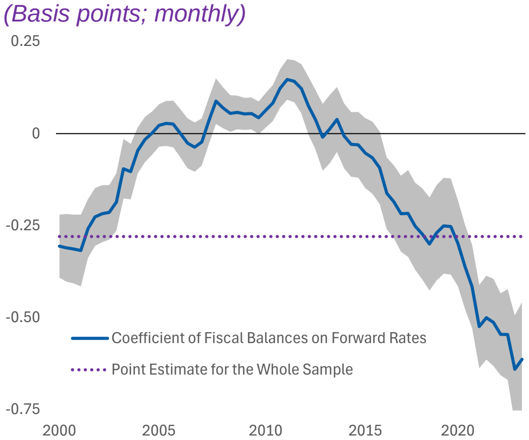
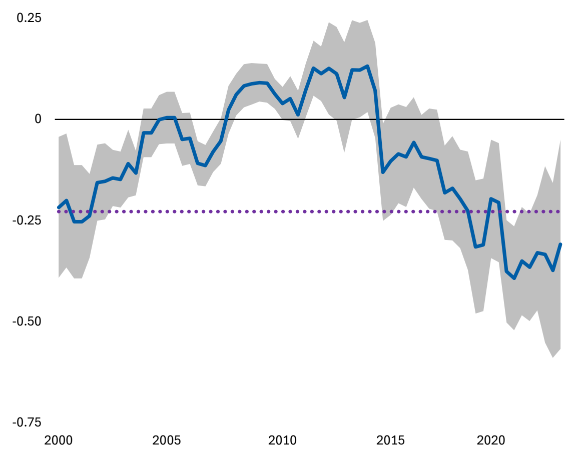


Sources: Federal Reserve, Congressional Budget Office Reports.

Online Annex Figure 1.1.2. Time-Varying Impact of Fiscal Balances on Term Premium
(Basis points; monthly)



Sources: Federal Reserve, Congressional Budget Office Reports.

[1] Prepared by Carlos Eduardo Gonçalves.

Online Annex 1.2. Debt-at-Risk[3]

This online annex presents details on the methodology and the estimation of the Debt-at-Risk results. For more information, refer to the October 2024 Fiscal Monitor and Furceri and others (2025).

Methodology

Risks to the global public debt outlook are quantified and assessed using the "Debt-at-Risk" framework, which produces a full distribution of projections for the public debt-to-GDP ratio at various horizons. The framework covers 47 economies (24 advanced economies and 23 emerging market and developing economies) accounting for more than 90 percent of global public debt (Online Annex Table 1.2.1). The dataset is annual, covering the periods from 2009 to 2024. The framework includes all economies with a continuous history of market access for government financing—i.e., available sovereign yields—during the sample period.

The exercise uses panel quantile regressions in which the variable being predicted is the percentile of the future public debt-to-GDP ratio. The predictors include not only economic factors (such as primary deficit and GDP growth), but also financial conditions and economic and policy uncertainty.[4] The predicted percentiles are then fitted to a skewed *t*-distribution to obtain a probability density function conditional on each predictor. Density functions for every country or country-aggregate and year are calculated as a weighted sum of the densities based on the individual predictors. The weights sum to one and maximize the out-of-sample predictive accuracy of the combined distribution.

Debt-at-Risk—the potential level of public debt in a severely adverse scenario—is defined at the 95th percentile of the debt-to-GDP ratio at the three-year-ahead forecast horizon. *Upside risks* to the debt outlook are quantified using the difference between the predicted 95th percentile and the median (i.e., 50th percentile) of the projected distribution. As the median projection is calibrated to match the debt "reference point" projection reported in the *World Economic Outlook*, the *upside risk* measures the deviation of *debt-at-risk* from the *World Economic Outlook*'s baseline debt projections. A country or country group's *debt-at-risk* may therefore increase from year to year due to both higher projected debt levels in the *future* and an increase in the *upside risk* around these projections due to changes in the current economic, political, or financial conditions, measured for example by an increase in sovereign spreads.

Contribution of conditioning factors to D*ebt-at-Risk*

The contribution of the individual conditioning factors to the change in global *debt-at-risk* from year to year (presented in Figure 1.14, panel 2 in the main text) is computed as follows:

$$Q^{combined}_{world,2027}(95) - Q^{combined}_{world,2026}(95) = Q^{initialdebt}_{world,2027}(50) - Q^{initialdebt}_{world,2026}(50) + \sum_m \omega_m \left[\left(Q^{m}_{world,2027}(95) - Q^{m}_{world,2027}(50)\right) - \left(Q^{m}_{world,2026}(95) - Q^{m}_{world,2026}(50)\right)\right] \quad \text{(Eq.1.2.1)}$$

where $Q^{m}_{world,y}(\tau)$ is the predicted τ-th quantile for the global debt-to-GDP distribution in year y conditional on predictor m. The difference between the *Debt-at-Risk* for 2027 reported in the main text and that for 2026 in the *October 2024 Fiscal Monitor* (the left-hand side of the above equation) is decomposed into two components: the first is the difference between the median debt projection conditional on initial debt only, which is calibrated to match the corresponding reference point projection

[3] Prepared by Faizaan Kisat.

[4] The following eight predictors used in the framework are: current debt-to-GDP, Financial Stress Index (Ahir and others 2023), sovereign spread, World Uncertainty Index (Ahir, Bloom, and Furceri 2022), Reported Social Unrest Index (Barrett and others 2022), primary balance-to-GDP ratio, real GDP growth, and inflation. Economic variables are sourced from the IMF's *World Economic Outlook* database.

in the *World Economic Outlook* (the second row in the equation above). The second is the change in the *upside risk* for 2026 and 2027 for the predicted percentile conditional on a single predictor multiplied by its weight ω_m in the combined distribution (the third row in the equation above).

Online Annex Table 1.2.1. Economies Coverage: *Debt-at-Risk* Analysis

Advanced Economies	**Emerging Market and Developing Economies**
Australia	Brazil
Austria	Bulgaria
Belgium	Chile
Canada	China
Denmark	Colombia
Finland	Hungary
France	India
Germany	Indonesia
Greece	Kenya
Hong Kong SAR	Malaysia
Ireland	Mexico
Israel	Morocco
Italy	Nigeria
Japan	Pakistan
Korea	Peru
Netherlands	Philippines
New Zealand	Romania
Norway	Russia
Portugal	South Africa
Spain	Tanzania
Sweden	Thailand
Switzerland	Vietnam
United Kingdom	Zambia
United States	

Note: The table displays the countries included in the sample of 47 economies used to produce the global debt distribution in the Debt-at-Risk analysis.

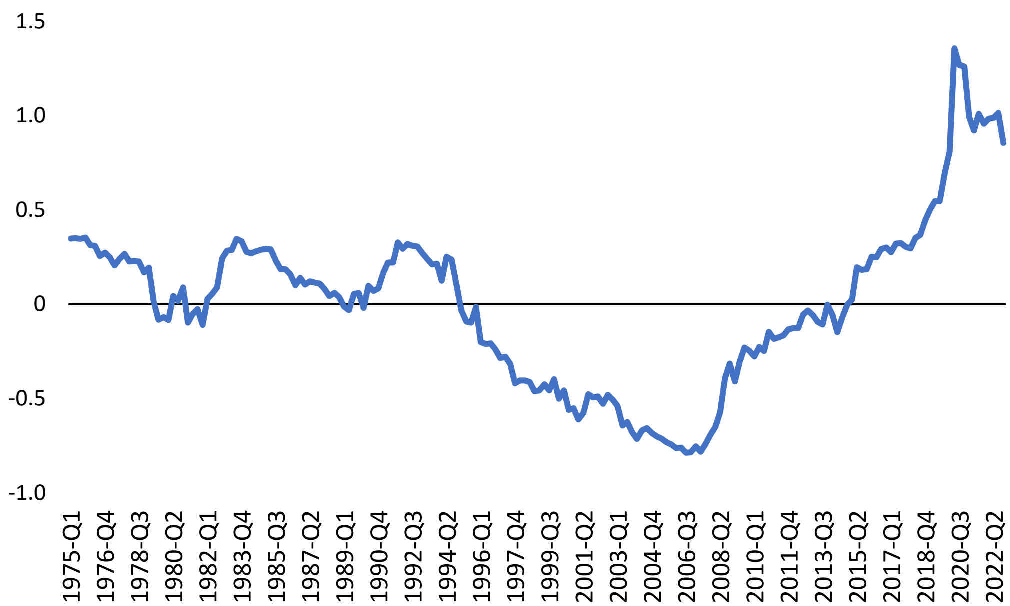
Online Annex 1.3. Fiscal Risks from Geoeconomic Uncertainty[1]

This online annex presents the data, methodology and additional findings of the analysis examining the impact of global geoeconomic uncertainty on the key macro-fiscal variables (Figures 1.15 and 1.16).

Data and Sample

All macro-fiscal variables come from the World Economic Outlook dataset while for geoeconomic uncertainty the Geopolitical Fragmentation Index (GFI) is taken from Villaverde, Mineyama, and Song (2024). The index is built by extracting a dynamic factor from a variety of empirical indicators that reflect different dimensions of geoeconomic uncertainty, including trade restrictions, capital controls, barriers to the movement of people, armed conflicts, UNGA voting patterns and others (Online Annex Figure 1.3.1). Geoeconomic uncertainty t manifests through disruptions to trade, investment flows, supply chains, financial systems, and technological cooperation, often driven by strategic competition (Villaverde, Mineyama, and Song, 2024). The estimation sample is based on an unbalanced panel of 57 countries covering the period 1973-2023 and comprises 2,927 country-year observation.

Online Annex Figure 1.3.1. Measuring Geoeconomic Uncertainty
(Standardized index)



Source: Fernández-Villaverde, Mineyama, and Song (2024).

Methodology

A Local Projection (LP) approach is used to estimate the impulse response function (IRF) of each of the macro-fiscal variables to shocks in geoeconomic uncertainty.

$$y_{i,t+h} - y_{i,t-1} = \gamma_i + b_0 + b_1^h gfi_t + \boldsymbol{cY}_{i,t-1} + u_{i,t+h} \quad , \qquad \text{(Eq1.3.1)}$$

[1] Prepared by Ervin Prifti.

where $\boldsymbol{Y}_{i,t} = \{gfi_t; s_{i,t}; p_{i,t}; y_{i,t}; exp_{i,t}; rev_{i,t}; d_{i,t}\}$ consists of the GFI index[2], and six macro-fiscal variables: the interest rate on long-term government bonds, the GDP deflator (log), real output (log), public expenditure and revenues as a share of GDP, and the debt to GDP ratio, all for country *i* in year t, except for the gfi_t which is global. The outcome $y_{i,t}$ represents one of the six macro-fiscal aggregates. The $\boldsymbol{\gamma}_i$ are country fixed effects, and $u_{i,t+h}$ is the error term. The coefficient b_1^h represents the IRF at horizon h, b_0 is a global intercept and $\boldsymbol{c}$ is a vector of coefficient. Confidence bands for the IRFs are based on robust standard errors.

Equation (1.3.1) is estimated by ordinary least squares (OLS), as we assume that the *gfi* index is exogenous, allowing it to affect each of the fiscal variables without any contemporaneous feedback from those variables. This assumption can be justified in the context of a cross-country panel regression considering that geoeconomic tensions are driven by external factors such as security concerns and global power dynamics, which can be thought of as independent from domestic fiscal policies. Moreover, individual countries, especially smaller ones, lack the influence to shape global or regional geoeconomic events. Even for larger economies, fiscal policies are assumed to not have direct or immediate feedback effects on the emergence or escalation of geoeconomic tensions.

Results

Baseline

The IRFs summarized in the main text by the bars in Figure 1.15 are presented in detail below (Online Annex Figure 1.3.2). Public debt responds significantly to geoeconomic uncertainty, increasing by 2 percent of GDP on impact. Effects linger four years on at almost 4 percent of GDP. The mechanisms underlying this effect can be motivated through the debt dynamic equation. In fact, rising geoeconomic uncertainty is associated with a fall in real output and widening fiscal deficits. A one standard deviation increase in geoeconomic uncertainty reduces real GDP by 2 percent at impact. The effects of the shock are persistent, as the GDP does not recover even in the medium term. Higher geoeconomic uncertainty leads to higher fiscal deficits. Expenditures increase by slightly more than a 1 percent of GDP, as countries may drive up spending on defense and production subsidies aimed at decoupling or reshoring production, while revenues shrink by 0.12 percent of GDP reflecting the decline in activity and trade. Risk premia increase in response to geoeconomic uncertainty, reflecting higher public debt. Finally, geoeconomic uncertainty leads to an increase in the consumer prices level between 1 and 2 percent in the medium term, as producers start passing on the higher production costs to consumers.

[2] The first difference of the geopolitical fragmentation index is used to capture short-term variations in geoeconomic uncertainty. This transformation helps mitigate the risk that the IRFs reflect a permanent geopolitical regime change rather than a temporary geopolitical shock.

Online Annex Figure 1.3.2. Economic and Fiscal Effects of Geoeconomic Uncertainty

(Percentage points of GDP; unless stated otherwise)

Sources: Fernández-Villaverde, Mineyama, and Song (2024); IMF, World Economic Outlook database; and IMF staff calculations.
Notes: The red dashed line indicates the response to a one standard deviation increase in Fernandez-Villaverde, Mineyama, and Song's (2024) index. The shaded area is the 90 percent confidence band. The x axis denotes time in years after the shock.

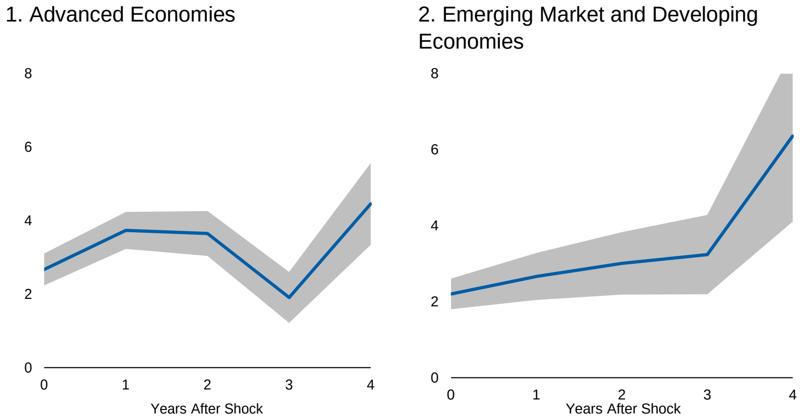
Results for Advanced Economies vs. Emerging Market and Developing Economies

This section presents LP estimates of fiscal aggregate responses to geoeconomic uncertainty shocks, comparing advanced economies (AEs) and emerging markets and developing economies (EMDEs), reported in Figure 1.16. The following equation is estimated:

$$y_{i,t+h} - y_{i,t-1} = \gamma_i + b_0 + b_1^h D^{AE} gfi_t + b_2^h (1 - D^{AE}) gfi_t + \boldsymbol{cY}_{i,t-1} + u_{i,t+h} \qquad \text{(Eq.1.3.2)}$$

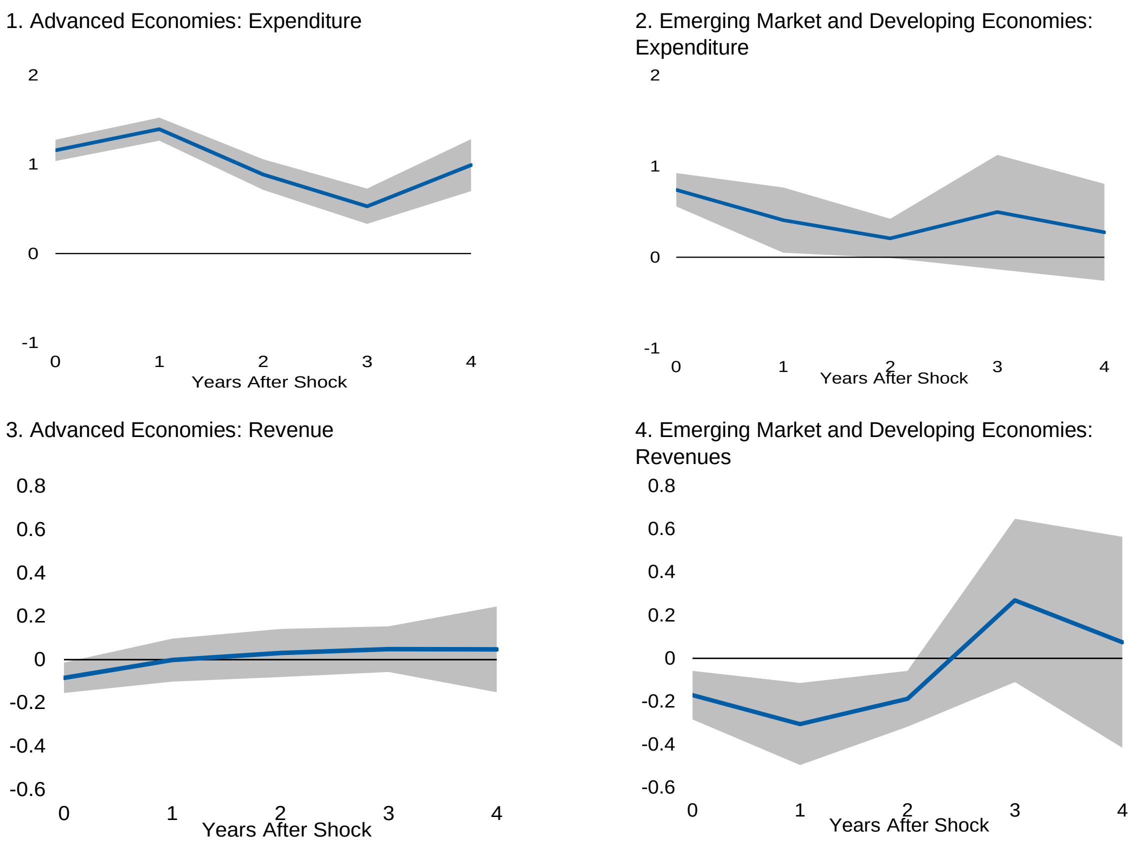
where D^{AE} is a dummy equal to 1 for advanced economies and b_1^h represents the IRF for AEs while b_2^h for EMDEs. The impulse response functions of AEs and EMDEs are similar and closely mirror those of the full sample, although there are significant differences for some horizons (Online Annex Figure 1.3.3). At horizon t=4, the effect in EMDEs is about 2 percentage points above that of AEs, although the confidence bands overlap. The effects of the index on the underlying drivers of public debt were similar for both groups of countries, confirming that geoeconomic uncertainty increases public debt primarily through lower growth and widening fiscal deficits, except for public spending which seems to be a bigger driver for AEs, likely because of higher military expenditures and production subsidies (Online Annex Figure 1.3.4). Moreover, the effect on revenues is larger and more persistent for EMDEs, since this group of countries may lose out more from international trade disputes or the fall in activity documented for the whole sample.

Online Annex Figure 1.3.3. Debt Effects Heterogeneity by Income Level
(Percentage points of GDP; unless stated otherwise)



Notes: The red dashed line indicates the response to a one standard deviation increase in Fernandez-Villaverde, Mineyama, and Song's (2024) index. The shaded area is the 90 percent confidence band. The x axis denotes time in years after the shock.

Online Annex Figure 1.3.4. Expenditure and Revenues Effects Heterogeneity by Income Level
(Percentage points of GDP; unless stated otherwise)



Notes: The red dashed line indicates the response to a one standard deviation increase in Fernandez-Villaverde, Mineyama, and Song's (2024) index. The shaded area is the 90 percent confidence band. The x axis denotes time in years after the shocks.

Quantile Regressions and Impact of Geoeconomic Uncertainty in Debt-at-Risk

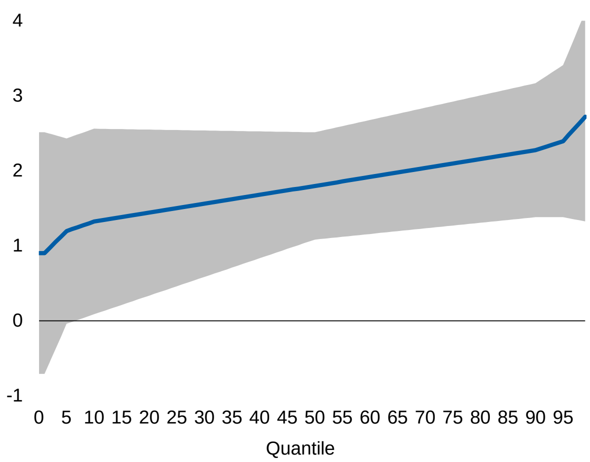
Further, to study the effects of geoeconomic uncertainty on the distribution of debt a quantile regression is applied on the same panel of countries. For the quantile regression method, a regression model is determined for each percentile of interest. Let $\tau_q(\mathbf{x})$ denote the q^{th} percentile of the distribution $F(y|\mathbf{x})$, i.e., $\tau_q(\mathbf{x}) = F_Y^{-1}(q) = inv\{y: F_Y(y|\mathbf{x}) \geq q\}$. To obtain the effect across different quantiles of the debt-to-GDP distribution at each horizon *h*, we estimate an additive regression model for panel data in which conditional percentiles are obtained as a function of the same covariates as above:

$$\tau_q(y_{i,t+h} - y_{i,t-1}) = \gamma_i + \mathrm{b}_0^{h,q} + b_1^{h,q} gfi_t + \boldsymbol{cY}_{i,t-1} + u_{i,t+h}, \qquad \text{(Eq.1.3.3)}$$

where $b_1^{h,q}$ now indicates the effect at the q^{th} quantile of the debt distribution at horizon h of a 1 standard deviation change in the *gfi* index. The rest of the notation is defined analogously to the previous equation.

The results show that geoeconomic uncertainty exerts a more significant impact on the right tail of the future debt distribution (Online Annex Figure 1.3.5). The findings indicate that higher geoeconomic uncertainty is associated with an increase of the 3-years ahead *Debt-at-Risk* of about 3 percentage points of GDP.

Online Annex Figure 1.3.5. Effects of Geoeconomic Uncertainty on Debt_at_Risk
(Percentage points of GDP)



Sources: Fernández-Villaverde, Mineyama, and Song (2024); IMF, World Economic Outlook database; and IMF staff calculations.
Note: The results are presented for the estimation of the effects of geopolitical uncertainty on public debt three-years ahead. "Quantile" in the horizontal axis denotes the estimated impact of geoeconomic uncertainty for public debt by the percentile of the distribution of the current public debt in the sample. Shaded areas represent 90 percent confidence bands.

Online Annex 1.4. Fiscal Policy and Sovereign Bond Yields in Emerging Markets and Developing Economies[7]

This annex describes the data, methodology, and additional results of the analysis on the effects of fiscal policy on domestic bond yields and how this effect is influenced by sovereign-bank nexus for EMDEs.

Effect of Fiscal Policy on 10-year Bond Yields in EMDEs

Data are retrieved from Bloomberg and include yields of sovereign bonds issued under domestic law in 75 EMDEs. The data are aggregated at semi-annual frequency and merged with bi-annual WEO forecasts (April and October) as well as cross-country data of sovereign-bank nexus, computed using IMF's Monetary and Financial Statistics. The sample period is from 2010:H1 to 2023:H2. The variables used in the estimations include: (i) four-year ahead forecast of primary fiscal deficits (in percent of GDP); (ii) 4-year ahead forecast of real GDP growth, CPI inflation, exchange rate depreciation; (iii) monetary policy rates; (iv) sovereign credit risk ratings; (v) U.S. 10-year Treasury forward bond rates and VIX, and (vi) demographic and inequality variables.

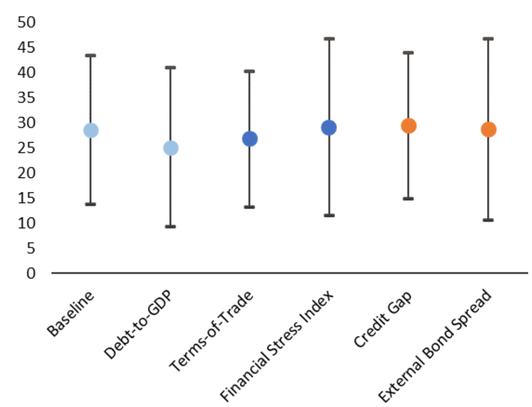
The following local projection method is estimated:

$$r_{c,t+h} - r_{c,t-1} = \beta^h E_t\left(g_{c,t+4}\right) + \theta^h X_{c,t} + \lambda_i + \tau_t + \epsilon_{c,t+h} \qquad \text{(Eq1.4.1)}$$

where r represents 10-year bond yields in country c and period t , $E_t\left(g_{c,t+4}\right)$ is 4-yeard ahead primary deficits, X includes macro and structural control variables as in the baseline. λ_c and τ_t are country and time fixed effects, respectively.

The results suggest that a 1 percent of GDP increase in the 4-year ahead primary fiscal deficit increases the 10-year sovereign bond yield by 29 basis points over four semi-annual periods (two years). This result is robust when controlling for additional factors affecting domestic bond yields, such as the country's sovereign credit risk (debt-to-GDP), commodity terms-of-trade, global financial stress and domestic credit conditions, and external bond spreads (Online Annex Figure 1.4.1)

Online Annex Figure 1.4.1. Effect of 4-year Ahead Primary Deficits on 10-year bond yields: Robustness checks with extended controls *(Basis points)*



Source: Bloomberg, WEO, Haver, and IMF staff calculations.
Note: The points indicate the cumulative impact of fiscal shock over two years under alternative specifications. 95 percent confidence intervals are shown in error bars.

Nonlinear Effect by Sovereign-Bank Nexus

Over the past two decades, EMDEs have increasingly relied on domestic sources of financing (Online Annex Figure 1.4.2, panel 1). This trend has accelerated after the COVID-19 pandemic as many EMDEs faced significant financing needs while facing diminished external market access. The creditor composition of domestic debt has become increasingly concentrated with domestic banks, while banks have increased the share of domestic bond in their portfolio composition. These two factors have strengthened what is denominated in the chapter the sovereign-bank nexus

[7] Prepared by Manabu Nose

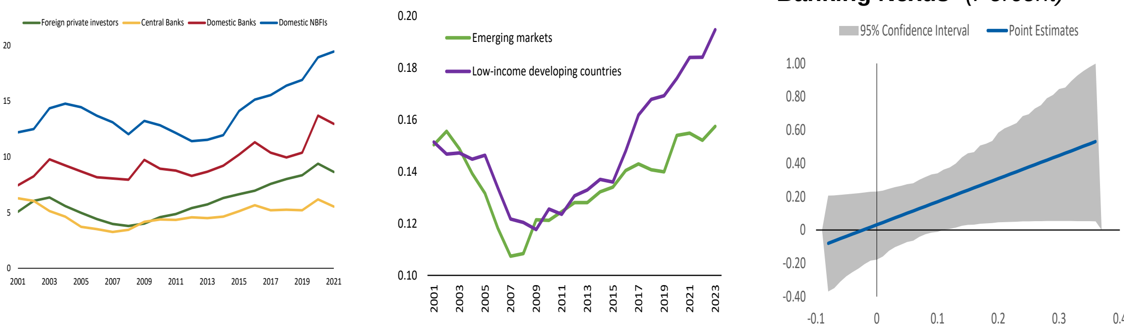
(Online Annex Figure 1.4.2, panel 2)—i.e., the domestic banks' exposure to sovereign bonds, as a share of banking sector assets.

Online Annex Figure 1.4.1. Domestic banks' exposure to public debt and risks of higher domestic bond yields in emerging market and developing economies (excluding China)

1. Level of Public Debt Held by Creditor *(Percent of GDP)*

2. Sovereign-Bank Nexus[2] *(Ratio)*

3. Effects of Expected Primary Deficit on 10-Year Bond Yield Conditional on Sovereign Banking Nexus[3] *(Percent)*



Sources: Arslanap and Tsuda (2014); Bloomberg; IMF World Economic Outlook database; Haver Analytics; and IMF staff calculations.
Notes: The lines in panel 1 show GDP-weighted average. Lines in panel 2 show sovereign-bank nexus and sovereign-central bank nexus are measured by the holding of domestic sovereign bonds as a share of each financial sector's total assets. The shaded area in panel 3 represents the 95 percent confidence intervals are shown in error bars. Estimates indicate cumulative impact over two years.

The analysis uses the Kitagawa-Blinder-Oaxaca (KBO) decomposition to estimate the impulse response heterogeneity due to the differences in sovereign-bank nexus across countries over time following Cloyne, Jordà, and Taylor (2023). First, the LP model is extended with a linear interaction term between 4-year ahead primary deficits and sovereign-bank nexus.

$$r_{c,t+h} - r_{c,t-1} = \beta^h E_t(g_{c,t+4}) + \gamma^h \widetilde{N_{c,t-1}} \cdot E_t(g_{c,t+4}) + \eta^h \widetilde{N_{c,t-1}}$$
$$+\theta^h X_{c,t} + \lambda_c + \tau_t + \epsilon_{c,t+h} \qquad \text{(Eq1.4.2)}$$

where $\widetilde{N}$ is sovereign-bank nexus (centered around pre-COVID global average).

Online Annex Figure 1.4.2, panel 3 shows the marginal effect of expected primary deficits on the 10-year bond yields as a y-axis, and how it varies over the distribution of the centered sovereign-bank nexus as x-axis. Estimates indicate that as the sovereign-bank nexus transitions from the 25th to the 75th percentile of its distribution, the impact of a 1 percentage point increase in the expected primary deficit relative to GDP on the 10-year domestic bond yield becomes more pronounced, leading to an average rise of 16 basis points. Hence, in economies with a strong sovereign-banking nexus, this effect can exceed 50 basis points. While $\widetilde{N}$ is assumed as exogenous, domestic banks' investment behavior may also be affected by market expectation of long-term fiscal stance. As an alternative specification, Nose and Menkulasi (2025) estimated a counterfactual LP model using a sensitivity instrument approach (Guren and others 2020; Nakamura and Steinsson 2014) which proceeds in two-steps: (1) estimate the sensitivity of sovereign-bank nexus (called "sensitivity-proxy") to 4-year ahead primary deficits with the same set of control variables in the first stage; and (2) estimate Equation (1.4.2) with the interaction term between expected primary deficits and the estimated sensitivity-proxy in the second stage. The robustness check confirms that 10-year bond yields react more strongly to expected fiscal expansion in EMDEs that rely more on deficit financing from domestic banks.

Online Annex 1.5. Crowding Out Effects Of Interest Expenses on Other Public Spending[8]

This annex describes the methodology and data used to produce Figure 1.19 in the main text.

Methodology

To analyze how interest expenditures have historically affected government budgets, we estimate:

$$y_{i,t+h} = \beta_h x_{i,t} + \phi_h' c_{i,t} + \delta_{N,i} + \delta_{T,t} + e_{i,t+h}^h \qquad \text{(Eq1.5.1)}$$

where i denote the country, t enumerates fiscal years, y is a budget line item like spending on subsidies or social benefits, x is interest expenditure, δ are deterministic country and time intercepts, and c is a vector of control variables containing two lags of y. Both y and x are measured as nominal expenditures in percent of nominal potential GDP. The coefficient of interest is β_h, which measures the response of the budget line item y, in percentage points of GDP, to a 1 percentage point increase in interest expenditures. The response is measured at horizon *h*=0,1,..5 years.

To address endogeneity problems an instrumental variable (IV) approach is used. The instruments are based on the interaction between US short-term interest rates and time-invariant characteristics for country i. We consider three different instruments, each of the form $r_t^{US}\xi_i$, where r_t^{US} is the 5-year rolling average of the 3-month constant maturity US Treasury interest rate and ξ_i is the average value of either the debt-to-GDP ratio, external debt-to-GDP ratio, or index of capital account openness over the full sample period.

Data and Sample

Online Annex Table 1.5.1 shows summary statistics and data sources for the variables in the dataset. Interest expenditures are available for 75 countries and 52 years.

Online Annex Table 1.5.1: Descriptive Statistics

type	variable	unit	N	T	NT	mean	min	max	std dev.
explanatory variable	interest expenditure	% of FY potential GDP	75	52	1,795	2.6	0.0	23.0	2.2
dependent variables	consump. fixed cap.	% of FY potential GDP	52	34	1,170	2.5	0.0	7.3	1.1
	non-interest exp.		74	52	1,732	36.1	4.7	65.9	10.2
	social benefits		74	44	1,563	12.5	0.0	27.4	6.4
	subsidies		74	36	1,558	1.5	0.0	9.2	1.3
instrumental variables	capital account openness	index	180	52	7,906	0.0	-1.9	2.3	1.5
	debt-to-GDP	%	67	64	2,114	56.1	0.9	502.6	38.0
	external debt-to-GDP	%	87	27	1,710	16.5	0.0	183.2	24.7
	US 3M int. rate	% p.a.	196	44	8,624	4.0	0.0	13.2	3.3

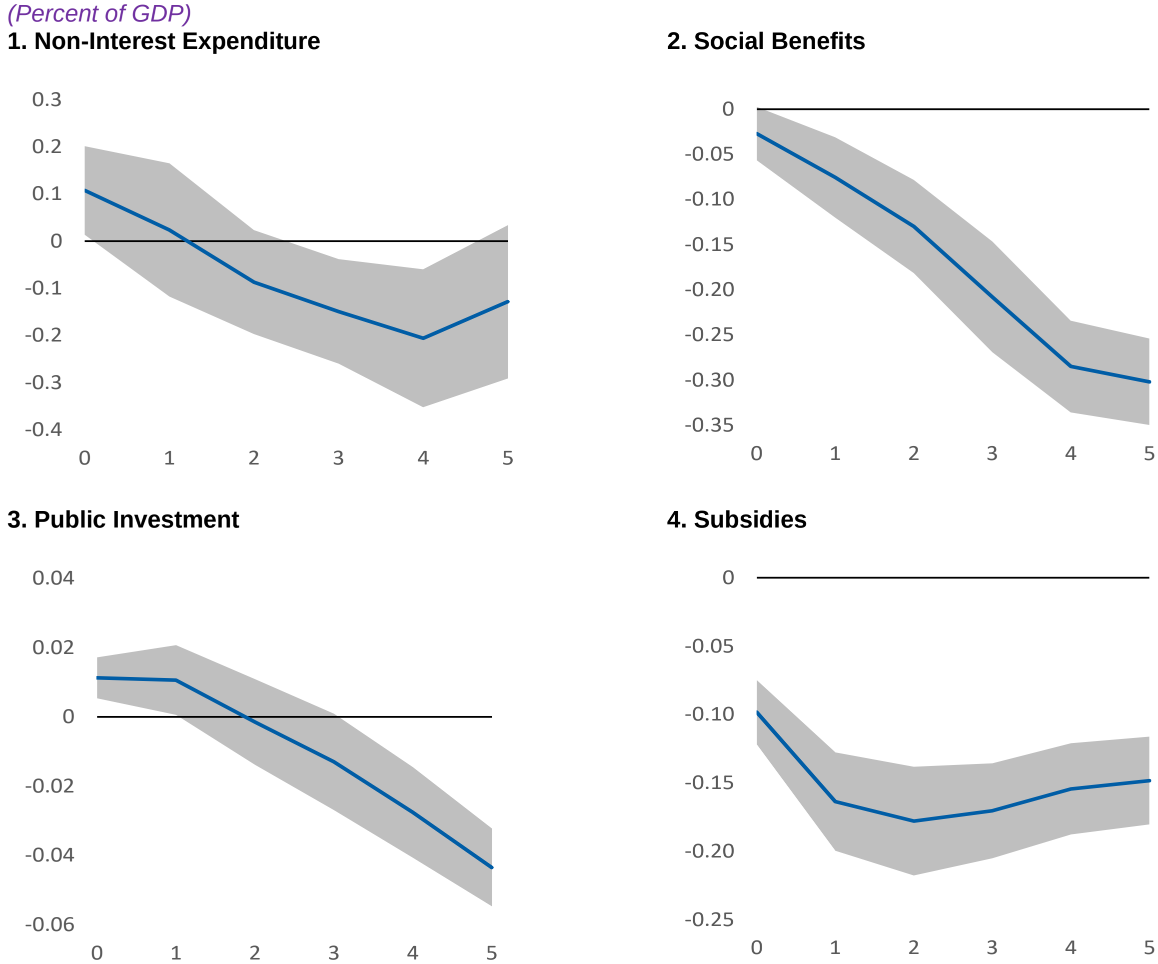
Source: IMF Government Finance Statistics; IMF World Economic Outlook database; IMF Global Debt Database; Federal Reserve H15 Release; Chinn and Ito (2006); World Bank Quarterly External Debt Statistics; and IMF staff estimates.
Notes: N = number of countries; T = number of years; NT = number of countries—years; FY = fiscal year; 3M = 3-month.

[8] Prepared by Galen Sher with assistance from Hongchi Li and Shelley Li.

Results using the Ordinary Least Squares Estimator

Online Annex Figure 1.5.1 shows the impulse-responses (i.e., the estimates of β_h) estimated using OLS. They show that non-interest expenditures tend to increase in the same year as interest expenditures rise, and then fall after 2 years, but these patterns are uncertain and difficult to distinguish from normal sampling variation. By contrast, social benefits and subsidies tend to fall in a statistically significant manner after interest expenditures increase. Using the OLS estimator, an increase in interest expenditures is associated with a marginal rise in public investment in the same year and subsequent year, but then a fall from years 3 to 5.

Online Annex Figure 1.5.1. Impulse-Responses under Ordinary Least Squares
(Percent of GDP)



Sources: IMF staff calculations.
Notes: These charts show estimates of parameter β_h using OLS. The shaded areas show pointwise 68 percent (i.e., one-standard deviation) confidence intervals using Driscoll—Kraay standard errors that allow for dependence across countries and years.

Results using the Instrumental Variables Estimator

When using IV approach, the two-stage least squares estimator is applied. The first stage specification is.

$$x_{i,t} = \alpha^{\times} r_t^{US} \xi_i + \alpha_c' c_{i,t} + \alpha_{N,i} + \alpha_{T,t} + u_{i,t} \qquad \text{(Eq1.5.2)}$$

where x, r, ξ, and c are defined as above, the αs are parameters to estimate, and u is a random error term that is assumed to be uncorrelated with $r_t^{US}\xi_i$. To investigate the plausibility of the instrumental variables $r_t^{US}\xi_i$, the following first stage specification is also estimated:

$$x_{i,t} = \alpha^{US} r_t^{US} + \alpha^{\times} r_t^{US}\xi_i + \alpha_{N,i} + u_{i,t} \qquad \text{(Eq1.5.2a)}$$

(Eq1.5.2a) approximates (Eq1.5.2), replacing $\alpha_{T,t}$ by $\alpha^{US} r_t^{US}$ so α^{US} can be estimated to check whether increases in US interest rates tend to drive up domestic government interest expenditures ($\alpha^{US} > 0$), as expected. Equation (Eq1.5.2a) maintains the term $\alpha^{\times} r_t^{US}\xi_i$, allowing to test whether $\alpha^{\times}$ is positive. Intuitively, a higher interest rate in the *United States* is expected to drive up domestic government interest expenditures more for those countries that have higher debt-to-GDP ratios, higher external debt-to-GDP ratios, and more open capital accounts. Online Annex Table 1.5.2 shows the estimates of α^{US} and $\alpha^{\times}$. They show that indeed the estimates of α^{US} and $\alpha^{\times}$ are positive, suggesting that the instrumental variable is working as expected. The *t*-statistic associated with parameter $\alpha^{\times}$ are moreover relatively high, as desired for valid finite sample inference.

Online Annex Table 1.5.2: Estimates of Approximate First Stage

	α^{US}	$\alpha^{\times}$	$t(\alpha^{\times})$
capital account openness	0.22	0.13	**6.1**
debt-to-GDP	0.05	0.01	**5.8**
external debt-to-GDP	0.29	0.00	**4.0**

Source: IMF staff estimates.
Notes: This table shows the results of estimating α^{US} and $\alpha^{\times}$ from equation (2a) by OLS. The t-statistic $t(\alpha^{\times})$ is computed using Driscoll—Kraay standard errors that allow for dependence across countries and years.

Online Annex Table 1.5.3 shows the results of formal tests of the informativeness of the instrumental variables $r_t^{US}\xi_i$. The results indicate that for all 6 horizons, the interaction of the US interest rate with the debt-to-GDP or external debt-to-GDP ratios create informative instruments for domestic government interest expenditure when the left-hand side variable is non-interest expenditure, social benefits, and consumption of fixed capital. When the left-hand side variable is subsidies or health expenditure, these instrumental variables are informative at 4 out of 6 horizons. By contrast, the instrumental variable using capital account openness as interaction term cannot be used because it is not informative.

Online Annex Table 1.5.3: First-Stage *F*-tests
(Number of horizons that are statistically significant)

	capital account openness	debt-to-GDP	external debt-to-GDP
non-interest exp.	0	6	6
social benefits	6	6	6
consump. fixed cap.	0	6	6
subsidies	4	6	4

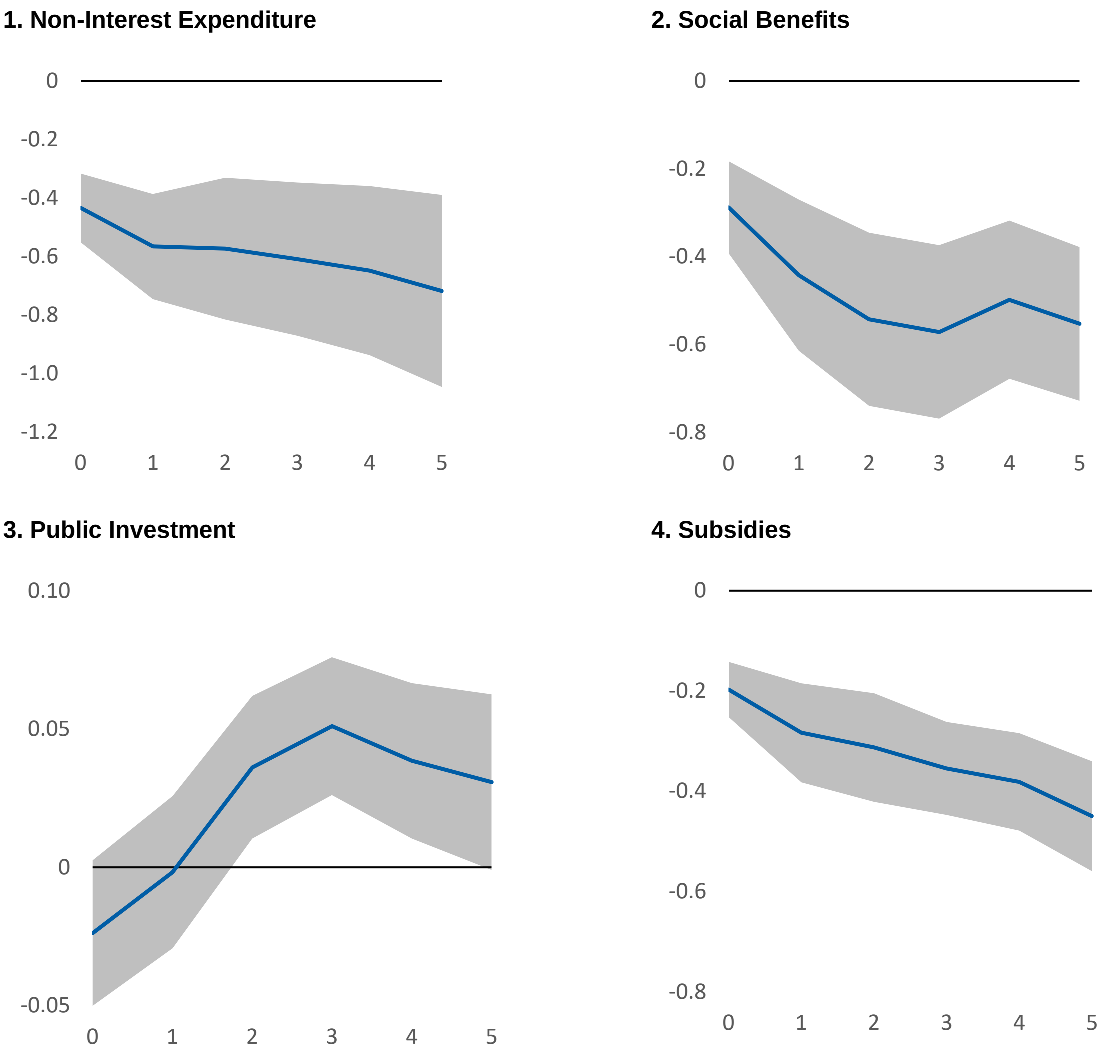
Source: IMF staff estimates.
Notes: This table shows the number of horizons (out of 6) with statistically significant F-tests at the 5 percent level following the method of Monteil Olea and Pflueger (2013) with τ = 0.2 and Driscoll—Kraay standard errors.

Given that both interaction terms using the debt-to-GDP and external debt-to-GDP provide informative instruments, Figure 1.19 in the chapter shows the estimates (of β_h) using them. For the results for the non-interest expenditure, social benefits, and subsidies, the interaction term used in the instrument is debt-to-GDP. For public investment, external debt-to-GDP is the interaction term used.

Online Annex Figures 1.5.2 and 1.5.3 show the impulse-response functions (IRFs) using instrumental variables with the U.S. short-term interest rates interacted with the debt-to-GDP ratio and external debt-to-GDP ratios, respectively. These IRFs confirm the results summarized in Figure 1.19.

Online Annex Figure 1.5.2. Impulse-Responses under the IV Estimator based on Debt-to-GDP

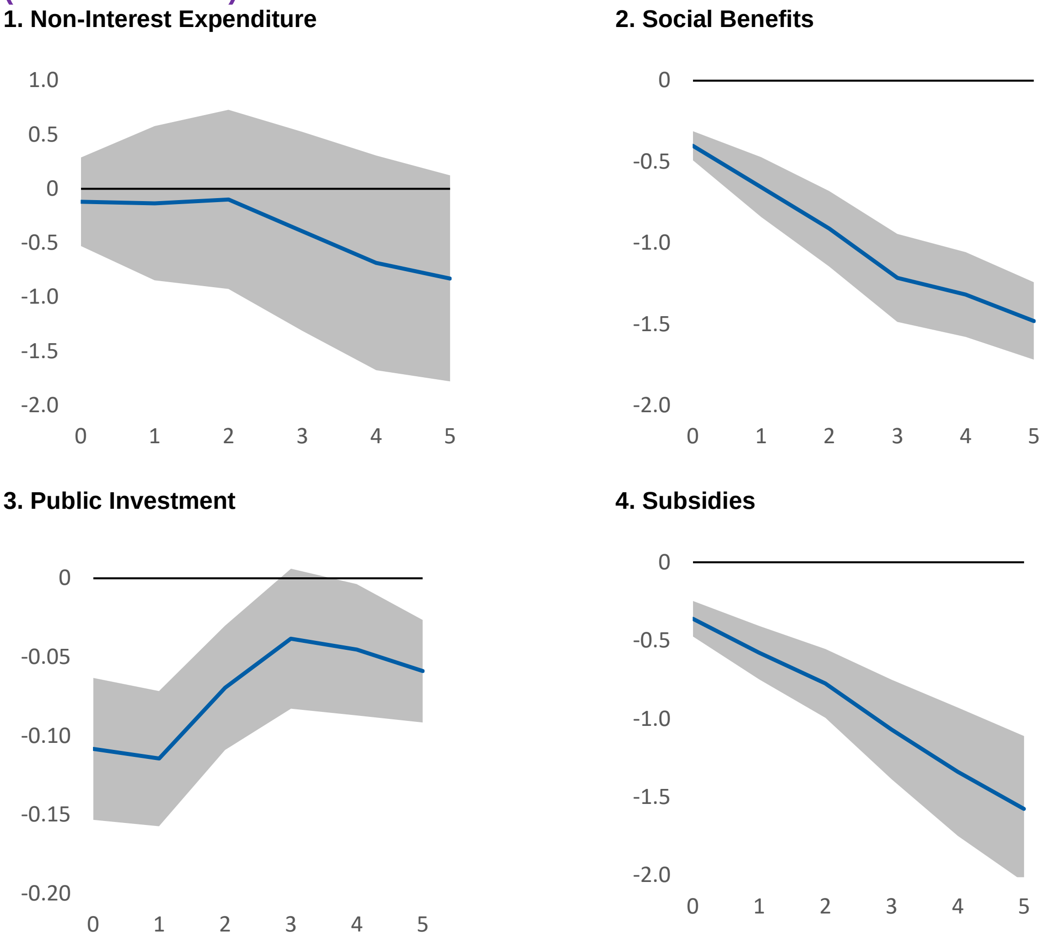
(Percent of GDP)



Sources: IMF staff calculations.

Notes: These charts show estimates of parameter β_h using the IV estimator where the instrument is the US interest rate interacted with the debt-to-GDP ratio. The shaded areas show pointwise 68 percent (i.e., one-standard deviation) confidence intervals using Driscoll—Kraay standard errors that allow for dependence across countries and years.

Online Annex Figure 1.5.3. Impulse-Responses under the IV Estimator based on External Debt-to-GDP
(Percent of GDP)



Sources: IMF staff calculations.
Notes: These charts show estimates of parameter β_h using the IV estimator where the instrument is the US interest rate interacted with the external debt-to-GDP ratio. The shaded areas show pointwise 68 percent (i.e., one-standard deviation) confidence intervals using Driscoll—Kraay standard errors that allow for dependence across countries and years.

Online Annex 1.6. Methodology used in Figure 1.21 and Figure 1.22[9]

Methodology for the analysis in Figure 1.21

The debt-stabilizing primary balance calculates the level of primary balance ($dspb_t$) that would stabilize a specific initial value of debt (d_{t-1})—in this case, the ratio of debt to GDP—in the previous year. That is given the values of the nominal effective interest rate (r_t) and growth rate (g_t) in the contemporaneous year.

Methodology for the analysis in Figure 1.22

An Autoregressive Integrated Moving Average (ARIMA) time-series model is estimated for each country in the sample, using a similar methodology of the Online Annex 1.5 of the April 2024 *Fiscal Monitor*. The orders of the autoregressive (AR) and moving average (MA) parts are optimized based on each country's time series pattern. The resulting estimated models are then used to forecast the primary valance distribution for each country and year, starting in 2025 and ending in 2030.

[9] Prepared by Carlos Eduardo Gonçalves, Arika Kayastha, Nicola Pierri, and Marcos Poplawski-Ribeiro.

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